Vision Sciences Society

7th Annual Meeting ▪ May 11-16, 2007 ▪ Sarasota, Florida

Ilona Kovacs

Table of Contents

Meeting Schedule

Friday, May 11

11:00 am - 7:30 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
1:00 – 3:00 pm	Member-Initiated Symposia, Session 1	*Hyatt, Various Rooms*
3:00 – 3:30 pm	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
3:30 – 5:30 pm	Member-Initiated Symposia, Session 2	*Hyatt, Various Rooms*
5:45 – 8:45 pm	Opening Night Reception	*Municipal Auditorium*
5:45 – 8:45 pm	Exhibits Open	*Municipal Auditorium*
5:45 – 8:45 pm	Poster Session A	*Municipal Auditorium*

Saturday, May 12

7:30 am - 5:30 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
8:00 – 8:30 am	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
8:30 – 10:00 am	Morning Talk Session 1	*North and South Hyatt Ballrooms*
8:30 am – 1:00 pm	Poster Session B	*Municipal Auditorium*
8:30 am – 4:00 pm	Exhibits Open	*Municipal Auditorium*
10:30 am – 12:15 pm	Morning Talk Session 2	*North and South Hyatt Ballrooms*
12:00 pm	Educational Outreach Event, Ione Fine	*G.WIZ Science Museum*
1:00 – 2:00 pm	Lunch Break	
2:00 – 3:30 pm	Afternoon Talk Session 1	*North and South Hyatt Ballrooms*
2:00 – 6:30 pm	Poster Session C	*Municipal Auditorium*
3:30 – 4:00 pm	Complimentary Coffee & Beverages	*Hyatt Ballroom Foyer*
4:00 – 5:45 pm	Afternoon Talk Session 2	*North and South Hyatt Ballrooms*

Sunday, May 13

8:00 – 8:30 am	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
8:00 am - 5:30 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
8:30 – 10:00 am	Morning Talk Session 1	*North and South Hyatt Ballrooms*
8:30 am – 1:00 pm	Poster Session D	*Municipal Auditorium*
8:30 am – 4:00 pm	Exhibits Open	*Municipal Auditorium*
10:30 am – 12:15 pm	Morning Talk Session 2	*North and South Hyatt Ballrooms*
1:00 – 2:00 pm	Lunch Break	
2:00 – 3:30 pm	Afternoon Talk Session 1	*North and South Hyatt Ballrooms*
2:00 – 6:30 pm	Poster Session E	*Municipal Auditorium*
3:30 – 4:00 pm	Complimentary Coffee & Beverages	*Hyatt Ballroom Foyer*
4:00 – 5:45 pm	Afternoon Talk Session 2	*North and South Hyatt Ballrooms*
7:00 – 8:30 pm	Keynote Address, Larry Abbott and Presentation of VSS Awards	*Hyatt Ballroom*

Monday, May 14

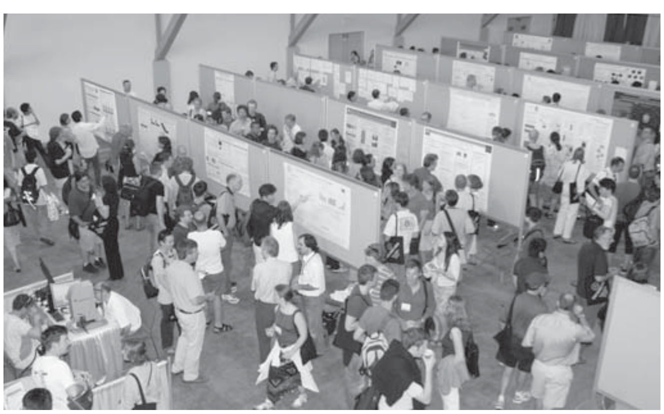
7:30 – 8:00 am	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
7:30 am - 4:30 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
8:00 – 9:30 am	Morning Talk Session 1	*North and South Hyatt Ballrooms*
8:00 am – 12:30 pm	Poster Session F	*Municipal Auditorium*
8:00 am – 4:00 pm	Exhibits Open	*Municipal Auditorium*
10:00 am – 11:45 pm	Morning Talk Session 2	*North and South Hyatt Ballrooms*
12:30 – 1:00 pm	Lunch Break	
1:00 – 2:00 pm	Business Meeting	*Hyatt Ballroom South*
2:00 – 2:30 pm	Complimentary Coffee & Beverages	*Hyatt Ballroom Foyer*
2:00 – 6:30 pm	Poster Session G	*Municipal Auditorium*
2:30 – 4:15 pm	Afternoon Talk Session	*North and South Hyatt Ballrooms*
7:00 – 10:00 pm	Demo Night	*G.WIZ Science Museum*

Tuesday, May 15

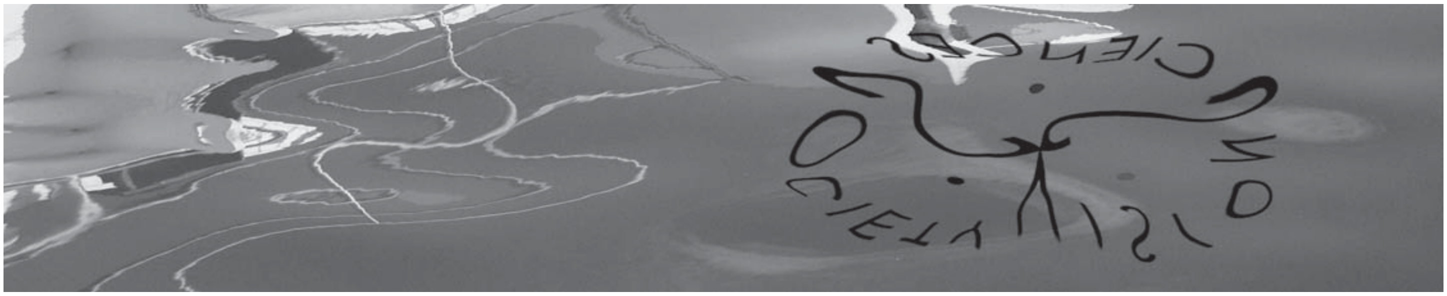
8:00 – 8:30 am	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
8:00 am - 5:30 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
8:30 – 10:00 am	Morning Talk Session 1	*North and South Hyatt Ballrooms*
8:30 am – 1:00 pm	Poster Session H	*Municipal Auditorium*
8:30 am – 4:00 pm	Exhibits Open	*Municipal Auditorium*
10:30 am – 12:15 pm	Morning Talk Session 2	*North and South Hyatt Ballrooms*
1:00 – 2:00 pm	Lunch Break	
2:00 – 3:30 pm	Afternoon Talk Session 1	*North and South Hyatt Ballrooms*
2:00 – 6:30 pm	Poster Session I	*Municipal Auditorium*
3:30 – 4:00 pm	Complimentary Coffee & Beverages	*Hyatt Ballroom Foyer*
4:00 – 5:45 pm	Afternoon Talk Session 2	*North and South Hyatt Ballrooms*
9:00 pm – 1:00 am	Club Vision	*Hyatt Ballroom South*

Wednesday, May 16

8:00 – 8:30 am	Complimentary Coffee Service	*Hyatt Ballroom Foyer*
8:00 am - 12:15 pm	Onsite and Pre-Registration Check In	*Hyatt Ballroom Foyer*
8:30 – 10:00 am	Morning Talk Session 1	*North and South Hyatt Ballrooms*
8:30 am – 1:00 pm	Poster Session J	*Municipal Auditorium*
10:30 am – 12:15 pm	Morning Talk Session 2	*North and South Hyatt Ballrooms*
1:00 pm	VSS 2007 Ends	



Poster Schedule



Please Note: Each poster session has *two* Author Presents times.

Poster Session A, Friday, May 11

5:45 - 8:45 pm

Setup: 5:30 -5:45 pm

Author Presents 1: 5:45 - 7:15 pm
Eye Movements: Cognitive I
2D Motion I
Perceptual Learning I

Author Presents 2: 7:15 – 8:45 pm
Face perception: Experience and Context
Rivalry and Bi-stability I
3D Perception: Cue Integration
Cortical Receptive Fields and Perception

Take Down: 8:45 - 9:00 pm

Poster Session B, Saturday, May 12

8:30 am - 1:00 pm

Setup: 8:15 -8:30 am

Author Presents 1: 8:30 - 10:15 am
Locomotion I: General
Visuomotor Control: Hand Movements
Attention: Neural Mechanisms

Author Presents 2: 10:30 am – 12:15 pm
Eye Movements: Saccades and Smooth Pursuit
Scene Perception I
2D Shape and Form
Special populations: Development

Take down: 1:00 - 1:30 pm

Poster Session C, Saturday, May 12

2:00 - 6:30 pm

Setup: 1:30 -2:00 pm

Author Presents 1: 2:00 - 3:45 pm
Brightness, Lightness and Luminance
Adaptation and Aftereffects
3D Perception: Space
Visual Control of Movement: Neural Mechanisms

Author Presents 2: 4:00 – 5:45 pm
V1 and Thalamus: Anatomy and Organizationg
Spatial Vision: Contrast and Masking
Multisensory Processing

Take down: 6:30 - 6:45 pm

Poster Session D, Sunday, May 13

8:30 am - 1:00 pm

Setup: 8:15 -8:30 am

Author Presents 1: 8:30 - 10:15 am
Rivalry and Bi-Stability II
Time Perception and Temporal Processing
Perception and action II

Author Presents 2: 10:30 am – 12:15 pm
Motion Integration
Attention: Selection, Enhancement, & Orienting

Take down: 1:00 - 1:30 pm

Poster Session E, Sunday, May 13

2:00 - 6:30 pm

Setup: 1:30 -2:00 pm

Author Presents 1: 2:00 - 3:45 pm

Perceptual Learning III
Biological Motion I
Reading
Special Populations: Disorder and Disease

Author Presents 2: 4:00 – 5:45 pm

Color and Surface Perception
Face Perception: Parts, Wholes, Features, and Configurations
Attention and Inhibition

Take down: 6:30 - 6:45 pm

Poster Session F, Monday, May 14

8:00 am - 12:30 pm

Setup: 7:45 - 8:00 am

Author Presents 1: 8:00 - 9:45 am

Spatial Vision: Mechanisms and Orientation
Eye Movements: Attention and Search
Attention: Divided Attention, Inattention, and Inhibition

Author Presents 2: 10:00 am – 11:45 pm

Perceptual Organization: Contours II
Face Perception: Neural mechanisms
Visual Working and Short-Memory Memory

Take down: 12:30 - 1:00 pm

Poster Session G, Monday, May 14

2:00 - 6:30 pm

Setup: 1:30 -2:00 pm

Author Presents 1: 2:00 - 3:45 pm

Color Vision Mechanisms
Eye Movements: Effects on Perception
Motion Adaptation and Aftereffects
Motion in Depth and Optic Flow

Author Presents 2: 4:00 – 5:45 pm

Attention: Interaction with Memory or Emotion
Attention: Training Effects and Subitizing
Search I
Navigation

Take down: 6:30 - 6:45 pm

Poster Session H, Tuesday, May 15

8:30 am - 1:00 pm

Setup: 8:15 -8:30 am

Author Presents 1: 8:30 - 10:15 am

Visual Memory
Auditory-Visual Interactions
Multiple Object Tracking

Author Presents 2: 10:30 am – 12:15 pm

Binocular Vision: Stereopsis and Fusion
3D Perception: Shape and Depth
Face Spaces and Adaptation

Take down: 1:00 - 1:30 pm

Poster Session I, Tuesday, May 15

2:00 - 6:30 pm

Setup: 1:30 -2:00 pm

Author Presents 1: 2:00 - 3:45 pm

Grouping and Segmentation II
Attention: Theoretical and Computational Models
Spatial Vision: Natural Scenes and Texture

Author Presents 2: 4:00 – 5:45 pm

Object Perception
Face Perception: Emotion I
Motion: Apparent Motion and Illusions

Take down: 6:30 - 6:45 pm

Poster Session J, Wednesday, May 16

8:30 am - 1:00 pm

Setup: 8:15 -8:30 am

Author Presents 1: 8:30 - 10:15 am

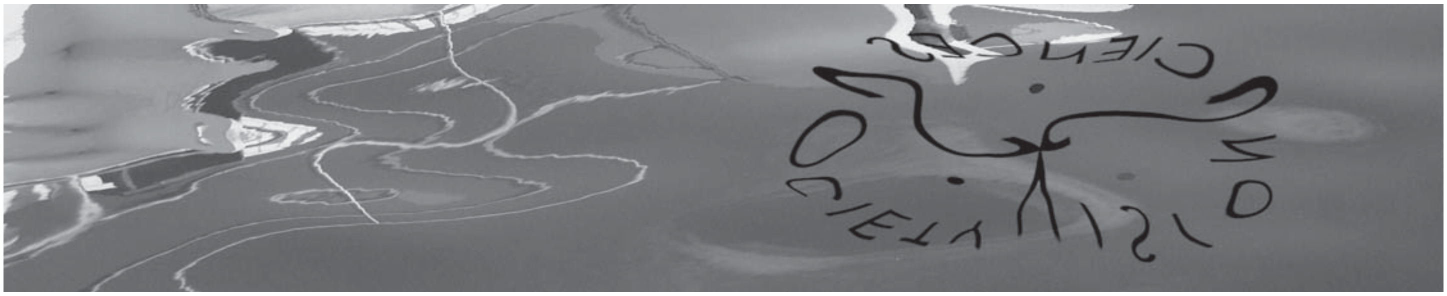
Locomotion II: Walking and Posture
Processing of Objects
Scene Perception II
Search II

Author Presents 2: 10:30 am – 12:15 pm

Attention: Object-based Selection
Attentional Capture
Attention: Temporal Selection
Attentional Modulation of Early Vision

Take down: 1:00 - 1:15 pm

Talk Schedule



Saturday, May 12

Time	Hyatt Ballroom North	Hyatt Ballroom South
8:30 - 10:00 am	3D Perception	Perceptual Learning II
10:30 am - 12:15 pm	The Many Functions of the Ventral Stream	Global Motion and Motion Integration
2:00 - 3:30 pm	Perceptual Organization: Contours I	Perception and Action I
4:00 - 5:45 pm	Attention: Objects, Scenes, and Search	Face Perception

Sunday, May 13

Time	Hyatt Ballroom North	Hyatt Ballroom South
8:30 - 10:00 am	Eye Movements: Mechanisms	Grouping and Segmentation I
10:30 am - 12:15 pm	Object Recognition	Early Visual Processing: Receptive Fields
2:00 - 3:30 pm	Spatial Vision I	Attention Modulation of Sensory Signals: Physiology
4:00 - 5:45 pm	Spatial Vision II	Memory

Monday, May 14

Time	Hyatt Ballroom North	Hyatt Ballroom South
8:00 - 9:30 am	Biological Motion II	Early Visual Development
10:00 - 11:45 am	Visuomotor Control: Goal-Directed Hand Movements	Lightness and Brightness
2:30 - 4:15 pm	Attention: Tracking and Shifting	Face Perception: Development, Learning, and Expertise

Tuesday, May 15

Time	Hyatt Ballroom North	Hyatt Ballroom South
8:30 - 10:00 am	Blindness, Amblyopia, Dyslexia, and Rehabilitation	Shape, Picture, and Scene Perception
10:30 am - 12:15 pm	Motion Mechanisms	Attention to Locations and Features
2:00 - 3:30 pm	Color, Luminance and Receptors	Perceptual Learning IV
4:00 - 5:45 pm	Binocular Vision: Rvalry and Mechanisms	Attention: Selection Over Space and Time

Wednesday, May 16

Time	Hyatt Ballroom North	Hyatt Ballroom South
8:30 - 10:00 am	Eye Movements: Cognitive II	Face Perception: Emotion II
10:30 am - 12:15 pm	Temporal Processing	2D Motion II

Member-Initiated Symposia

Friday, May 11, 2007

Schedule Overview

Friday, May 11, 1:00 - 3:00 pm

Visual Organization and Computation, *Hyatt Salons A/B*

Multivariate Decoding of Neural Representations in Electrophysiology and Functional Imaging, *Hyatt Salons E/F*

Visual Plasticity in Abnormal and Damaged Adult Brains, *Hyatt Salons C/D*

Neural Substrate of Bottom-up and Top-Down Visual Attentional Selection, *Hyatt Salons G/H*

Friday, May 11, 3:30 - 5:30 pm

How to Use Individual Differences to Isolate Functional, Neural and Genetic Mechanisms of Vision, *Hyatt Salons A/B*

Natural Scene Understanding: Statistics, Recognition and Representation, *Hyatt Salons G/H*

Neural Mechanisms of Depth Perception, *Hyatt Salons C/D*

Classification Images in Vision Research, *Hyatt Salons E/F*

Visual Organization and Computation

Friday, May 11, 1:00 - 3:00 pm, Hyatt Salons A/B

Organizers: Sergei Gepshtein (Brain Science Institute, RIKEN) & Laurence T. Maloney (Psychology & Neural Science,NYU)

Symposium Summary

In many visual tasks, the goal is to draw accurate inferences about properties of the world. One potential source of relevant information are joint distributions of co-occurrence of features in the environment. Wilson Geisler and Jitendra Malik will describe two distinct approaches to measuring such prior distributions and modeling how a visual system might make use of them in perceptual organization. James Elder will then describe a coarse-to-fine Bayesian algorithm for perceptual organization. In his approach, candidate contours are extracted at a coarse scale and then used to generate spatial priors on the location of possible contours at finer scales. Jacob Feldman will describe an alternative model of spatial organization as a hierarchical ('tree') structure. A Bayesian approach to perceptual organization then reduces to Bayesian estimation of this tree; the perceived organization will correspond to the tree that best explains the observed spatial configuration.

A fundamental challenge to research of perceptual organization is to discover how different factors interact to affect perception. Michael Kubovy will describe experimental work on perceptual grouping. He will show that in some static displays, such as dot lattices, emergent organizations (presumably generated by nonlinear processes) combine additively. He will discuss examples using multi-stable regular dots patterns and develop a mathematical model of perceptual organization of such stimuli.

Sergei Gepshtein will present a normative theory based on optimal allocation of neural 'resources', analogous to neoclassical economic theory. In this theory the visual system allocates resources to different conditions of stimulation according to the degree of balance between measurement uncertainties and stimulus uncertainties. He will describe how the theory predicts maximal-sensitivity and isosensitivity sets of human vision and how it helps to reconcile apparently inconsistent data on perceptual organization of dynamic stimuli.

The symposium will conclude with a guided discussion (Laurence T. Maloney).

Presentations

S1 **A Bayesian multi-scale model of perceptual organization**

James Elder & Francisco Estrada; York University, Canada

Humans have a remarkable ability to rapidly group and organize image data into coherent representations reflecting the structure of the visual scene. However current computer vision algorithms are by comparison relatively primitive in their performance. Key issues include the combinatorial complexity of the problem and difficulties capturing and combining global constraints with local cues. In this work we develop a coarse-to-fine Bayesian algorithm that addresses these issues.

In our approach, candidate contours are extracted at a coarse scale and then used to generate spatial priors on the location of possible contours at finer scales. In this way, a rough estimate of the shape of an object is progressively refined. The coarse estimate provides robustness to texture and clutter while the refinement process allows for the extraction of detailed shape information. The grouping algorithm is probabilistic and uses multiple grouping cues derived from natural scene statistics. We present a quantitative evaluation of grouping performance on natural images and show that the multi-scale approach outperforms single-scale contour extraction algorithms. We suggest that the substantial feedback connections known to exist in ventral stream of the visual cortex may support an analogous refinement of perceptual representations in the human brain.

S2 **Seeing the forest in a tree: Bayesian estimation of hierarchical spatial organization**

Jacob Feldman; Rutgers University

Vision is about more than little local patches in the image; as the Gestaltists emphasized, it is also about the apprehension of the spatial organization among all the little patches. Spatial organization can conveniently be depicted via a tree diagram that represents the spatial relations among visual elements---and the spatial relations among groups of elements (subtrees), and among groups of groups of elements, and so forth, in a hierarchical manner. A Bayesian approach to perceptual organization then reduces to Bayesian estimation of this tree; the perceived organization will correspond to the tree that best explains the observed spatial configuration, including both its many local relations (smaller subtrees) and its overall configural structure (larger subtrees). This approach formalizes the notion of a qualitative interpretation, allowing us to understand the formal rules (including but not limited to Bayesian ones) that make one tree interpretation of the image "better" (more Pragnant) than another. In this sense the "forest" – the whole – is best apprehended by estimating the right "tree."

S3 **Bayesian scene statistics and perceptual organization**

Wilson S. Geisler; University of Texas at Austin

There are two general types of natural scene statistics. "Absolute statistics" characterize probability distributions of properties either within the environment or within the retinal October 23, 2006 2 of 5 image. They are useful for understanding coding and representation, but say little about the relationship between the environment and the retinal image, and hence are not very useful for understanding the information relevant to specific natural tasks. In most natural tasks, the goal is to draw accurate inferences about properties of the physical environment (e.g., physical boundaries, shapes, motions, distances, and so on) from properties of the retinal image. In this case, the relevant statistics are "Bayesian statistics," which characterize the distribution of distal physical properties, conditional on properties of the retinal image. A potentially powerful method for measuring Bayesian statistics is to analyze natural images that have been hand segmented by human observers. The central assumption is that humans can, under some circumstances, perform veridical segmentations of images to provide an approximate "ground-truth." These ground-truth segmentations can then be used to determine the likelihood and prior probability distributions needed for optimal (Bayesian) perceptual inference. I will describe examples of measuring Bayesian statistics that illustrate their potential value for (i) understanding the information relevant for performing natural perceptual organization tasks, (ii) generating plausible hypotheses for neural mechanisms, and (iii) designing experimental tests of those hypothesized mechanisms.

S4 **Non-Bayesian normative theory of dynamic perceptual organization**

Sergei Gepshtein & Ivan Tyukin; Brain Science Institute, RIKEN

Visual perception is constrained by such basic factors as the measurement principle of uncertainty (Gabor, 1946) and the structural stability of visual measuring devices (receptive fields). We propose a new normative theory in which the aforementioned constraints, together with statistics of optical stimulation, control the ability for perceptual organization of dynamic stimulation. Similar to how the optimal allocation of resources is achieved in neoclassical economic theory, in our theory vision allocates its resources to different conditions of stimulation in proportion to the degree of balance between measurement uncertainties and stimulus uncertainties: These conditions are (A) optimal where the uncertainties are balanced exactly, and (B) equally suboptimal where the uncertainties are unbalanced to the same degree. We show that the maximal sensitivity set (predicted by A) and the isosensitivity sets (predicted by B) of human vision follow the optimal prescription. Statistics of natural stimulation affect the shapes of both predictions A and B, making them closer to empirical data. Changes in the statistics of stimulation (as in adaptation studies) and in system goals (e.g., induced by change of task: localization vs. identification of moving objects) also affect the shapes of predicted sets. But these changes are only modulatory; the overall shape of human motion sensitivity (e.g., summarized by the spatiotemporal sensitivity function; Kelly, 1979) is determined by the balance of measurement uncertainties. The theory explains why well-known but seemingly inconsistent results on suprathreshold apparent motion are consistent with one another and with measurements at the threshold.

S5 **Grouping by spatial distance is additive with other forms of static dissimilarity but not with distance in time**

Michael Kubovy; University of Virginia

In some static displays such as dot lattices, pairs of emergent organizations, presumably generated by nonlinear processes, combine additively to affect perceptual organization. I will discuss two examples, both using multistable regular dots patterns briefly presented well above threshold, in which different organizations compete for perceptual salience. For example, when lightness is pitted against spatial distance, the greater the heterogeneity of lightness in the organization which is heterogeneous with respect to lightness, the smaller the spatial distance must be between these heterogeneous elements to be in equilibrium with an alternative organization in which the elements are homogeneous with respect to lightness and the distance between elements is held constant. As one manipulates these variables, relative distance and some other grouping principles additively affect the probability of seeing one organization rather than its competitors. This is true even when the competition is between curved and rectilinear organizations. These results are consistent with Garner's ideas about the separability of types of similarity in the determination of multidimensional similarity, and it raises the question of whether we should think of spatial distance as a form of similarity. On the other hand, in dynamic displays, grouping by spatial proximity and grouping by temporal proximity interact inseparably. Spatial configuration #1, presented at time t1, is affected by spatial configuration #2, presented at a later time t2, when apparent motion is perceived. A fundamental challenge to theories of perceptual organization is to discover what determines how different factors interact to affect perceptual organization.

S6 **Ecological statistics of perceptual organization**

Jitendra Malik; University of California at Berkeley

Visual grouping and figure-ground discrimination were first studied by the Gestalt school of visual perception nearly a century ago. However, they left open (at least) three major problems (1) there wasn't a precise operationalization of the various grouping and figureground factors for general images, (2) the interaction of these factors was ill understood (3) and there was no justification for why these might be helpful to an observer interacting with the visual world. In my research group, we have tackled these problems in the framework of what we call "ecological statistics". We start with a set of natural images and use human observers to mark the perceptual groups and assign figure-ground labels to the various boundary contours. We construct computational models of various grouping and figure-ground factors inspired by corresponding mechanisms in visual cortex. Finally we calibrate and optimally combine the grouping and figure-ground factors by using the principle that vision evolved to be adaptive to the statistics of objects in the natural world. Over the last few years of research in this framework, we have been able to quantitatively characterize the grouping cues of brightness, color, and texture similarity and curvilinear continuity, and figure-ground cues of size, lower-region and convexity. I shall summarize some of these results in my talk. We have also made an initial attempt at a computational model which pulls these cues together. This research is joint work with Charless Fowlkes, David Martin and Xiaofeng Ren.

Multivariate Decoding of Neural Representations in Electrophysiology and Functional Imaging

Friday, May 11, 1:00 - 3:00 pm, Hyatt Salons E/F

Organizers: John-Dylan Haynes (Max Planck Institute for Cognitive and Brain Sciences) & Nikolaus Kriegeskorte (Laboratory of Brain and Cognition, National Institute of Mental Health)

Symposium Summary

Neural representations are inherently a parallel, multi-unit phenomenon. In order to fully understand them, many channels should be measured simultaneously and the analysis should handle their multivariate complexity. This Symposium explores a current trend of convergence between neuroimaging and electrophysiology, in which multi-channel measurement and multivariate decoding are combined to address basic questions about neural representations. We bring together key researchers following this approach in the still largely separate neuroimaging and electrophysiology communities. The presentations will take a fresh look at the degree to which neural codes are sparse or distributed as well as at their conscious accessibility and temporal dynamics. Data presented stem from single-cell and multiunit recordings in humans and monkeys, local field potentials, as well as conventional and high-field/high-resolution fMRI. We will show how multi-channel measurement combined with multivariate decoding can dramatically increase the sensitivity to subtle effects and help bridge the gap between fMRI and cell recordings. Information theory and decoding have long been central to neuroscience. But only recently have they emerged as a powerful theoretical and data-analytical framework to deal with the increasing complexity of massively multi-channel data. This common theory-and-analysis framework will help integrate animal and human studies as well as neuroimaging and invasive cell recording.

Presentations

S7 Decoding conscious and unconscious perception from dynamic brain patterns

John-Dylan Haynes; Max Planck Institute for Cognitive and Brain Sciences

It has recently emerged that the sensitivity of fMRI can be dramatically increased if the full information present in large ensembles of voxels is appropriately taken into account. For example, supervised learning can be used to train a pattern classifier to distinguish between several orientation stimuli viewed by a subject based on the characteristic distributed brain responses they evoke in visual cortex. This holds even though the relevant features are represented at a finer spatial scale than the nominal resolution of single voxels, which is consistent with a biased sampling model. Here several studies will be presented that apply such pattern recognition to the study of conscious and unconscious perception in humans. In one study the information about a stimulus that is available to a subject for a perceptual decision is compared to the information that can be decoded from early visual areas. This reveals that V1 has information about stimulus features even when they are rendered completely invisible due to masking, suggesting that V1 can have information about visual stimuli that is not available for conscious access. A second study demonstrates that pattern classification can be used to accurately predict on a second-by-second basis participants' conscious perception while it undergoes many spontaneous changes during binocular rivalry. Importantly, this reveals that the source of predictive information differs between visual areas, being more eye-based in V1 and more percept-based in V3. Taken together this provides valuable information about the nature of perceptual coding in these areas.

S8 Object recognition by decoding spikes and local field potentials

Gabriel Kreiman; Children's Hospital Boston, Harvard Medical School

One of the most remarkable abilities of our visual system is the possibility of recognizing (e.g. categorizing or identifying) objects under many different views and transformations. We directly quantified the ability of populations of spiking units in macaque monkey inferior temporal (IT) cortex to encode information about complex objects by using a biologically plausible statistical classifier. We observed that we could accurately read out information about object category and identity (performance > 90%) in very brief time intervals (12.5 ms) using a small neuronal ensemble (approximately 100 neurons). The performance of the linear classifier that we used for decoding could, at least in principle, correspond to the information available for read-out by targets of IT, such as a neuron in prefrontal cortex. During such short 12.5 ms intervals, neurons typically conveyed only one or a few spikes, suggesting the possibility of a binary representation of object features. We also showed that we could decode information from the local field potentials (LFP) in inferior temporal cortex. The LFP signal is composed mostly of dendritic potential and shows a stronger correlation with the BOLD measurements in fMRI. Importantly, the population response generalized across object positions and scales. This scale and position invariance was evident even for novel objects that the animal never observed before. Furthermore, we showed that the observations obtained upon recording from populations of IT neurons can be explained by a hierarchical non-linear model of object recognition. The model quantitatively matches the performance of IT neuronal populations.

S9 Discovering regional macropopulation codes for visual objects by information-based brain mapping

Nikolaus Kriegeskorte; Laboratory of Brain and Cognition, National Institute of Mental Health

Brain mapping analysis in neuroimaging has focused on the discovery of activation, i.e. of extended brain regions whose average activity changes across experimental conditions. Here we ask a more general question of the data: Where in the brain does the activity pattern contain information about the experimental condition? To address this question we scan the imaged volume with a spherical "searchlight", whose contents are analyzed multivariately at each location.

We apply this method to explore human inferotemporal response patterns to single object images (high-resolution fMRI at 3T and 7T), searching the measured volume for regional macropopulation codes. For each region of interest, we estimate in bits the amount of between- and within-category information present in the spatial response patterns. This approach yields some unexpected results. Fusiform face and parahippocampal place regions both contain category information not only in the spatial-mean response usually studied but also in the spatial shape of their response patterns. The combinatorial representation in these regions seems to emphasize the object category at the expense of the idiosyncrasies defining object identity. Although the fusiform face region is considered to serve individual-level face representation, we do not detect face-exemplar information there. Face exemplar-information appears to be more pronounced in anterior inferotemporal cortex.

S10 Distributed representations of faces and objects analyzed as multi-voxel patterns in fMRI

James Haxby; Princeton University

S11 Decoding visual inputs from human single cell recordings

Rodrigo Quian Quiroga; Department of Engineering, University of Leicester

We recently reported the presence of neurons in the human medial temporal lobe (MTL) that fire in a remarkably selective manner to different views of familiar individuals and objects. These data supports a sparse and invariant representation in MTL, suggesting that the identity of individuals is encoded by a small number of neurons. Given such explicit representation, we asked whether it is possible to predict which stimuli was shown in each trial from the activity of these cells.

Subjects were 11 patients with pharmacologically intractable epilepsy implanted with depth electrodes in order to localize the focus of seizure onsets. Stimuli were different pictures of individuals, animals, objects and landmark buildings. Using a novel spike detection and sorting algorithm, in 35 experimental sessions we recorded from 1547 units (45.5 units per session) and for each session we predicted the presentation of images using a linear classifier.

About 4 spikes triggered between 300-600 ms in a handful of neurons predicted the identity of images far above chance. Decoding performance increased linearly with the number of units considered, peaked between 400 and 500 ms, did not improve when considering correlations among simultaneously recorded units and generalized to very different images. These results show that it is possible to predict visual sensory inputs from a handful of neurons, further supporting the idea of sparse and explicit neuronal representation in the human medial temporal lobe. Besides getting further understanding on mechanisms of visual perception, the possibility of reading-out information from simultaneously recorded neurons in humans is of great value to assess the feasibility and constrains of brain machine interfaces and the development of neural prosthesis.

S12 Tracking category-specific cortical representations during memory search

Sean M. Polyn; Department of Psychology, University of Pennsylvania

Pattern-classification techniques give us unprecedented temporal resolution in the domain of fMRI – allowing us to characterize patterns of brain activity present in a single brain image. These algorithms generate estimates based on the signal present in many voxels simultaneously, which opens the possibility of tracking time-varying cognitive processes as they unfold. Here, I describe an experiment in which we applied these techniques in the domain of human memory search (Polyn et al., 2005). These pattern-classification techniques were used to characterize the patterns of brain activity associated with the study of three stimulus categories: celebrity faces, famous locations and common objects. The technique was then applied to data from the recall period of the experiment, in which subjects were asked to recall the studied items in any order they liked. The reappearance of a given category's activity pattern correlates with verbal recalls from that category and precedes the recall event by several seconds.

These results are consistent with the hypothesis that these category-related patterns of brain activity are being used to cue the memory system to recall stored items. By its very nature, the recall period of a free-recall paradigm is resistant to analysis: Each subject uses an idiosyncratic strategy to carry out a self-paced memory search. Pattern classification techniques can be fruitfully applied in this and other domains, and open up the possibility of tracking the contents of thought on a second-by-second basis.

Visual Plasticity in Abnormal and Damaged Adult Brains

Friday, May 11, 1:00 - 3:00 pm, Hyatt Salons C/D

Organizers: Arash Sahraie (University of Aberdeen) & Krystel R. Huxlin (University of Rochester Medical Center)

Symposium Summary

Structural re-organisation is well-described following pre-natal brain insults such as porencephalic cysts or brain tumours, and following damage early in post-natal development. As a result of extensive spontaneous re-organisation, the permanent deficits caused by such lesions are far less than those expected from identical damage in the adult brain. While most of the evidence to date favors the existence of significant functional plasticity in the adult visual system, conditions that have to be met to trigger functionally-useful changes in abnormal or damaged adult visual systems are not fully understood. This has given rise to significant controversy in the field. As part of this symposium, a panel of neuroscientists who use a wide range of experimental approaches, will discuss the types of changes in visual performance that can be attained following visuo-behavioral manipulations in abnormal or damaged visual systems. This phenomenon will be explored in several adult mammalian species, including humans. The panel will address the following specific questions: (1) Is adult visual plasticity fact or fallacy? (2) What forms does it take? (3) What conditions need to be met for it to occur? (4) Does physical damage to visual circuitry preclude significant plasticity in the adult - i.e. is greater plasticity attained in amblyopes or cases of monocular deprivation because the visual system is intact, albeit misconnected? It is hoped that insights gained from this symposium will assist us in attaining some consensus about the degree of plasticity that is inherent and/or inducible in the adult visual system. Such understanding is essential if we are to design more effective strategies to treat disorders of the visual system in our aging population.

Presentations

S13 **Plasticity in human blindsight**

Arash Sahraie; University of Aberdeen

Lesions of occipital cortex or optic radiation can lead to impairments in the corresponding visual field, termed cortical blindness. Apart from some spontaneous recovery that takes place shortly after the initial injury, it is thought that any remaining visual deficits are permanent. Some residual visual capacities may persist within the field defect and are termed blindsight. Detailed psychophysical investigations of mechanisms leading to blindsight indicate that such processing channels have specific spatial and temporal properties. Repeated stimulation of field locations deep within the blind visual field by stimuli designed to be optimally detected by channels of processing mediating blindsight, result in increased visual sensitivity. These findings show evidence for plasticity within the adult visual system, in chronic stages of brain damage.

S14 **Improving global motion perception in the blind field of adult humans with V1 damage**

Krystel R. Huxlin; University of Rochester Medical Center

Damage to the adult primary visual cortex (V1) is an important cause of blindness in humans. By contrast with well-documented cases of training-induced recovery following damage to adult motor and somatosensory cortices, reports of training-induced recovery after V1 damage remain controversial. This raises questions about the ability of the adult visual system to attain functional recovery after permanent damage, a level of plasticity that appears inherent in other cortical systems. Our experiments in a small number of patients with stable, stroke-induced homonymous visual field defects suggest that improvements of global, visual motion thresholds can be achieved in adult humans with permanent V1 damage. These improvements, while spatially localized to retrained locations, generalized to performance on perimetric visual field tests and to the detection of moving objects in an immersive, dynamic, three-dimensional virtual environment. These data provide evidence for significant perceptual plasticity in the damaged, adult visual system in the absence of one of its principal components. It also suggests that by forcing the damaged visual circuitry to discriminate complex moving stimuli in the absence of V1, a recovery of conscious visual motion perception can be reliably attained.

S15 **Improving vision in adult amblyopia by perceptual learning**

Uri Polat; Goldschleger Eye Research Institute, Faculty of Medicine Tel Aviv University, Sheba Medical Center

Amblyopia is characterized by several functional abnormalities in spatial vision including reductions in visual acuity, contrast sensitivity function, and abnormal spatial interactions. The visual deficiencies are thought to be irreversible after the first decade of life, by which time the developmental maturation window has been terminated. We employed perceptual learning procedure that was designed to train the deficient neuronal populations by efficiently stimulating their spatial interactions. By systematic low-level training of an adult visual system, we show that induction of low level changes might yields significant perceptual benefits that transfer to higher visual tasks. The training procedure resulted in a twofold improvement in contrast sensitivity and in visual acuity. Even though the training was monocular (amblyopic eye), the binocular functions were improved as well. The improved visual functions retained after one year of testing. These findings demonstrate that perceptual learning can improve basic representations within an adult visual system that did not develop during the critical period.

S16 **Reactivation of juvenile-like ocular dominance plasticity in the adult visual cortex**

Elizabeth M. Quinlan, Ph.D.; Department of Biology Neuroscience and Cognitive Sciences Program University of Maryland

The shift in ocular dominance induced by monocular deprivation is a sensitive index of the synaptic plasticity available in the binocular visual cortex. In juvenile rats, brief (<3 days) monocular deprivation induces a rapid shift in ocular dominance (OD) toward the non-deprived eye. In adults, brief monocular deprivation is ineffective. We have recently shown that persistent, juvenile-like OD plasticity can be restored in the adult visual cortex following visual deprivation. In visually-deprived adults, brief monocular deprivation induces a rapid depression in the response to stimulation of the deprived eye, previously only reported in juveniles, and an acceleration of the potentiation of the response to stimulation of the non-deprived eye, previously found to emerge slowly in juveniles and adults. This is associated with a significant decrease in the level of GABAA receptors relative to AMPA receptors, and a return to the juvenile form of NMDA receptors. We propose that these two activity-dependent changes enable the reactivation of rapid OD plasticity in deprived adults. The ability to recover visual function in an eye deprived of vision from birth declines significantly with age. In juveniles, removing the occlusion and patching the previously non-deprived eye can facilitate recovery of vision in the occluded eye. In adults, such reverse occlusion therapy is ineffective. However, reverse occlusion successfully reverses the effects of lifelong monocular deprivation in adults if performed following a period of visual deprivation. The reactivation of ocular dominance plasticity by visual deprivation in adults provides evidence that the adult cortex maintains significant potential for synaptic plasticity and demonstrates that ocular dominance plasticity can be bi-directionally regulated by visual experience throughout life.

S17 **Primate area V1 reorganization following retinal lesions: where do things stand?**

Stelios Smirnakis, M.D. Ph.D.; Brigham and Women's Hospital, Department of Neurology

To what extent does the adult brain have the capacity to reorganize after injury? This question is a first step towards understanding the mechanisms that potentiate neural recovery at the systems level. Several aspects of cortical organization are thought to remain plastic into adulthood, allowing cortical sensori-motor maps to be modified continuously by experience. This dynamic nature of cortical circuitry is important for learning, as well as for repair following nervous system injury. Electrophysiology studies suggest that adult macaque primary visual cortex (area V1) undergoes large-scale reorganization within a few months after retinal lesions, but this issue has not been conclusively settled (Horton and Hocking, J. Neurosci. 18: 5433-55, 1998). Here we apply functional magnetic resonance imaging (fMRI) to study how cortical topography changes in macaque V1 after binocular retinal lesions. FMRI allows non-invasive, in vivo, long-term monitoring of cortical activity, sampling signals from multiple neurons per unit cortical area. We show that, contrary to the majority of prior studies, adult macaque V1 topography does not shift towards the de-afferented zone's interior and V1 does not approach normal responsivity during 7.5 months of follow up after homonymous retinal lesions (Smirnakis et al., Nature 435:300-7, 2005). Multi-unit electrophysiology experiments corroborated the fMRI results. This suggests that macaque V1 has limited potential for spontaneous reorganization in adulthood. Human fMRI studies of V1reorganization in subjects with macular degeneration have so far provided conflicting results. We will discuss potential reasons for the differences and explore ways that promise to enhance the degree of cortical reorganization.

Neural Substrate of Bottom-up and Top-Down Visual Attentional Selection

Friday, May 11, 1:00 - 3:00 pm, Hyatt Salons G/H

Organizer: Jan Theeuwes (Cognitive Psychology Vrije Universiteit Amsterdam)

Symposium Summary

One of the most fundamental questions in vision is the extent to which we are able to exert control over what we select from the environment. Overt or covert selection may either be controlled by the properties of the stimulus field or by intentions, goals and beliefs of the obser¬ver. When an observer intentionally selects only those objects required for the task at hand, selection is said to occur in a top-down, voluntary, goal-directed manner. When specific properties present in the visual field determine selection independent of the observer's goals and beliefs, selection is said to occur in an involuntary, bottom-up, stimulus-driven manner. We hypothesize that bottom-up signals, mediated primarily by magnocellular visual inputs, combine with top-down signals at several cortical (e.g., frontal, parietal) and subcortical (e.g., basal ganglia, superior colliculus, thalamus) stages to guide spatial attention and target selection. Bottom-up and top-down controls of attention represent the interplay of exogenous (feedforward) and endogenous (feedback) neuronal activities within the cortex.
Over the last years, within several of the vision research disciplines, research efforts have been devoted to the very basic question of the control of visual selection. In this symposium we bring together researchers from diverse disciplines (physiology, modeling, psychophysics and cognitive neuroscience) each having their own unique view on this central research question. The different perspectives will lead to stimulating discussions and may result in a deeper understanding of the mechanism and neural substrates involved in top-down and bottom-up control of visual selection.

Presentations

S18 **Early bottom-up and later top-down attentional selection**

Jan Theeuwes; Cognitive Psychology Vrije Universiteit Amsterdam

On the basis of a series of experiments we show that top-down control for non-spatial information cannot modulate the initial sweep of information through the brain. This suggests the first feedforward sweep is bottom-up and not biased by top-down information. The saliency map encodes the saliency of objects in their visual environment. Neurons in this map compete among each other giving rise to a single winning location (cf. winner take all) that contains the most salient element. After the initial feedforward sweep, the initial bottom-up saliency map may be modified by recurrent processing. Information is assumed to flow through varies horizontal connections within and between areas and feedback connections from higher areas back to lower ones. We assume that the modifications of the initial bottom-up saliency map through recurrent processing is the way top-down control is implemented in the brain. The reentrance signals deriving from various parts of the brain modulate the neural activity within the saliency map to fit the current goals of an observer. Thus over time, initial bottom-up driven selection may become more and more goal-driven as more reentrance signals arrive at the saliency map.

S19 **Visuomotor transformations guiding overt and covert orienting**

Doug Munoz; Centre for Neuroscience Studies Queen's University

Salient events in the visual world have consequences on future actions. Stimulus-driven (bottomup) events in the visual world activate components of the "visual grasp reflex" having implications on attention (covert) and oculomotor (overt) processing. An abrupt onset is capable of capturing attention overtly via an express saccade or covertly without an eye movement. Here we will show that many of the behavioural consequences of reflexive overt and covert orienting arise from direct mapping of visual signals onto motor systems that need not implicate higher brain structures or strategies. Our lab has been using an oculomotor cueing task to investigate bottom-up and topdown components of overt and covert orienting. We have monitored neuronal activity is several brain structures including the superior colliculus (SC). In this task, subjects fixate a central marker while a cue is flashed somewhere in the visual field. Then, the central marker disappears and a target is presented simultaneously at either the same location as the cue or to the opposite. By varying the time between cue and target presentation, we can induce attention capture (CTOA < 100 ms) or inhibition of return (CTOA > 100-200 ms). We have demonstrated that signals recorded from visuomotor neurons in the SC correlate highly with behaviour. Top-down inputs to the SC can interact directly with these bottom-up signals to alter behaviour.

S20 **Top-down attention on the visuomotor processing without the primary visual cortex (V1); an experimental study in monkeys with unilateral lesion of V1**

Tadashi Isa; Developmental Physiology National Institute for Physiological Sciences

It has been described that patients with damage to the primary visual cortex (V1) exhibits loss of visual awareness, but some of them exhibit ability to reach their arm to, or direct their gaze to the objects presented in the "blind" part of the visual field. Such phenomenon is called "blindsight" and suggests the function of the visuomotor pathway that bypasses V1. In this study, we investigated whether the visuomotor processing through the pathway that bypasses V1 is subject to top-down attention or not, by testing the performance of 2 macaque monkeys (Macaca Fuscata) with unilateral V1 lesion. The monkeys were trained to perform the saccade version of Posner's central cueing paradigm, in which saccade targets appear in the hemifield predicted by the direction of an arrow presented at the central fixation point with 50-400ms delay in 80 % of the trials (valid cue trials), while the targets are presented on the contralateral side in the remaining 20% of the trials (invalid cue trials). Both monkeys exhibited higher success ratio and shorter reaction time in valid cue trials than in invalid trials. These results suggest that the visuomotor processing through the pathway bypassing the V1 is subject to top-down attention.

S21 **Beyond bottom-up: A computational model of task-dependent influences on eye position during natural vision**

Laurent Itti & Robert J. Peters; Computer Science University of Southern California

Recent studies have shown that high-level cognitive states are intimately linked with observers' eye movements during the performance of natural, interactive visual tasks, yet the underlying neurocomputational mechanisms for these task-dependent influences remain largely unknown.

Some existing computational models for predicting eye position have focused exclusively on bottom-up factors, while other models have included top-down factors but have been applied only to static images or artificial laboratory stimuli. We describe a fully computational model that draws from a large body of literature and is able to predict eye movements in a dynamic and interactive visual task with naturalistic stimuli. This model moves beyond purely stimulus-driven bottom-up models, by capturing task-dependent top-down influences on eye movements. We find that thetopdown model alone predicts eye position about twice as well as does the bottom-up model alone; in addition, when the two models are combined by simple point-wise multiplication, the combined prediction is significantly better than either the bottom-up or top-down model alone. Qualitatively, the combined model predicts some easy-to-describe but hard-to-compute aspects of gaze, such as observers gazing leftward when approaching a left turn.

Thus, the proposed architecture and computational model for task-dependent effects offers some of the strongest purely computational general-purpose eye movement predictions to date; yet it relies only on simple visual features, without requiring any high-level semantic scene description.

How to Use Individual Differences to Isolate Functional, Neural and Genetic Mechanisms of Vision

Friday, May 11, 3:30 - 5:30 pm, Hyatt Salons A/B

Organizer: Jeremy B. Wilmer (University of Pennsylvania)

Symposium Summary

Individual differences provide a powerful source of information for fractionating and associating behavioral mechanisms and for tying them to their biological bases (Kosslyn et al, 2002; Plomin & Kosslyn, 2001). However, the study of individual differences in vision is still in its infancy. This symposium showcases recent work isolating basic functional and biological mechanisms of vision through a consideration of individual differences. This work encompasses a broad range of techniques (psychophysics, eye-tracking, event-related potentials, fMRI, behavioral genetics) as well as topic areas (motion, color, faces, objects, attention, stereopsis, contrast, oculomotor control, and visual working memory).

Individual differences are useful to researchers with a variety of goals: At the level of behavior, our speakers use individual differences to demonstrate that diverse aspects of vision, for example perception and action, rely upon common mechanisms; and that potentially seamless aspects of vision, for example face and object processing, rely upon distinct mechanisms. At the level of underlying biology, our speakers correlate individual differences with genetic and neural variation to uncover biological substrates of functions such as stereopsis and visual working memory.

It is worth emphasizing that individual differences not only inform us about basic functional and biological mechanisms. They also enhance our understanding of how such mechanisms vary, easing the translation of basic science for clinical use while helping to answer the question: “What is this visual mechanism good for?

This symposium is the first demonstration of the broad utility of individual differences-based methods to vision science. Our target audience: Anyone who is curious about the origins or consequences of individual differences observed in their own research, or who wants to know what can be learned about basic visual mechanisms by systematically studying such differences. Attendees from a variety of content areas should come away with ideas for how to make use of individual differences in their own work.

Presentations

S22 **Cracking sensory codes using individual differences**

David H. Peterzell; University of California at San Diego

The careful study of variability allows researchers to extract sensory, cognitive, neural and genetic codes from data, and to discover their functional interconnections. In this (mostly) non-statistical review and tutorial, I provide a short history of individual differences in vision and a general framework for thinking about the various approaches presented at this symposium. I show that variability in data is often systematic (not due to error). I review how I and others have harvested covariance and independence to a) develop computational models of structures and processes underlying human and animal vision, b) analyze and delineate the developing visual system, c) compare typical and abnormal visual systems, d) relate visual behavior, anatomy, physiology and molecular biology, and e) interrelate sensory processes and cognitive performance. My examples will come primarily from my nearly 20 years of factor-analytic research on spatiotemporal, chromatic, and attentional processing in adults and infants. Past successes in studying individual differences in vision seem to provide a roadmap for future discoveries.

S23 **Faces and objects are processed by independent mechanisms: Evidence from Individual differences**

Galit Yovel; Tel Aviv University

It is well established that faces engage specialized mechanisms. However, the nature of processing of these mechanisms and the extent to which they are used for non-face stimuli are still under extensive investigation. Most studies examining these questions have used the group-based approach, in which differences across individuals are treated as noise. However, some of the variance in visual processing abilities is reliable and can be used to assess whether faces and objects are processed by common or distinct mechanisms. Our first study examines whether information about the shape of parts and the spacing among them in faces and non-face stimuli are processed by distinct or common mechanisms. Our findings show that spacing and parts are extracted by a common mechanism for only upright faces, but by distinct mechanisms for inverted faces and non-face stimuli. In the second experiment we examined the recent findings that bodies may be processed by 'face-like' configural mechanisms. Our correlational analyses showed that faces and bodies are processed by stimulus-specific, distinct mechanisms at perceptual stages, but by stimulus-general memory mechanisms. Finally, in functional MRI studies we revealed that the variance in size or response of the FFA is closely linked to two wellestablished face-specific behavioral effects: the face inversion effect and the left-visual-field superiority in face recognition. Taken together, our studies show that the individual differences approach can provide information that is complementary to the traditional group-based approach and thus expand our understanding on the nature and structure of perceptual mechanisms.

S24 **Two distinct visual motion mechanisms for smooth pursuit, and a behavioral genetic study of stereopsis**

Jeremy B. Wilmer; University of Pennsylvania

I present two results whose inferences depend critically upon individual differences: the first suggests that two distinct visual motion processing mechanisms contribute independently to smooth pursuit eye movements; the second suggests that individual differences in precision of stereoscopic depth processing are substantially genetic.

Study 1. Smooth pursuit eye movements to a moving target are more accurate after the first saccade than before, an enhancement that is poorly understood. We present a novel individual differences based method for identifying mechanisms underlying a physiological response, and use it to test whether visual motion signals driving pursuit differ pre- and post-saccade. Correlating moment-to-moment measurements of pursuit over time with two psychophysical measures of speed estimation during fixation, we find two independent associations across individuals. Presaccadic pursuit acceleration is predicted by the precision of low level (motion energy based) speed estimation, and postsaccadic pursuit precision is predicted by the precision of high level (position tracking) speed estimation. These results suggest that the precision of postsaccadic pursuit is determined by a high level motion signal independent of the low level motion signal that putatively drives pursuit acceleration presaccade.

Study 2. Large individual differences exist in stereoscopic depth processing, yet the relative contribution of genes and environment to these differences is unknown. I present preliminary results from an ongoing twin study, which suggest that a large portion of these differences may be genetic in origin. This work provides a first step toward identifying genes that influence stereopsis.

S25 **Visual working memory capacity as an index of attentional control: A neurally-based individual differences approach**

Edward K. Vogel; University of Oregon

The capacity of visual working memory is well known to be highly limited, but it is also known to vary considerably across individuals. Individual differences in memory capacity appear to be a stable trait of the observer and are often positively correlated with many high-level aptitude measures such as fluid intelligence and reasoning. In this presentation, I will describe recent work from my laboratory in which we examine the relationship between an individual's visual working memory capacity and their ability to control the focus of selective attention. In particular, we use a new event-related potential technique that allows us to measure the active representations of objects within the focus of attention across different task conditions. In general, we have found that low memory capacity individuals are substantially poorer than high capacity individuals in terms of their attentional filtering efficiency as well as in their ability to attentionally track multiple moving objects. These results suggest a tight relationship between the constructs of memory capacity and the control of attention.

S26 **Individual differences in perceptual norms**

Michael A. Webster; University of Nevada, Reno

Many percepts are consistent with a norm-based code, in which stimuli are represented relative to a prototype that has a neutral and potentially special status. Individuals often differ in the stimuli that they judge as neutral. Do these subjective differences reflect sensitivity differences in the norms underlying visual coding? This question can be addressed by probing sensitivity with adaptation, in order to define the neutral adapting stimulus. For example, adapting to red causes the hue of stimuli to appear greener and vice versa, and thus an intermediate adapting level can be found that does not bias the observer's achromatic point. This level reflects the intrinsic sensitivity norm of the mechanisms affected by the adaptation, and should covary with the observers' subjective white point if the norm is established at the adaptation site. Conversely, a dissociation between subjective and sensitivity norms predicts paradoxically that adaptation to a stimulus that "appears" neutral will nevertheless induce an aftereffect. Applications of these ideas will be illustrated for both color perception and face perception. The same tests can also be applied to differences within a single observer (e.g. at different retinal loci, or during development or aging) and these will be illustrated by comparing perceptual norms and adaptation tocolor and blur in the fovea and periphery. Such measures provide a tool for exploring the relationships between visual coding and phenomenology and for exploring how and at what levels norms are established in visual representations.

S27 **Developmental prosopagnosia**

Ken Nakayama; Harvard University

Human beings vary widely in their ability to recognize faces. In a normal population, there are a surprisingly large number of individuals whose abilities are as poor as the classic cases of acquired prosopagnosia. Two independent estimates place the frequency of developmental prosopagnosics (DP) at approximately 2%. This high incidence provides a unique opportunity to examine the mechanisms of face processing. The pattern of deficits in this large population support several key aspects of Bruce and Young's theory on the architecture of face processing. This includes: (1) a separate parallel stream for semantic knowledge about faces: emotion, attractiveness, and gender. (2) a set of sequential stages(face detection, face perception and face memory) each of which limits the performance of later stages. We also report that prosopagnosia runs in families as do its different forms (pure prosopagnosia vs prosopagnosia accompanied by "within category" agnosia). This raises the possibility of two object level visual functions having different genetic origins.

Natural Scene Understanding: Statistics, Recognition and Representation

Friday, May 11, 3:30 - 5:30 pm, Hyatt Salons G/H

Organizers: Fei-Fei Li (Princeton University) & Aude Oliva (MIT)

Symposium Summary

From oriented bars to isolated objects, the field of vision science is moving rapidly forward to uncover the mechanisms that enable the perception of our visual world. Natural scene understanding therefore stands as one of the most challenging and yet unsolved problems in vision: humans are able to ascribe meanings to complex natural images, achieving a remarkable level of understanding within a single glance and with little effort. Over the last decade, researchers have made substantial progress toward understanding the cognitive, neural and computational underpinning of scene analysis. In this symposium, 6 speakers from representative domains in the visual sciences will present an integrative view on the mechanisms and representation subtending natural image understanding. From computational analysis to studies of scene gist, each speaker will offer a multidisciplinary view in their presentation, with the aim of integrating classical theories with recent breakthroughs in the behavioral, cognitive neuroscience and modeling aspects of scene understanding.

Dr. Simon Thorpe's works using ERP studies on the speed of image categorization have challenged traditional theories of visual recognition. He will review the speed at which natural image analysis occurs in the brain, as well as introduce paradigms dedicated to evaluating the computational constraints of feed-forward analysis. Addressing the topic of image statistics from a cognitive neuroscience perspective, Dr. Bruno Olshausen will describe the fundamental role of image statistics in shaping brain mechanisms of natural image recognition. Next, leading the discussion to address semantic comprehension, Dr. Russell Epstein will portray the brain network involved in real world scene and place recognition based on fMRI studies. Dr. Irving Biederman will describe a cognitive neuroscience theory of how human emotion and preference shape our immediate perception of the natural world. Dr. Aude Oliva will review computational neuroscience accounts of scene gist understanding, and evaluate the role of spatial layout and objects in place recognition. Finally, Dr. Fei-Fei Li will further illustrate the striking robustness of natural scene and gist perception in behavioral studies, as well as present a computer vision model for scene categorization in a Bayesian framework.

Presentations

S28 **Natural scene categorization: from humans to computers**

Fei-Fei Li; Princeton University

This talk will be divided into two halves. In the first half, we will discuss psychophysics experiments that probe into the rapid perception of real-world scenes by human subjects. Our experiments show that rapid natural scene categorization can easily escape visual attention, while seemingly much simpler stimuli cannot. We will also present a series of recent results on experiments aimed to titrate how much humans can perceive from a briefly presented real-world image. We propose a working definition of the gist of a natural scene. In the second half of the talk, we will briefly present a computer vision model for natural scene recognition based on local patches and their textures. This probabilistic model attempts to characterize natural scenes by grouping local patches into hidden themes, and then themes into categories. We will shows experimental results of the model using a dataset of 13 classes of natural scenes. (Joint work with Asha Iyer, Rufin VanRullen, Christof Koch and Pietro Perona).

S29 **Building the gist of the scene from spatial envelope properties**

Aude Oliva; MIT

Human scene understanding is truly remarkable: with only a brief glance at an image, we comprehend an abundance of information (spatial layout, scene function, semantic label, etc). Traditionally, behavioral and modeling research in scene understanding has concentrated on the objects that a scene contains. According to an object-centered approach, high-level scene recognition would need first to parse the image input into candidate objects, understand the identity of these objects as well as their relationships and, with all of this information, interpret the scene before you. More recent work has raised trouble for this account by demonstrating conditions under which observers can categorize a scene without being able to recognize its composite objects. Based on behavioral and computational evidence, we will describe a holistic and space-centered theory of scene gist understanding, which does not rely on object analysis. The space-centered approach is based on a statistical summary of spatial layout properties of the scene (such as perspective, mean depth) that collectively combined to provide superordinate and basic level description of the scene. We will provide behavioral evidence that these properties are used by human observers during rapid scene categorization as well as formal evidence that these spatial layout properties alone can be sufficient for comprehend the gist of real world scenes (Joint work with Michelle Greene and Antonio Torralba).

S30 **A neural basis of natural scene perceptual preference**

Irvine Biederman; University of Southern California

Our selection of which movie to see, whether to stay in a conversation at a party or freshen our drink, and where to look with our next fixation is decidedly non random. What controls this selection when an individual is not engaged in the classical survival modes of satisfying hunger, avoiding harm, searching for her car keys, etc? And how can this expression of interest be manifested in real time, at the rate of three visual fixations per second? The surprising discovery of a gradient of mu-opioid receptors in cortical areas associated with perception and cognition may provide the key for understanding the spontaneous selectivity of perception and thought. These receptors are sparse in the early sensory areas and dense in the association areas. If we assume that experiences are preferred that maximize this opioid activity, then preferred inputs will tend to be those that are richly interpretable (not just complex) insofar as they would produce high activation of associative connections in areas that have the greatest density of mu-opioid receptors. Once an input is experienced, however, competitive learning would serve to reduce associative activity and hence opioid activity, resulting in habituation and boredom. Behavioral and neuroimaging tests while viewing natural scenes provide some confirmation of this account. This system serves to maximize the rate at which we acquire new but interpretable information--rendering us infovores--and leads to an understanding of the neural basis of visual scene and space aesthetics (Joint work with Xiaomin Yue and Edward Vessel).

S31 **EEG and behavioral studies of object recognition in natural images**

Bruno Olshausen; University of California, Berkeley

Many studies have now shown that early stages of processing in the visual system are well matched to the structure of natural images. Here we explore how later stages of processing are matched to natural images by using a combination of EEG and behavioral studies of object recognition. Target-related responses to objects embedded in natural scenes arise in the EEG between 150-300 ms, depending on reaction time, suggesting that the timecourse of recognition is extremely fast but also varies with task difficulty. Moreover, these neurophysiological signals appear to correspond to post-sensory processes, meaning that perceptual categorization may occur even earlier. When objects are only partially visible due to either occlusion or deletion, subjects exhibit higher accuracy when occluders are present rather than absent, suggesting that the visual system is well adapted to the compositional structure of natural scenes. (Joint work with Jeff Johnson, UC Davis)

S32 **Neural systems for visual scene recognition**

Russel Epstein, Ph.D.; University of Pennsylvania

fMRI studies have identified cortical regions that respond more strongly to visual scenes such as landscapes, cityscapes, and rooms than to other stimuli such as faces or decontextualized objects. This network includes the parahippocampal place area (PPA), retrosplenial cortex (RSC), and the transverse occipital sulcus (TOS). These findings are intriguing when considered in the light of behavioral results that indicate that human observers can interpret visual scenes very rapidly. Thus, one possibility is that these regions form a network for scene recognition, which might be complementary to other cortical networks dedicated to face or object recognition. But what kind of scene recognition? Recent data from our laboratory suggest that these regions might be particularly involved in location identification -- the use of visual information to identify one's location and orientation within the larger spatial environment -- rather than other scene recognition tasks such as scene categorization. Furthermore, our data argue for a certain amount of specialization within the PPA-RSC-TOS cortical network, with PPA and TOS more concerned with the perceptual representation of the currently-visible scene and RSC more concerned with linking the current scene to stored representations of the broader environment that extends beyond the current horizon. Thus, the preferential response to scenes in these regions seems to reflect the engagement of mechanisms that support the transformation of visual input into spatial codes useful for navigation. These results indicate that scene recognition is not a unitary phenomenon; rather, different neural circuits are engaged by different scene recognition tasks.

S33 **Ultra-rapid scene processing: Temporal constraints and neural computation**

Simone Thorpe, Ph.D.; Centre de Recherche Cerveau et Cognition – CNRS – University P. Sabatier Toulouse 3

Ten years ago we reported that humans can decide whether a natural scene contains an animal on the basis of roughly 150 ms of processing (Thorpe et al, 1996). Recently, we have developed another experimental paradigm using a saccadic choice task that demonstrates that underlying processing must be even faster (Kirchner & Thorpe, 2006). When subjects are presented with two images, they can initiate saccades to the side containing an animal in as little as 130 ms. This time includes not just visual processing but also response execution. Recently, we have found that the speed with which these saccades can be initiated depends on the specific target and is particularly fast for certain highly familiar visual forms such as faces that elicit reliable saccades from just 100-110 ms. Few computational models are consistent with such severe constraints, but one option uses the wave of spikes generated by the onset of the stimulus. Simulation studies have shown that it is possible to develop robust selectivity for patterns by learning which combinations of neurons in V1 fire first when the stimulus is presented. Furthermore, we have found that an unsupervised learning mechanism based on Spike Time Dependent Plasticity naturally learn to detect those visual patterns that are particularly frequently present in the input. We argue that this ability to rapidly detect important and frequently occurring diagnostic feature combinations may be a key to understanding the extraordinary speed of scene processing. (Joint work with Holle Kirchner, Sebastien Crouzet, Rudy Guyonneau & Tim Masquelier).

Neural Mechanisms of Depth Perception

Friday, May 11, 3:30 - 5:30 pm, Hyatt Salons C/D

Organizer: Peter H. Schiller (Massachusetts Institute of Technology)

Symposium Summary

Reconstruction of the third dimension in the visual scene from the two dimensional images formed on the retina is one of the central tasks of the visual system. To accomplish this several neural mechanisms have evolved that can process such depth cues as disparity for stereoscopic vision, motion parallax and shading. The past few years have provided us with significant new findings about how these cues are processed in the brain. The purpose of this symposium is to present some of the major new advances that have been made by outstanding investigators in the field. The speakers will present material based on both human and monkey psychophysical studies, on physiological studies carried out in monkeys, and will consider various relevant models of depth perception. The first speaker, Ian Howard, will review the evidence that depth can be created by monocular zones. The second speaker, Suzanne McKee, will describe how the images from the two eyes are combined to create a unique depth map and what accounts for the exquisite sensitivity to relative disparity. The third speaker, Ralph Freeman, will provide new facts about how single neurons in area V1 encode the fine resolution of stereoscopic images and how these findings bear on models of stereoscopic vision. The fourth speaker, Gregory DeAngelis, will describe the role of extrastriate area MT in stereoscopic depth perception. The last speaker, Peter Schiller, will describe the role various retinal parallel channels play in stereopsis and motion parallax.

Presentations

S34 What role do the parallel channels of the retina play in the processing of stereopsis and motion parallax?

Peter H. Schiller; Massachusetts Institute of Technology

Previous work has established that (1) the parasol retinal ganglion cells in the primate retina receive convergent input from the red, green and blue cones, have dendritic arbors and receptive fields three times those of midget cells, and are not capable of processing information at high spatial frequencies, and (2) the midget and koniocellular cells break down color information along two major axes, the red/green and the blue/yellow (Derrington, Krauskopf and Lennie, 1984). We have developed a random-dot display that can provide disparity and motion parallax cues separately or in combination. By systematically manipulating the spatial frequency and chrominance of the display, the parallel channels of the retina could be selectively inactivated. The parasol system was rendered unresponsive by using high-spatial-frequency isoluminant random dot displays. When this was done, performance of the animals was greatly attenuated on the motion parallax task but was largely unaffected on the disparity task suggesting that in monkeys the parasol system plays a central role in the processing of motion parallax information. The red/green and blue/yellow axes in our experiments were selectively activated by presenting cone isolating displays at isoluminance. When this was done, performance of the monkeys on the disparity task remained outstanding with red/green displays, but became significantly impaired with blue/yellow display suggesting that the red/green midget cells of the retina play a central role in processing stereopsis and that the blue/yellow midget and koniocellular cells play a minor role in this process.

Stereoscopic phenomena that present difficulties for disparity-detection mechanisms.

S35 Stereoscopic phenomena that present difficulties for disparity-detection mechanisms

Ian P. Howard; Centre for Vision Research, York University

I will review binocular depth effects that disparity-detection mechanisms do not seem to explain. We can detect the sign of depth of a vertical line with up to about 10° of disparity relative to a fixated line, with both lines on the midline. There are three problems for this stimulus. 1) The images in the two eyes are in reversed order. 2) A fused image lies between the disparate images. Thus, the disparity gradient is <2 and the disparate images cannot be fused. 3) The disparate images project to opposite sides of the brain. In each hemisphere there is a monocular image adjacent to a fused image, which is Panum's limiting case. But our results indicate that disparity limits exceed those predicted from Panum's limiting case. I will discuss the possible relationships between DaVinci stereopsis and Panum's limiting case. Depth can be created by monocular zones that indicate partial occlusion of one surface by another (DaVinci stereopsis). Depth can also be created by monocular zones that create an impression of transparency. Also, under certain circumstances, binocular rivalry can create an impression of depth.

S36 Stereo matching and stereoacuity

Suzanne P. Mckee; Smith Kettlewell Eye Institute

Thirty years ago, the burning questions in stereopsis were 1) how are the two monocular images combined to create a unique depth map and 2) what accounts for our exquisite sensitivity (10 arcsec) to relative disparity. We now believe that we have adequate answers for both these questions. Any half-way decent computational algorithm can resolve the matching ambiguity of a random dot stereogram; the secret is to use some combination of the distributed activity across scaled disparity detectors. Stereoacuity, like all the other hyperacuities, is undoubtedly limited by the contrast sensitivity of fine scale disparity detectors, probably hiding out in V1. Curiously, the modelers who explain stereo matching seldom worry about stereoacuity, perhaps because it seems like a passive property of the system – if the disparity signal is above the noise, the homunculus will find it. In fact, fine stereoacuity is not determined by the most sensitive disparity mechanism. Instead it is contingent on stereo matching; the chosen match determines whether the observer has access to the finest disparity signal. Using wallpaper patterns that support multiple matches, we found that stereoacuity could either be very poor or exquisitely fine without any change in the physical stimulus. Our particular 'wallpaper' was a grating segment, 6 deg in width. These segments are initially matched at the disparity of the edges, in this case, a disparity of 20 arcmin. However, if the eyes are converged steadily on a plane in front of the segment, the segment appears to shift forward to the fixation plane after a few seconds. Stereoacuity for the initial match at the edge disparity was about 60 arcsec; once the match shifted to the fixation plane, thresholds fell to ~12 arcsec.

S37 The physiological basis of stereoscopic depth

Ralph Freeman; University of California, Berkeley

The fine resolution of stereoscopic vision is accomplished via a comparison of very small positional differences between left and right eye images. The classical idea is that the required information is encoded by differences in receptive field positions of right and left eyes. An alternative notion, based on the energy model, is that stereoscopic information is encoded by a system in which differences in the internal structure of right and left eye receptive fields are compared. These internal structural or phase differences are then encoded. The required information is transmitted to simple cells in the visual cortex. The information is then carried forward in a hierarchical manner to a subset of complex cells which are especially suited for the processing of depth information. A review will be given of physiological data from studies of cats and monkeys that are relevant to the alternative encoding notion.

S38 Roles of area MT in coarse and fine stereopsis revealed through reversible inactivation

Gregory C. DeAngelis; Washington University School of Medicine

Although much is known about how single neurons signal disparity in early stages of the visual cortex, the functional roles of different visual areas in 3D vision remain largely unclear. With regard to area MT, we have previously shown that microstimulation of MT influences coarse depth judgments in the presence of noise (DeAngelis et al. 1998). However, it has also been shown that permanent lesions of MT do not disrupt fine depth discrimination (Schiller 1993). To clarify the roles of MT in coarse vs. fine stereopsis, we have reversibly inactivated area MT (using muscimol) in monkeys trained to perform both coarse and fine depth tasks. Prior to any training on the fine depth task, inactivation of MT devastates performance of the coarse depth task (as well as direction discrimination). However, after training on the fine depth task, MT inactivation has little or no effect on coarse stereopsis (but still disrupts direction discrimination). MT inactivation has no significant effect on the fine depth task, consistent with the results of Schiller (1993). These results establish a selective role for MT in coarse stereopsis, and demonstrate dramatic training-induced plasticity in the 'read-out' of disparity signals from MT that inform perceptual decisions. We suggest that this pattern of results is explained by the fact that MT neurons represent absolute disparities, but do not code the relative disparities needed for fine depth discrimination.

Classification Images in Vision Research

Friday, May 11, 3:30 - 5:30 pm, Hyatt Salons E/F

Organizer: Dario Ringach (Department of Neurobiology and Psychology, UCLA)

Symposium Summary

The use of stochastic stimuli has been a hallmark in electrophysiological studies of receptive fields in the visual system, from the retina to the visual cortex. In recent years, however, analogous methods have also found broad applicability in the design and analysis of psychophysical tasks.

A central goal of the symposium is to showcase the application of classification images in a wide range of studies of visual perception. The five talks proposed will address: (a) perceptual learning of Vernier acuity in amblyopia (Dennis Levi and Roger Li), (b) the processing and detection of textured surfaces (Jonathan Victor and Mary Conte), (c) the study of crowding in letter identification (Anirvan Nandy and Bosco Tjan), (d) the investigation of the information driving eye movements and the underlying attentional mechanisms of spatial neglect in human patients (Miguel Eckstein et al); and (e) the dynamics of contour grouping (Brian Keane, Hongjing Lu and Phil Kellman).

Presentations

S39 Processing of low- and high-order image statistics studied by classification images extracted via regularized regression

Jonathan D. Victor & Mary Conte; Department of Neurology & Neuroscience, Weill Med Col Cornell University

Classification images (CI's) provide an appealing psychophysical strategy to gain insight into the neural computations underlying visual perception (Ahumada & Lovell JASA 1971; Eckstein & Ahumada, JOV 2002). Determination of CI's typically requires analysis of thousands of psychophysical trials, and usually consists of "reverse correlation" of the psychophysical responses with the individual trial images. It thus presents a computational problem similar to that of receptive field analysis and functional brain imaging, both in terms of its highly multivariate nature and the potential for inaccuracy due to chance correlations within the multivariate dataset. Here, we determine CI's in a texturediscrimination task, and adopt strategies that have proven useful in imaging and receptive-field mapping in an attempt to improve on a reverse correlation analysis.

Subjects were asked to identify the location of a 16 x 64-pixel texture-defined target, which could appear at one of four positions within a 64 x 64-pixel background array. The target and the background texture were chosen from a two-dimensional perceptual space of binary textures. One axis in this space, gamma, specifies the bias in luminance statistics (gamma= 1 for all white, 0 for a 50:50 mix, -1 for all black). The second axis, alpha, specifies the bias in local fourth-order statistics (Julesz et al. 1978), with alpha=1 for the "even" texture, and -1 for the "odd" texture. Gamma and alpha vary independently within a gamut, and each pair uniquely specifies a Markov random field texture. We varied the parameters along eight rays emanating from the origin, over a range for which performance varied from just above chance to near ceiling. Data from 4320 such trials were collected from each of four subjects. As previously reported (Victor, Chubb, & Conte, Vision Res. 2005) psychophysical performance along each ray was well-described by a Weibull function with exponent near 2. Sensitivity along the luminance axis (gamma) was approximately four times the sensitivity along the fourth-order axis (alpha). For oblique directions, cues combined in a manner consistent with probability summation, leading to elliptical isodiscrimination contours. CI's were determined after preprocessing each stimulus to create "derived images" that represented of pixel-by-pixel estimates of gamma or alpha, reduction to a 32 x 32 grid, and alignment to the perceived target location. Standard reverse correlation yielded CI's that identified the footprint of the target but did not reveal internal structure. These CI's showed no difference between derived images based on gamma or alpha. While regression alone did not yield useful CI's (the number of trials was only slightly larger than the number of grid points), regression combined with regularization identified consistent structure not seen in the reverse correlation CI's. In particular, for regularized CI's based on luminance statistics, there is an accentuation at the perceived target edge and attenuation in the interior of the target -- essentially a Mach band. Regularized CI's based on local fourth-order correlation show no interior scalloping within the target. That is, the regularized CI's suggest that low-order statistics contribute to texture segmentation via local comparisons, while high-order statistics are pooled over larger areas. These findings were present with several kinds of regularization strategies (ridge regression (Hastie et al. 2001), penalized regression (Machens et al. 2004), and a GIFA-like approach (Yokoo et al., 2001)), alone and in combination, for a wide range of regularization parameters. They demonstrate the utility of such procedures in CI analysis, and that CI's reflecting nonlinear processes may be readily obtained via analysis of appropriately derived images.

S40 Eclectic classification image investigations

Miguel Eckstein; Department of Psychology, University of California, Santa Barbara

We discuss two studies using classification images. In the first, we introduce a new technique, saccade-contingent reverse correlation, that measures the time course of visual information accrual driving the first and second saccades. Observers searched for a contrast-defined target among distractors. Independent contrast noise was added to the target and distractors every 25 ms. Only noise presented in the time interval in which the brain accumulates information will influence the saccadic decisions. Therefore, we can retrieve the time course of saccadic information accrual by averaging the time course of the noise, aligned to saccade initiation, across all trials with saccades to distractors. Results show that before the first saccade, visual information is being accumulated simultaneously for the first and second saccades. Furthermore, information presented immediately before the first saccade is not used in making the first saccadic decision but instead is stored and used by the neural processes driving the second saccade. In the second study, we describe how the classification image method was successfully used to study attentional mechanisms in two patients with spatial neglect.

S41 Psychophysical Reverse correlation – a new tool for learning about learning in normal and amblyopic vision

Denis Levi & Roger Li; School of Optometry, University of California, Berkely

Studies of perceptual learning suggest that the adult brain shows a remarkable of plasticity, both in normal and amblyopic vision. A key question is what is learned? Psychophysical reverse correlation can be used to retrieve “perceptive fields” (classification images or templates) that are remarkably similar to analogous receptive fields in single neurons (Neri & Levi, 2006). However, standard reverse correlation procedures often require many thousands of trials, so they are not well suited to capturing the changes that may occur during perceptual learning. We have developed a very efficient method reverse correlation method using a Vernier acuity target made of discrete samples, each subjected to binary positional noise to estimate the behavioral perceptive field in as little as 100 trials, and a novel “ten-pass” method to quantify the internal noise that limits position acuity. Our results show that in normal foveal vision, perceptual learning results in a roughly 25% improvement in performance. This improvement is accompanied by a re-tuning of the perceptive field, making it more efficient, and the observer more acute, over the course of 3000 trials. In contrast, adults with amblyopia show substantially greater learning over the course of more than 30 kilotrials, with a marked change in the perceptive field and a considerable reduction in internal noise. We believe that this slow learning is unprecedented in normal vision. Understanding the time-course, limits and mechanisms involved is essential to understanding the neural changes that occur both in perceptual learning and in the course of treatment of amblyopia.

S42 The nature of letter crowding as revealed by first- and second-order classification images

Bosco Tjan & Arnivan Nandy; University of Southern California

Visual crowding refers to the marked inability to identify an otherwise perfectly identifiable object when it is flanked by other objects. Crowding places a significant limit on form vision in the visual periphery; its mechanism is, however, unknown. Building on the method of signal-clamped classification images (Tjan & Nandy, 2006), we developed a series of first- and second-order classification-image techniques to investigate the nature of crowding without presupposing any model of crowding. Using an “o” vs. “x” letter-identification task, we found that: 1) crowding significantly reduced the contrast of first-order classification images, although it did not alter the shape of the classification images; 2) response errors during crowding were strongly correlated with the spatial structures of the flankers that resembled those of the erroneously perceived targets; 3) crowding had no systematic effect on intrinsic spatial uncertainty of an observer nor did it suppress feature detection; and 4) analysis of the second-order classification images revealed that crowding reduced the amount of valid features used by the visual system while at the same time it increased the amount invalid features used. Our findings strongly support the feature mis- localization or source confusion hypothesis as one of the proximal contributors of crowding. Our data also agrees with the inappropriate feature integration account with the requirement that feature integration be a competitive process. However, the feature masking account and a front-end version of the spatial attention account of crowding are not supported by our data.

S43 **Classification images of spatiotemporal illusory figures: Interpretations and implications**

Brian Keane, Honjing Lu, & Phil Kellman; Department of Psychology, UCLA

A major goal of vision science is to understand how the visual system represents the shape of static or moving objects, given the inconstancies associated with dynamic environments (due to occlusion, articulation, etc.). We investigated this issue by examining interpolation between fragments that appear sequentially. Interpolation between simultaneously presented object parts is affected by the luminance of points near the interpolation path (Gold, Murray, Bennett, & Sekuler, 2000), but here we examine if the same result holds when object parts are separated by gaps in space and time. In two experiments, participants discriminated sequentially presented "fat" and "thin" noise-corrupted figures, when the figures were stationary or moving, and when the vertical connections across gaps were either real (real condition), interpolated (illusory condition) or absent (fragmented condition). For both stationary and moving objects, resulting classification images reveal that noise pixels affect discrimination performance comparably in the real and illusory conditions, but significantly less so in the fragmented condition. Thus whether object parts are presented simultaneously or sequentially, interpolated shape depends partly on the luminance information near interpolation paths. We then offer a novel interpretation of classification image characteristics, such as contrast polarity, and suggest that noise pixels in the fat/thin task bias interpolation in a way that is consistent with perceived object lightness. We derive implications of our interpretation, and conclude by addressing potential criticisms of classification imaging as a tool for understanding visual representations.

Poster Session A

Friday, May 11, 5:45 - 8:45 pm, Municipal Auditorium

Face Perception: Experience and Context

Author Presents: 7:15 - 8:45 pm

A1 101 **View-invariant representation of unfamiliar faces in the fusiform face area**

Galit Yovel[1] (galit@freud.tau.ac.il), Inbal Bartal[1]; [1]Department of Psychology, Tel Aviv University, Israel

The role of the FFA in the processing of face identity has been convincingly demonstrated in several studies. However, it is still unclear whether face identity information is represented in a view-invariant or view-specific manner. Specifically for unfamiliar faces, most studies that examined this question concluded that the FFA representation is view-specific. In the current study we used an event-related fMR-adaptation paradigm with a very short delay (ISI=150 ms) between the first and second face. Subjects viewed sequential presentation of pairs of same-view unfamiliar faces that were of the same-identity or different-identity, as well as pairs of same-identity/different-view faces that differed in 30, 60 or 90 degrees. Behavioral data we collected in a sequential face matching task show that subjects discrimiated pairs of faces that differed in 30 and 60 degrees as well as two same-view faces, but performance deteriorated for faces that differed in 90 degrees. Functional MRI findings showed higher response to different-identity/same-view than same-identity/same-view pairs of faces (fMR-adaptation effect), which replicates pervious reports. Importantly, consistent with our behavioral findings, we found an fMR-adaptation effect for same-identity/different-view pairs of faces that differed in 30 or 60 degrees, but not for same-identity/different-view faces that differed in 90 degrees. Our results suggest that the representation of the identity of unfamiliar faces in the FFA is view-invariant, at least for angular differences of 30 and 60 degrees. We hypothesize that the FFA maintains such a general identity representation for a very short period of time and therefore it has not been revealed in fMRI repetition studies that have employed longer repetition delays.

Acknowledgement: supported by a grant from the Adams Super Center for Brain Studies

A2 102 **FMR-adaptation reveals a view-invariant representation for familiar faces in the fusiform face area.**

Timothy Andrews[1] (t.andrews@psych.york.ac.uk), Michael Ewbank[2]; [1]Department of Psychology, University of York, York UK, [2]MRC Cognition and Brain Sciences Unit, Cambridge UK

Recognising complex objects, such as faces, is a simple and effortless process for most human observers. However, as we move about or as gaze or expression change, the size and shape of the face image on the retina also changes. To facilitate recognition, the visual system must take into account these sources of variation. The aim of this study was to explore whether face recognition is dependent on a viewpoint-dependent or viewpoint-invariant neural representation. Using the technique of fMR-adaptation, we measured the MR response to repeated images of the same face. We report that activity in the face-selective FFA was reduced following repeated presentations of the same face. This adaptation was similar for both familiar and unfamiliar faces. To establish if the neural representation of faces in the FFA was invariant to changes in viewpoint, we varied the viewing angle of the face between successive presentations. We found that adaptation to familiar faces was apparent across all changes in viewpoint. In contrast, we found signficant adaptation in the FFA to unfamiliar faces only occurred when the viewing angle between successive images was 2 degrees or less. Face-selective regions in the superior temporal lobe failed to adapt to repeated presentations of the same face. These results are consistent with cognitive models of face perception that predict a view-invariant neural representation underlies the recognition of familiar faces.

A3 103 **Our own faces: perceiving fluctuating asymmetry in the highly familiar objects**

Kazuya Ishibashi[1] (isibasi@lit.kobe-u.ac.jp), Shinichi Kita[1]; [1]Department of Psychology, Kobe University, Japan

The human visual system shows skilled performance in perceiving familiar objects. Visual search experiments have been employed to investigate this superiority of familiar objects. One of the most useful indexes is search asymmetry that familiar targets are less detectable than unfamiliar ones against the homogeneous background. Familiarity concerns faces. Faces are almost symmetrical, but strictly speaking, they are pseudo-symmetrical because of the slight differences between normal and mirror-reversed images of them. The present study focuses on this fluctuating asymmetry by examining if the human visual system draws a line between the normal and mirror-reversed images of our own faces in the visual search experiment. Before examining the facial asymmetry, we confirmed the validity of search asymmetry by comparing the search performance for our own faces and that for other faces. Observers made a slower response in the condition of their detecting the image of their own faces against the background of the images of others than in the reversed condition. This asymmetrical result reflected the specialty in perceiving our own faces. The same procedure was applied to examine the discrimination between the normal and mirror-reversed images of our own faces. The result showed the availability of the slight differences between the normal and mirror-reversed images of observers' own faces. This acute sensitivity thus yielded search asymmetry that better performance was obtained in the condition that the observers searched the mirror-reversed image among normal images compared with the reversed condition. This search asymmetry reflected the advantage of mirror-image over the normal image in familiarity. The human visual system holds a refined representation for our own faces as mirror-reversal. Such sensitivity may refer to the upper-bound of the visual ability for objects, because daily experiences of viewing the mirror-reversed face in the mirror have sharpened the sensitivity up to the highest level.

A4 104 The importance of spatial frequency and familiarity in face recognition

Karin Pilz[1,2] (karin.pilz@tuebingen.mpg.de), Heinrich Bülthoff[1], Quoc Vuong[3]; [1]Max Planck Institute for Biological Cybernetics, Tübingen, Germany, [2]Graduate School of Neural and Behavioural Sciences, Tübingen, Germany, [3]Division of Psychology, Newcastle University, Newcastle upon Tyne

Using a delayed visual search paradigm, we showed that non-rigidly moving faces are better encoded than static faces (Pilz. Thornton and Bülthoff, 2006). In this task, observers learned one dynamic and one static face, and then searched for either target in a static search array. Here, we used high (HSF) and low (LSF) frequency filtered faces during visual search to investigate whether the difference lies in the encoding of different spatial frequencies. In Experiment 1 (N=12), we used a learning procedure which only required observers to rate the targets along different character traits. We found no advantage for dynamically-learned faces, but HSF faces were recognized more accurately ($p<.05$). In Experiment 2, we used our previous learning procedure which required observers to assess both targets' personality and facial features using a detailed questionnaire. Observers (N=8) were faster at finding dynamically-learned faces ($p<.05$), and more accurate at finding LSF faces ($p=0.07$). Taken together, these results show that the nature of learning can affect face encoding strategies. Furthermore, the frequency effects suggest that less familiar faces may be recognized more from features than from configural information. In Experiment 3, we tested whether the dynamic advantage was due to the higher familiarity of dynamically-learned faces. Observers (N=8) searched for a colleague and an unfamiliar face, learned with the procedure from Experiment 2. We found that observers were faster ($p<.01$) and more accurate ($p<.01$) at finding their colleagues, which suggests that the dynamic advantage partly depends on the level of familiarity with the target face.

A5 105 Sex matters when you ask the right question: What affects eye movements in face comparison tasks?

Regine Armann[1] (regine.armann@tuebingen.mpg.de), Isabelle Buelthoff[1]; [1]Max Planck-Institut for Biological Cybernetics, Tuebingen, Germany

Eye-tracking studies on face perception have mostly investigated observer's eye movement behavior when studying single faces. However, in day-to-day situations, humans also compare faces or try to match a person's face to a photograph. During comparison, facial information remains visually accessible. This frees observers from time and encoding constraints (Galpin & Underwood, 2005). Here, we present eye movement data of participants required to compare two faces that were presented side by side. We used (1) two different tasks (discrimination or categorization), and (2) two types of face stimuli: faces differing either in identity or in sex. In addition, we varied for (3) task difficulty i.e. the similarity of the two faces in a pair. Eye-fixations in predefined facial regions were recorded and analyzed, for example, with regards to their frequency and duration. Our findings reveal, for instance, that the eyes were fixated more often in the discrimination tasks (38% of all fixations) than in the categorization task (29%), while the total number of fixations increased significantly with increasing task difficulty ($p < 0.001$ in all cases, N=20). Faces differing in sex were more difficult to discriminate than faces differing in identity (63 % versus 76 % correct responses), which was reflected by increased fixations to face pairs that differed in sex (14.4 versus 11.8 fixations per trial). Unexpectedly, we found a striking effect of tasks on performance measures, as over 80 % of participants could detect the more feminine of two faces (categorization task) even at the most similar level, but for the same face pairs their performance in a discrimination task was less than 30 % correct. Viewing behavior of male and female participants differed, but only when the sex of the faces was relevant for the task.

A6 106 Influence of encoding context on face recognition

Isabelle Bülthoff[1] (isabelle.buelthoff@tuebingen.mpg.de), Quoc Vuong[1,2]; [1]Max-Planck-Institut für biologische Kybernetik, Tübingen, Germany, [2]Division of Psychology, Newcastle University, Newcastle upon Tyne, UK

We quickly and automatically categorize faces, for example, as Asian or Caucasian, or as male or female. At the same time we are also good at recognizing individual faces. One issue is whether face categorization and recognition are parallel or serial processes. Here we investigated whether the presence of other faces of the same category interacts with the recognition of individual faces. More specifically: Do participants encode a more robust face representation when there is more than one face of the same race as the encoded face? To investigate this question we used sets of six faces which had different numbers of Caucasian and Asian faces (1-5, 3-3, and 5-1). On each trial, Caucasian participants performed an ancillary task to insure that they looked at all faces during an encoding stage. Subsequently, their recognition performance was tested in a same/different task on a single target face in each set . The results of two experiments showed that Caucasian participants were more accurate at recognizing Caucasian targets when five same-race faces were present instead of a single same-race face, while this effect was not evident for Asian targets. Surprisingly, the participants were significantly better at recognizing Asian than Caucasian targets in 3-3 sets. A similar series of experiments using novel objects instead of faces tested possible alternative explanations such as similarity and expertise . Overall, the effect of encoding context suggests that face categorization and recognition processes interact, pointing to a high degree of interdependency of these two processes.

A7 107 The role of surface and shape information in the other-race face effect

Caroline Michel[1] (caroline.michel@psp.ucl.ac.be), Bruno Rossion[1], William Hayward[2], Isabelle Buelthoff[3], Quoc Vuong[3]; [1]Unite Cognition et Developpement et laboratoire de neurophysiologie, UCL, ouvain-la-neuve, Belgium, [2]Department of Psychology, University of Hong Kong, Hong Kong, [3]Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Both shape and surface dimensions play an important role in face (e.g. O'Toole et al., 1999) and race recognition (Hill et al., 1995). However, the relative contribution of these cues to other-race (OR) face recognition has not been investigated. Some facial properties may be diagnostic in one race but not in the other (e.g. Valentine, 1991). Observers of different races would rely on facial cues that are diagnostic for their own-race faces, a phenomenon which could partly explain our relative difficulty at recognizing OR faces at the individual level (the so-called other-race effect). Here, we tested this hypothesis by examining the relative role of shape and surface properties in the other-race effect (ORE). For this purpose, we used Asian and Caucasian faces from the MPI face database (Vetter & Blanz, 1999) so that we could vary both shape and surface information, only shape information (in which the surface texture was averaged across individual faces of the same race), or only surface information (in which shape was averaged). The ORE was measured in Asian and Caucasian participants using an old/new recognition task. When faces varied along both shape and surface dimensions, Asians and Caucasians showed a strong ORE (i.e. a better recognition performance for same- than other-race faces). With faces varying along only shape dimensions, the ORE was no longer observed in Asians, but remained present in Caucasians. Finally, when presented with faces varying only along surface dimensions, the ORE was not found for Caucasians whereas it was present in Asians. These results suggest that the difficulty in recognizing OR faces for Asian observers can be partly due to their inability to discriminate among surface properties of OR faces, whereas ORE for Caucasian participants would be mainly due to their inability to discriminate among shape cues of OR faces.

A8 108 **Women, but not men, prefer to fixate on the right side of a face**

Joan Chiao[1] (jchiao@northwestern.edu), Steven Franconeri[1]; [1]Northwestern University

Previous studies have shown that people perceive greater emotion from the right-side relative to the left side of the face. Additionally, females have been shown to have greater emotional acuity relative to males. Here we examined gender differences in face perception using eye-tracking. Female and male participants viewed pictures of female and male neutral faces, separated by blank intervals, and were asked intentionally encoded each face while eye movements were recorded. Each of the total 33,000 fixations were coded as falling in one of 22 individual face regions. For each subject, the average percentage of the 5 second looking time spent in each region was calculated, and 4 regions were fixated a standard deviation more than the rest. Results indicate that females preferred to look at the eye region significantly more than males, regardless of the gender of the face target. Moreover, females especially preferred to look at the right eye relative to the left eye o! f both female and male faces while males did not demonstrate a laterality preference. By contrast, males spent significantly more time looking at the upper nose region relative to females, regardless of whether they were looking at a male or female face. Taken together, these results reveal a striking gender difference in the visual strategy employed during face encoding, and this lateralization difference in perceptual strategy may have further implications for understanding how and why gender differences in emotional acuity occur.

A9 109 **Jane and Ling: Holistic Processing and Sensitivity to the Spacing of Features in Own- versus Other-race Faces**

Natalie Elms[1] (natalie.elms@brocku.ca), Catherine Mondloch[1], Daphne Maurer[2]; [1]Psychology Department, Brock University, Ontario, Canada, [2]Department of Psychology, Neuroscience & Behaviour, McMaster University, Ontario, Canada

Adults' expert face recognition is limited to the kinds of faces they encounter on a daily basis (typically upright human faces of the same race). Adults process own-race faces holistically (i.e., as a gestalt) and are exquisitely sensitive to small differences among faces in the spacing of features. Previously we showed that adults' expertise is shaped by experience: they were 9% more accurate in seeing differences in the spacing of features in upright human than in upright monkey faces (Mondloch et al., 2006). Here we report evidence for poorer processing of spacing among features in other-race than in own-race faces, despite matching physical differences and despite evidence for robust holistic processing of other-race faces. We tested Caucasian adults (n=30) living in rural Pennsylvania who had minimal exposure to other-race faces. We created four versions of two faces (Chinese and Caucasian) that differed only in the spacing of features. Participants showed an own-race advantage when making same/different judgments ($p < .01$), consistent with two recent studies that used different manipulations of spacing cues (Hayward et al., in press; Rhodes, et al., 2006). We also tested them on a composite face task (Young et al., 1987), a measure of holistic processing. Adults find it difficult to recognize that the top halves of two faces are the same when they are aligned with different bottoms; their accuracy improves when the two halves are misaligned, a manipulation that disrupts holistic processing. The size of this composite face effect did not differ with race of face ($p > .20$), in contrast to the results of Michel et al. (2006). The results indicate that an other-race disadvantage for the processing of the differences among faces in the spacing of features can co-exist with holistic processing.

A10 110 **The face of race: Revealing the visual prototype of Black and White faces in Caucasian subjects**

Daniel Fiset[1] (fisetda@uvic.ca), Brandon Wagar[1], James Tanaka[1], Frederic Gosselin[2,3], Daniel Bub[1]; [1]Department of Psychology, University of Victoria, [2]Departement de Psychologie, Universite de Montreal, [3]Centre de Recherche en Neuropsychologie et Cognition

What is the information mediating race categorization? Mangini & Biederman (2004; see also Konsevitch & Tyler, 2004) have recently proposed an original application of the reverse-correlation technique in which the base stimulus (i.e. the stimulus on which the decision is done) is ambiguous with respect to the task at hand (e.g. in a task where the subject had to identify John Travolta and Tom Cruise, the stimulus was a morph of both). This methodology permits to reveal the information mediating face classification and the combination of the noise classification image with the base stimulus explicitly shows the prototype used by the subject for the decision process in the task. We selected 6 faces of White and Black men. Each pair of black/white faces (36 possible combinations) was morphed by incorporating different amount of the black and white faces (e.g. 10% white, 90% Black; 16% white, 84% Black and so on) to find the combination that led observers to categorize the stimulus as Black (or White), 50% of the time. We then asked 5 subjects to categorize 10,000 times the resulting 36 ambiguous stimuli embedded in white Gaussian noise. The subjects were unaware that each base face was ambiguous with respect to race, with only the noise tipping one way or the other. We then computed the classification image by subtracting the average noise fields for which the subjects responded "White", from the average noise fields for which they responded "Black". The resulting classification images, computed on an individual basis, reveal what information mediates race categorization as well as the prototype used by each subject to respond. These results will be discussed in relation to the racial prejudices shown by each individual subject.

A11 111 **Face adaptation does not improve perceptual salience**

Minna Ng[1,2] (mng@salk.edu), Geoffrey Boynton[2], Ione Fine[3]; [1]Psychology Dept, University of California, San Diego, [2]Systems Neurobiology, The Salk Institute for Biological Studies, [3]Department of Ophthalmology, Zilkha Neurogenetic Institute, University of Southern California

Purpose: Adaptation to female faces makes a face that was previously seen as gender-neutral appear male (Webster et al., 2004). This face adaptation technique has been widely used as a tool for examining selectivity for properties such as identity and expression. Here, we asked what might be the perceptual benefit of selective face adaptation by examining whether adaptation affects the relative salience of faces. Methods: Subjects were pre-adapted for 3 minutes to a series of faces (1 face/sec). Adaptor faces belonged to 3 of 4 categories, for example: male Asian, female Caucasian, and male Caucasian. On each trial subjects were asked to detect target faces in either a rapid serial visual presentation (RSVP) or visual search (VS) task. Each subject was tested on two target categories: an unadapted category (female Asian in this example), and a fully adapted category (male Caucasian). Each trial was followed by a 12 sec top-up adaptation period. Each target category was tested in a separate session, and in each session we measured performance both before and after adaptation. All combinations of adaptors and targets were tested for each subject. In the 2IFC RSVP task, subjects were asked to indicate which interval contained a face belonging to the target category. Masks consisted of faces belonging to the remaining three categories. Percent correct was measured as a function of presentation rate. In the VS task, 4 faces appeared simultaneously: the target and faces from the remaining three categories. Subjects reported the spatial location of the target. Response time and accuracy was recorded. Results: We found no evidence that adaptation affects saliency. We saw no effects of adaptation between fully adapted and the non-adapted targets, in either task, both within and across subjects.

Acknowledgement: EY12925, EY14645

A12 112 **Squirrel monkeys' (Saimili sciureus) peculiar facial recognition in the discrimination between own and other species.**

Ryuzaburo Nakata[1,2] (ryu3@din.or.jp), Yoshihisa Osada[1]; [1]Rikkyo University, [2]JSPS Research Fellow

Friday Posters

PURPOSE: Previous research shows that squirrel monkeys have two different strategies for facial recognition in the individual discrimination of their own species and those of other species: one strategy is similar to that of humans, while the other is specific to squirrel monkeys. But it is unclear whether the monkeys use the same strategies for the discrimination between faces of their own and other species. This is the question we explore in this research.

METHOD: Subjects were two squirrel monkeys. The stimuli were faces of squirrel monkeys and humans, which were unfamiliar to the subjects. In the training phase, the subjects were trained to discriminate between squirrel monkey and human faces so as to achieve a performance of 80% correct. In the test phase, we introduced several types of probe stimuli. Presented were only some facial features of the training stimuli (e.g., configuration of eyes, outer facial boundary and so on), and the whole body of both species.

RESULTS AND DISCUSSION: One monkey could discriminate between his own and other species. The configuration of eyes had a significant effect (binominal test < .05) on the discriminating performance in choosing other species in distinction from his own species. Furthermore, the monkey could use outside features of monkey faces in choosing his own species. These results suggest that squirrel monkeys utilize the same cues for discrimination between species through facial recognition as well as for individual discrimination between their own species. These two alternative strategies of facial recognition may reflect the face information including both communality to comprehensive species and peculiarity to particular species.

Acknowledgement: This work was supported by RARC (Rikkyo Amusement Research Center) and JSPS Research Fellowship for Young Scientists.

A13 113 Universality and cultural specificity in social dominance perception: Effects of gender and culture on facial judgments

Donna Bridge[1] (jchiao@northwestern.edu), Zhang Li[1], Michelle Tsao[1], Joan Chiao[1]; [1]Department of Psychology, Northwestern University

People are able to rapidly infer social dominance from facial cues. What aspects of social dominance perception are universal and culturally-specified? In this experiment, participants viewed greyscale images of Caucasian and Chinese male and female facial postures, varying in eye gaze direction (i.e. direct or averted) and vertical head orientation (i.e. up, straight or down), followed by a greyscale mask. Presentation duration was parametrically varied (i.e. 17ms, 33ms, 68ms, 167ms, unlimited) and participants were asked to judge how dominant each face seemed on a Likert scale of 1 (not at all) to 7 (very much). All groups of participants judged male faces as significantly more dominant to female faces. By contrast, Caucasian-American and native-born Chinese participants judged own-culture faces as significantly more dominant relative to other-culture faces. Interestingly, Chinese participants living in America did not show a significant difference in judgments of social dominance for Chinese and Caucasian faces. Hence, the effect of gender on perceived social dominance did not vary across groups of participants; however, culture had a significant effect on perceived social dominance such that faces of one's own cultural group were perceived as more dominant relative to faces of individuals from another culture, except in participants with a bicultural identity who perceived faces of both cultures as equally dominant. These results reveal both universality and cultural specificity in facial judgments of social dominance.

A14 114 What drives the political gender gap?: The role of gender on facial judgments of politicians

Nicholas E. Bowman[1] (nickbowman80@gmail.com), Joan Y. Chiao[1]; [1]Department of Psychology, Northwestern University

In U.S. electoral politics, men are more likely to run and be elected to political office (Fox and Lawless, 2004). Moreover, previous research demonstrates that perceived competence from facial appearance alone can predict the outcome and margin of victory in political races, such as the U.S. Senate and U.S. House of Representative elections (Todorov et al., 2005). However, little is known about the role of gender on facial judgments of elected political officials. Here we examine the role of gender on facial judgments of male and female winners of recent U.S. House of Representative races. Twenty-three college-aged participants judged how competent, dominant, warm and approachable the faces of elected U.S. Representative leaders seemed on a Likert scale from 1 (not at all) to 7 (very much). All participants judged faces of male politicians as significantly more competent relative to female politicians. Moreover, participants judged the faces of female politicians as significantly more dominant and more approachable relative to faces of male politicians. There was no difference in perceived warmth of male and female elected officials' faces. These results suggest that the political gender gap may be driven by differences in perceived competence of male and female political leaders from the face and that female politicians who are elected, succeed potentially due to a highly dominant and approachable facial appearance.

A15 115 Who's looking at you? Gender and familiarity modulate gaze cueing.

Jocelyn L. Sy[1] (sy@psych.ucsb.edu), Barry Giesbrecht[1]; [1]University of California, Santa Barbara

Gaze direction is an important social cue that can induce shifts of attention (Friesen & Kingstone, 1998). Recent studies have found that familiarity of male faces modulates the degree that gaze directs attention in females but not in males (Deaner et al., 2006). It is possible that this familiarity effect is unique to female viewers, however, it is also possible that the familiarity effect occurs in both genders but is strongest when the gaze is displayed by the opposite gender. We tested these two hypotheses by manipulating the familiarity of both male and female face-cues. In the 'familiar' condition, participants were exposed to, and tested on, information about the identity and background of a male and a female face. In the 'unfamiliar' condition, the same participants were exposed to different male and female faces, but were not given any information about them. Each trial began with the presentation of a familiar or unfamiliar face with the eyes diverted to the left or right. Participants discriminated a target letter presented in the gazed-at or the non-gazed-at location. The face-target SOA ranged from 147-1200 ms and the gaze direction did not predict the target location. The analysis revealed an interaction between familiarity, target location (gazed-at vs. not-gazed-at), face gender, and participant gender. In the unfamiliar condition, gaze cueing was greater when the genders of the face and participant were the same than when the genders were different. The reverse pattern was found for familiar faces: gaze cueing was largest when the face and participant genders were different than when the genders were the same. Results suggest that the extent to which both women and men are sensitive to gaze direction depends on familiarity and the gender of the observer in relation to the gender of other individuals.

Acknowledgement: Bailey Bondura

A16 116 Associating reward and loss with faces: Effects on rapid face recognition

Jennifer O'Brien[1] (psp020@bangor.ac.uk), Jane E. Raymond[1]; [1]University of Wales, Bangor

Previous studies (using visual search, change blindness, and the attentional blink) have shown that when complex images such as faces are extremely familiar, they are encoded more quickly and require less attention to be processed than other less familiar stimuli. This suggests that repeated exposure to stimuli alters perceptual processing. Another body of work has shown that emotionally salient stimuli are also processed faster and require less attention than non-valenced stimuli. It in not clear, either for familiarity or emotional valence, how perceptual processing advantages are achieved. To address this question and to bring familiarity and emotionality together, we combined an associative learning task with visual perceptual tasks. Animal studies indicate that learned reward and loss value of stimuli have different effects on amygdala activity (Paz et al., 2006) that could potentially modulate activity in visual cortex via amygdalate-cortical pathways (Amaral & Price, 1984). Thus associative

learning might modulate perceptual processing. To test this we exposed participants to face stimuli that were differentially associated with reward or loss in an effort to control the emotional value of faces whilst controlling for their perceptual exposure. Participants learned associations with computer-generated faces by playing a simple betting game. Faces were shown in pairs and participants had to choose between them in attempt to maximize payoff. Each face was associated with a probability (high or low) of gain, loss, or no financial outcome. (Different faces were used for different participants eliminating item effects.) After training, we quantified face perception by measuring the minimum stimulus onset asynchrony between a target face stimulus and a scrambled-face mask needed for criteria detection. We also measured detection of trained faces as the second target in an attentional blink task. The results indicate that reward and punishment learning have consequences for perceptual processing.

A17 117 Self-range defined by gaze perception is robust against the size and viewing distance variations.

Yuko Isogaya[1] (gayan-tky@umin.ac.jp), Kazushi Maruya[2,3], Yutaka Nakajima[4], Yusuke Tani[5], Takao Sato[4]; [1]Department of Mental Health, Graduate School of Medicine, The University of Tokyo, [2]Department of Medicine, Jikei Univesity, [3]Department of Psychology, Vanderbilt University, [4]Department of Psychology, Graduate School of Humanities and sociology, The University of Tokyo, [5]Intelligent Modeling Laboratory, the University of Tokyo

Self-range is defined as a range of gaze direction of a looker within which the perceiver feels like he/she is being looked at. In our past study, by using actual-size pictures displayed on a CRT screen, we found that the viewing-distance does not affect the decision. This means that the gaze perception does not depend on geometric calculations. In this study, to further pursue this point, we measured gaze perception larger faces while varying the face size and the viewing distance. The stimuli were full-color pictures of four young persons with gaze shifted in 11 steps between 15 degs to the right and to the left of the center. Three stimulus sizes (10-, 5-, 2.5-times of the actual size) and two viewing distances (570 cm, 285 cm) were used. The experiment was conducted by sessions, and the stimulus size was fixed within a session. The size was varied within participant, and the distance was varied between participants. Participants were asked to judge whether the stimulus person was looking at them. It was found that the estimated self-range within which % being-looked-at is higher than 50 % was fairly constant over the size and distance. The averaged values for all conditions fell within 2.5 to 3 degs either to the right or to the left from the center, and they were consistent with our past results with actual-size pictures. The present results indicate that perceivers' judgments whether they are being looked at are little affected by the size and distance. That is, perceivers do not convey geometric calculation using the deviation angle, the viewing distance, and the face size. Rather, their judgments seem to depend solely on figural cues, especially the pupil position within eyes.

Acknowledgement: KM & YN were supported by a grant from JSPS.

A18 118 The development of face discrimination skill in infants

Yumiko Otsuka[1,2] (yiu15793@nifty.com), So Kanazawa[3], Masami Yamaguchi[1,4], Hervé Abdi[5], Alice O'Toole[5]; [1]Chuo University, [2]Japan Society for the Promotion of Science, [3]Shukutoku University, [4]PRESTO Japan Science & Technology Agency, [5]The University of Texas at Dallas

Recent developmental studies provided evidence that a few months of experience can be sufficient to induce preference for own race faces in young infants (Kelly et al., 2005; Bar-Haim et al., 2006). The aim of the present study was to explore the effect of facial experience on the development of face discrimination skill in infancy. Specifically, we examined the face discrimination ability of Japanese infants using Japanese faces and Caucasian faces.

A total of 48 Japanese infants aged 3-4 and 7-8 months participated in the present study. The guardians of these infants reported that infants had little or no experience with Caucasian people in their daily life. Stimuli were monochromatic pictures of female Japanese/ Caucasian faces with the same hair style. Half of the infants at each age group were assigned randomly to the Japanese face discrimination condition, and the rest of the infants were assigned to the Caucasian face discrimination condition. Infants were familiarized with a face for 60 seconds, and then were shown a familiar face and novel face side by side. In this paradigm, we infer that infants have discriminated between the faces, if they show a preference for the novel face.

Both the 3-4 and 7-8 month old infants showed a significant preference for a novel face in the Japanese face condition, but showed no preference in the Caucasian face condition. These results suggest that Japanese infants in both age groups discriminated only Japanese faces. Our findings are consistent with previous studies that found preference for own race faces in 3-month-olds (Kelly et al., 2005; Bar-Haim et al., 2006), and that found better recognition of own race face in 3-month-old Caucasian infants (Sangrigoli & De Schonen, 2004). We will provide further data from additional experiments that systematically changed discriminability of the faces using morphing technique.

Acknowledgement: We would like to thank Dr. Hiroshi Yamada for providing us with images of Japanese faces collected for the face database project at Nihon University (FIND). This study was supported by RISTEX and PRESTO, Japan Science and Technology Agency, and by a Grant-in-Aid for scientific research (18000090) from the Japan Society for the Promotion of Science.

A19 119 Infants' brain activity on perception of different view faces using Near-infrared spectroscopy

Emi Nakato[1,2] (enakato@komazawa-u.ac.jp), Yumiko Otsuka[2,3], Akira Midorikawa[1], Masami K Yamaguchi[1, 4], Ryusuke Kakigi[5, 6]; [1]Department of Psychology, Chuo University, [2]Department of Psychology, Komazawa University, [3]Japan Society for the Promotion of Science, [4]PRESTO, Japan Science and Technology Agency, [5]National Institute for Physiological Sciences, [6]RISTEX, Japan Science and Technology Agency

Recently, near infrared spectroscopy (NIRS) has been clarified awake infants' brain activity on face processing (Otsuka et al., 2006). They demonstrated that the concentration of oxyhemoglobin (oxy-Hb) and total hemoglobin (total-Hb) significantly increased in the right lateral area during presenting only upright faces, not inverted faces. This study suggests that 5-month-old infants recognize faces based on the specific mechanism in their brain.

In the present study, we investigated that (1) the measurement of infants' brain activity on perceiving frontal and profile views using NIRS and (2) the developmental changes of brain responses on both left and right temporal regions by comparing between 5- and 8-month-old infants.

Several studies indicated 6- to 8-month-olds could discriminate unfamiliar faces on different views such as three-quarter and profile views (Fagan, 1976; Nakato et al., submitted). By 8 months of age, infants can recognize faces from not only frontal but also profile views.

The participants were 13 healty infants, six 5-month-olds and seven 8-month-olds. Full color photo images of 5 vegetables, 5 unfamiliar female frontal and profile views were presented, and infants looked each photo image passively as long as they could.

Our finding was that the hemodynamic response increased in the right temporal regions at both frontal and profile views presentations. It suggests that there is an advantage of the right hemisphere in the infants' face perception, consisted with our previous NIRS study (Otsuka et al., 2006). As for the developmental change, in 5-month-old infants, the concentration of oxy- and total-Hb increased only during frontal views presentation. By contrast, in 8-month-olds the concentration of oxy- and total-Hb increased during both frontal and profile views presentations. Our hemodynamic data suggest that not 5 but 8-month-old infants would have an ability of the view-invariant representation of faces.

Eye Movements: Cognitive I

Author Presents: 5:45 - 7:15 pm

A20 120 Effect of training to an area-cue on human saccadic eye movements.

Olga Savina[1] (olga.savina@mcgill.ca), Andre Bergeron[1], Daniel Guitton[1]; [1]McGill University

Introduction. Eye movement latency to targets can be shortened by advanced preparation of saccadic programs. Specifically, advanced saccade preparation can be enhanced through training to attend to a specific location in space (Paré & Munoz, 1996). However, people often know the area where a target will appear rather than its precise location. Here, we investigated how saccades were affected by training to attend to a circular area within which a target appeared at random locations. Additionally, we looked at how training to attend to an area of one size influenced saccades to targets presented in a larger circular area.

Methods. Each trial began with a central fixation point, followed by simultaneously presenting a circular area-cue (6° or 10° diameter), for 400ms. These disappeared, and following a gap period (170ms or 220ms), the target was flashed for 68ms. Participants were required to quickly and accurately saccade to the target once it appeared. Saccade reaction time and position were recorded. To prevent anticipatory saccades, catch trials were included in pre- and post-training sessions where some targets were presented outside the area-cues. During the training sessions, the target was always presented within a 6° area at random locations.

Results. Post-training goal-directed saccades were mostly anticipatory. Participants each developed a preferred region inside the trained area, where post-training anticipatory saccades were directed. This preferred region scaled with cued-area size, i.e. post-training distributions of saccade-end points greatly overlapped once normalized for cued-area position and size. From the preferred region subjects often generated visually driven corrective saccades to the target inside the area cue. Over all, there was no speed-accuracy trade off.

Discussion. Present findings show that oculomotor preparations extend to areas, not just to a single target location. Compared to pre-training, the learned strategy assures that targets are acquired more quickly without loss of accuracy.

Acknowledgement: This work was funded by the Canadian Institutes for Health Research

A21 121 Dependence of Fixational Saccades on the Visual Task and Image Fading Conditions

Martina Poletti[1] (martinap@cns.bu.edu), Michele Rucci[1]; [1]Boston University, Cognitive and Neural Systems Department

Our eyes are constantly in motion, even during visual fixation, when periods of drifts alternate with small fixational saccades. It is known that visual percepts tend to fade when images are stabilized on the retina. However, it has long been debated whether, during natural viewing, fixational saccades have other functions in addition to preventing the visual scene from fading. In this study, we examined the frequency of fixational saccades under different viewing conditions and tasks. In agreement with the results of previous studies, fixational saccades were highly influenced by the visual task. The same subjects performed virtually no fixational saccades while freely scanning a scene but exhibited, instead, frequent saccades when discriminating the orientation of a grating. We also examined the influence of image fading on fixational saccades. Natural images were displayed for 10 s under 4 different fading conditions: (1) Sustained fixation. (2) Contrast fading; the contrast of the image was progressively lowered during presentation. (3) Frequency fading; the image was low-pass filtered at a progressively lower cut-off frequency during presentation. (4) Retinal stabilization. In conditions 2 and 3, the stimulus changed faster in the periphery than at the center of the visual field to closely resemble natural fading. Artificial fading had little effect on fixational saccades. The rate and characteristics of fixational saccades measured in conditions 2 and 3 were identical to those measured under sustained fixation. Unexpectedly, the rate of fixational saccades was significantly lower under retinal stabilization, a condition which enhanced image fading. Furthermore, in control experiments, fixational saccades were unaffected by increments in image contrast and cut-off frequency, which simulated visibility enhancements. These results do not support a causal relationship between image fading and the production of fixational saccades.

Acknowledgement: Supported by NIH-EY015732

A22 122 Eye movements for active learning of objects

Thomas Tanner[1] (tanner@tuebingen.mpg.de), Roland Fleming[1], Heinrich Bülthoff[1]; [1]Dept. Cognitive and Computational Psychophysics, Max-Planck-Institute for Biological Cybernetics, Tübingen, Germany

We investigated how humans use eye movements to direct their attention to informative features in a categorization task. More specifically, we test the hypothesis that eye movements are influenced by prior knowledge about a task and by information gathered in previous fixations. Our novel stimuli, which belonged to either one of two probabilistic classes, were large circular contours with several regular perturbations at which the curvature was varied as a continous feature dimension. With this design the spatial separation of single features generally required several closer fixations to make a confident decision about class membership.

Each feature value varied stochastically from trial to trial according to a characteristic distribution for each category (external noise). The features were independent and varied in diagnosticity. Subjects had to learn the categories by using immediate feedback about the true category after each trial (4 subjects, 10 sessions of 250 trials). We estimated the internal noise, which was much smaller then the external noise, based on an independent experiment measuring curvature discrimination performance for different eccentricites (0-12°), finding approx. linear decrease in sensitivity with increasing curvature.

The subjects were able to learn to discriminate the categories (avg. performance for ideal observer vs. subjects was 0.82 vs 0.68). Trial by trial fluctations in performance follow the ideal observer (MAE 0.32). With increasing expertise reaction times became shorter and fixations became more focused, possibly reflecting the subjects' belief about relevant features. We compare the results with Bayesian learner models which take into account the peripheral fall-off in discriminability, while directing their attention to the currently most informative features.

A23 123 Inefficient eye movements correlate with difficulties in perceiving global stimuli in Balint's syndrome

Kirsten A. Dalrymple[1] (kdalrymple@psych.ubc.ca), Walter F. Bischof[2], David Cameron[1], Jason J.S. Barton[1,3,4], Alan Kingstone[1]; [1]Department of Psychology, University of British Columbia, [2]Department of Computing Science, University of Alberta, [3]Department of Visual Sciences and Ophthalmology, University of British Columbia, [4]Department of Neurology, University of British Columbia

Patients with Balint's syndrome often report Local portions of visual scenes, but not the Global percept. Other researchers have reported that the eye movements of Balint's patients while they identified Local and Global levels of hierarchical letters do not differ between successful and unsuccessful trials. We replicated and extended this experiment by recording eye movements of a Balint's patient (SL) and of controls while they identified, on separate trials, letters at Global or Local levels of hierarchical stimuli. Controls were highly accurate for Global and Local trials and made only a few fixations, most of which landed at centre-screen. SL took longer and made more fixations per second than controls, with fewer fixations to centre-screen. She had normal accuracy for identifying Local elements, but poor accuracy during Global trials. SL's performance differed between Global and Local tasks, with Global trials showing longer reaction times, fewer fixations per second, and a lower proportion of fixations overlapping with the letter stimulus. When comparing SL's successful to unsuccessful Global trials, while there were no significant differences in the distribution of fixations in different regions of the screen, SL did have shorter reaction times and a higher proportion of fixations overlapping with the letter stimulus per second during successful trials than during unsuccessful trials. We conclude that SL demonstrates a need to explore Global and Local letters more than controls, reflecting her difficulty with information accrual during fixations, consistent with her attentional difficulties. The more difficult Global task is associated with a reduced fixation rate and less fixation-stimulus overlap. Fixation-stimulus overlap is further decreased in Global trials on which she made errors. These features suggest that any preserved Global perception in SL may be dependent on local fixations of the stimulus, consistent with a spatial constriction of attention.

A24 124 More efficient scanning for familiar faces

Jennifer J. Heisz[1] (heiszjj@mcmaster.ca), David I. Shore[1]; [1]Department of Psychology, Neuroscience and Behaviour, McMaster University

The present study reveals changes in eye-movement patterns as newly learned faces become more familiar. Observers received multiple exposures to newly learned faces over four consecutive days. Recall tasks were performed on all four days, and a recognition task was performed on the fourth day. Eye-movement behaviour was compared across facial exposure and task type. Overall, the eyes were viewed for longer and more often than any other facial region, regardless of face familiarity. As a face became more familiar observers made fewer fixations during recall and recognition. In addition, with increased exposure observers sampled more from the eyes and nose regions, and sampled less from the mouth, forehead, chin, and cheek regions. Interestingly, this observation was significant for recall tasks, but not for recognition.

A25 125 Gaze duration differences during a complex scene color preference test occur based on identical vs. dissimilar scenes.

John Pospisil[1] (jpospisi@lexmark.com), Kelly Rutan[1]; [1]Imaging Sciences Department, Consumer Product Division, Lexmark International

The majority of research on scene preference and eye movements assumes that gaze time is positively correlated with attentional focus and decision-making. Previous research also demonstrates that, at least when participants view faces, gaze time is positively correlated with perceived attractiveness of the stimuli.

Color preference testing in complex scenes requires rendering scenes with identical content to show shifts in color space. This task is different that other discrimination tasks in which an individual might compare dissimilar stimuli (e.g. different faces to rate facial attractiveness). Furthermore, it is assumed that when comparing stimuli that are identical except for color shifts, a viewer compares the physical sample to a memory of an ideal or appropriate color for the stimulus. In case of the latter, one's cognitive task may shift from identifying the most-preferred scene to identifying the scene most different from one's expectations. Accordingly, it was hypothesized that when comparing dissimilar stimuli, participants would gaze longer at the preferred sample in a 2AFC color preference test. In contrast, it was hypothesized that participants would gaze longer at the least-preferred stimuli in a 2AFC color preference test comparing otherwise identical stimuli.

Participants wore a head-mounted eye tracking unit during a 2AFC color preference test in which similar and dissimilar scenes were presented. To isolate color as a variable and to minimize the effect of print artifacts, individuals were seated approximately two meters away from the stimuli. The samples were illuminated by a Gretag-Macbeth light booth set to "cool white". Results support both hypotheses. Participants gaze longer at the least preferred samples when comparing identical scenes but longer at the most preferred samples when comparing dissimilar stimuli.

A26 126 Mondrian, Eye Movements, and the Oblique Effect

James Schirillo[1] (schirija@wfu.edu); [1]Wake Forest University

Observers prefer paintings by Mondrian in their original orientation compared to when rotated – "The Oblique Effect" (Latto, et. al., 2000). We tested whether eye movements provide any insight into this aesthetic bias. We presented 8 Mondrian paintings (1921-1944) on a CRT in either their original or seven rotated positions to 10 observers. These 64 images were presented pseudo-randomly for 20 sec each while recording eye movement fixation duration and saccade length. During the 5 sec ISI observers used a 1-7 Likert-scale to report how (dis)pleasing they found each image. In 6 cases an original orientation was judged as significantly more pleasing that a rotated image, while a rotated image was preferred in 3 cases. Overall, over the 20 sec trial interval, fixation durations increased linearly, where pleasing images fixation duration increased more than non-pleasing images. Moreover, saccade distances oscillated over the viewing interval; with the pleasing image fit being more variable (i.e., saccade distance oscillations were larger) than the non-pleasing image fit. Both these findings agree with earlier work by Nodine, Lochear and colleague; and suggest that the more pleasing an abstract painting is, the greater the diversive/specific types of image exploration become (Berlyne, 1971).

References:

Berlyne (1971). Aesthetics and Psychobiology. New York, Appleton-Century Crofts.

Latto, Brain & Kelly (2000). An oblique effect in aesthetics: Homage to Mondrian (1872-1944). Perception 29: 981-987.

Locher & Nodine (1987). Symmetry catches the eye. In: Eye Movements: From Physiology to Cognition. O'Regan & Levy-Schoen. North-Holland, Elsevier Science Publishers: 353-361.

Nodine, Locher & Krupinski (1993). The role of formal art training on perception and aesthetic judgment of art compositions. Leonardo 26(3): 219-237.

A27 127 Task dependence of space-time statistics at point of gaze revealed by eye tracking in natural wooded environmen

Jeff Pelz[1] (pelz@cis.rit.edu), Constantin Rothkopf[2], Christopher DeAngelis[1]; [1]Center for Imaging Science, Rochester Institute of Technology, [2]Center for Visual Science, Brain and Cognitive Sciences, University of Rochester

Theories of optimal coding propose to understand early sensory processing of stimuli as being adapted to the statistics of the signals naturally occurring when interacting with the environment. Given that perception is active, the stimuli at the retina are dependent on oculomotor control and therefore on the executed task. How do different tasks affect the statistics of image features at the fixation location? In the past a number of studies have shown that the features at fixation locations are different from those selected randomly in natural scenes. Those results were obtained by subjects looking at briefly presented static images of natural scenes subtending a limited visual angle in a laboratory environment while mostly executing the so-called 'free-view' task. How do these results transfer from the laboratory environment to real natural environments in which subjects execute natural goal-directed behavior?

In order to address this question, eye movements of human subjects acting in a natural wooded environment were tracked with a custom-made portable eye tracker. An HD-video camera mounted on a bicycle helmet recorded the visual scene with a diagonal field of view of 75 degrees.

This high-resolution video allowed for the accurate analysis of visual features at fixation location versus locations chosen randomly within the visual scene. Three subjects each executed a search task, a 'free-view' task and a walking task. Each task had duration of approximately 90 seconds. The eye tracker was calibrated between trials.

Here we report results from the analysis of the spatiotemporal autocorrelation functions obtained from the natural scene sequences separately for the three different tasks and sets of image patches chosen according to three random sampling methods. The data show significant statistical differences between the tasks. We therefore conclude that theories of optimal coding of sensory stimuli should take into account explicit task dependencies.

A28 128 **Influence of perceived depth in a reverse perspective stimulus on vergence**

Dagmar Wismeijer[1] (d.a.wismeijer@phys.uu.nl), Raymond van Ee[1], Casper Erkelens[1]; [1]Helmholtz Institute, Utrecht University, The Netherlands

We investigated the influence of perceived depth on vergence eye movements while binocularly viewing a reverse perspective stimulus. In a reverse perspective stimulus, the perspective depth of a scene painted on a 3D surface strongly conflicts with the physical depth of the 3D surface. Subjects unfamiliar with the reverse perspective stimulus usually perceive the depth suggested by the perspective cue. Thus, of the two possible perceived depths, the one induced by the perspective cue is highly favored over the other one related to the physical dimensions of the 3D surface.

In an earlier experiment we did not find an influence of perceived surface slant polarity on vergence while viewing a bistable slant rivalry stimulus [ECVP 2006]. This negative result is not sufficient to conclude that such an influence does not exist, as the vergence changes related to the perceived slant may have been too small to be measurable. We hypothesize that as perceived depth is stable while viewing the reverse perspective stimulus, the influence of perceived depth on vergence ought to be stronger than in the bistable stimulus experiment.

We used a stimulus inspired by a 3D reverse perspective model of Wade and Hughes (“Cloudy Doors”, 1999). The stimulus (15x15 cm) was viewed at a distance of 55 cm. Vergence changes predicted by the physical dimensions of the surface were less than 1^o. Vergence changes predicted by the perceived depth, however, ranged from 0^o to about 6^o in the opposite direction.

The results showed vergence changes of about 1^o or less in directions predicted by the physical dimensions of the 3D surface. Thus, vergence changes in binocular viewing conditions corresponded better with the predictions based on the physical dimensions of the surface than with the predictions based on the perceived illusory depth.

A29 129 **Relating contrast statistics at fixation location to navigational control law**

Constantin Rothkopf[1] (crothkopf@bcs.rochester.edu), Dana Ballard[2]; [1]Center for Visual Science, University of Rochester, [2]Department of Computer Science, University of Texas at Austin

The allocation of gaze is commonly thought to be determined by features of visual stimuli. A number of studies have analyzed the statistical properties of features such as luminance, contrast, and spatial frequency content at locations selected by gaze versus randomly chosen locations. Significant differences were found between these two classes of regions but it remains controversial whether such effects are correlational or causal. However compelling evidence exists for the task dependence of visual attention. Here we report results from an experiment that demonstrates that in a navigational task in which subjects avoid obstacles and pickup objects the feature statistics at fixation location are dependent on the ongoing task and can be explained by the different control laws used in navigating towards or around objects.

Ten human subjects walked along a path in a virtual environment and were instructed to stay on the path and either avoid or pickup rectangular objects. As previously reported, luminance contrast was elevated at fixation locations. However, mean contrast was significantly different when subjects looked at objects when approaching them to pick them up (-5%) and when they looked at the same objects in the context of walking around them (+3%). The explanation for this is that the spatial distribution of fixations with respect to the objects depended on the type of interaction. When approaching objects for pickup, subjects tended to look at their center while when avoiding obstacles they tended to look at the object's edges.

This suggests that the local luminance contrast differences are not causal but correlational. Depending on the ongoing task, subjects selected different gaze targets such as edges versus centers so as to obtain relevant information for the control of movement. Thus different control laws in navigating around or towards objects determine which information is selected by the visual system.

A30 130 **Saliency maps and ultra-rapid choice saccade tasks**

Simon Thorpe[1] (simon.thorpe@cerco.ups-tlse.fr), Sébastien Crouzet[1], Holle Kirchner[1]; [1]CerCo, CNRS-Université Toulouse 3, F-31062, Toulouse, France

When two complex natural scenes are simultaneously flashed left and right of fixation, subjects can make reliable saccades toward animal targets in as little as 120 ms (Kirchner & Thorpe, Vis Res, 2006). This is less than half the time required to perform a manual go/nogo task with the same sort of material (Bacon-Macé et al, JEP:HPP in press). One feature of manual tasks is that participants can easily switch between target categories from block to block, for example, between animals and means of transport (VanRullen & Thorpe, Perception, 2001), or between animal and human faces (Rousselet et al., JOV, 2004). Here we tested whether subjects can also easily reverse the target category in a choice saccade task. To our surprise, we found very strong asymmetries. For example, when using photographs of humans and means of transport, we found that when humans were the target, saccades were initiated in as little as 100 ms with mean RT of 140 ms and accuracy of 89%. However, using the same materiel, when the target was a means of transport, performance was much poorer (mean RT = 170 ms, 71% correct). Furthermore, fast saccades were often made in the wrong direction as if the eye is automatically drawn to one of the two stimuli. Since there are populations of neurons that fire earlier to human faces than to other classes of stimuli (Kiani et al, J Neurophysiol, 2005), such neurons could feed into a form of high-level saliency map and thus lead to very fast saccadic reactions to important types of stimulus. However, unlike slower manual responses, it may be that this sort of activation cannot be modulated by top down control, making it difficult or maybe even impossible to modify the target stimuli category from block to block.

Acknowledgement: EU Project Decisions in Motion, ANR "NatStats"

A31 131 **The role of awareness in saccadic conditioning**

James Tse[1] (jtse@binghamton.edu), Thomas Baker[2], Scott Adler[2], Peter Gerhardstein[1]; [1]Binghamton University SUNY, [2]York University

We investigated the role of awareness in eye movement conditioning in adults using a modification of the infant cued visual expectation paradigm reported in Adler, Zilberberg, and Chockalingam (VSS 2005). In Exp. 1, participants observed a sequence of shapes each presented individually one at a time on a computer display while their eye movements were recorded. One group of the participants was presented with a sequence of shapes that contained a Predictive cue-target relationship. Specifically, a central cue shape would always predict the location (left or right) of a subsequent target shape. The remaining group received a Non-predictive cue-target relationship where the cue did not predict the target’s location. The dependent measure was the proportion of correct anticipatory saccades to the target’s location prior to its onset. Participants in the Predictive group anticipated at a rate of .61, which was significantly above a chance rate of .50. However, this anticipation rate was significantly lower than .75 reported with 6-month-old infants in other cued visual expectation studies. About half of the participants reported being explicitly aware of the cue-target relationship and awareness was significantly correlated with anticipation performance. In Exp. 2, participants were given various hints about the cue-target relationship. The Partially Informed group was told to look for a pattern in the sequence of shapes that may be present. The Fully Informed group was explicitly told of the cue-target relationship. The hints improved adults’ correct anticipations up to .88 (thereby establishing a ceiling performance of the procedure). Again, awareness score was correlated with anticipation performance. These findings are similar to studies linking awareness to conditional responding in trace differential eye blink conditioning (Clark, Manns, & Squire, 2002). We will also report on manipulations intended to improve the rate of correct anticipations without the use of instructional hints.

A32 132 Control of sensorimotor variability

Laurent Madelain[1] (laurent.madelain@univ-lille3.fr), Lucie Champrenaut[1], Alan Chauvin[1]; [1]Laboratoire Ureca, Université Ch. De Gaulle Lille III, France

PURPOSE. Studies of reaction time distributions provide a useful quantitative approach to understand decision processes at the neural level and at the behavioral level. A strong relationship between the spread of latencies and the median is generally accepted even though there has been no attempt to disentangle experimentally these two parameters. Here we test the ability to independently control the median and the variability in reaction times. METHODS. Reaction times were measured in human subjects instructed to make a discrimination between a target and a distractor in a 2AFC task. In a first experiment, saccadic latencies were measured. In a second experiment, we used manual response reaction times. In each experiment subjects were trained to produce four different reaction time distributions. A reinforcing feedback was given depending on both the variability and the median of the latency distributions. RESULTS. When low variability was reinforced the standard deviation of reaction time distributions were reduced by a factor of two and when high variability was reinforced, the standard deviation returned to baseline level. Our procedure independently affected the spread and the median of the distribution patterns. By fitting the latency distributions using the Reddi and Carpenter LATER model, we found that these effects could be simulated by changing the distribution of the noise affecting the decision process. Our results demonstrate that learned contingencies can affect reaction time variability and support the view that the so-called noise level in decision processes can undergo long-term changes.

2D Motion I

Author Presents: 5:45 - 7:15 pm

A33 133 "Motion streaks" improve fine direction discrimination

Deborah Apthorp[1] (deborah.apthorp@gmail.com), David Alais[1], Peter Wenderoth[2]; [1]Department of Psychology, Faculty of Science, Sydney University, [2]Department of Psychology, Division of Linguistics and Psychology, Macquarie University

Due to temporal integration, fast-moving objects leave neural "streaks". Because orientation perception is very finely tuned, Geisler (1999) suggested signals from these streaks could combine with those from more broadly-tuned motion-sensitive neurons to improve direction perception. Here, in a direction discrimination experiment, we directly manipulate streak length while holding other factors constant. In a 2IFC procedure, subjects judged the direction of motion of RDKs (120ms) composed of Gaussian blobs 12 min wide, moving horizontally at narrow directional separations. Experiment 1: High contrast dots were either fixed-walk or random-walk, with coherence held constant at 50%. Streak length was manipulated by varying the number of fixed-walk frames. Five speeds were tested (10, 5, 2.5, 1.25, 0.625°/sec) and three streak lengths (8, 4, 2 frames). At the faster speeds, direction discrimination thresholds were significantly lower for long streaks, but not below a critical speed of around 2°/sec, similar to Geisler's estimated "streak threshold" of one dot width per 100ms. Experiment 2: Contrast thresholds for detecting coherent motion were measured at each speed and streak length. We found no differences between streak lengths (and a U-shaped function of speed). Experiment 3: Direction discrimination was performed at 2*contrast threshold. The enhanced discrimination provided by long streaks was lost. We conclude that direction discrimination is improved by the presence of oriented "motion streaks". The loss of this advantage at low contrast probably reflects a weakened a streak signal, due to the shallow contrast response functions for P-pathway units compared to M-pathway. Different results were found using hard-edged dots, suggesting it is important to control spatial frequency spectra by using Gaussian or DOG elements. It is probable that natural scenes contain enough high spatial frequency information for streaks to be useful even at low speeds. The similar contrast thresholds across streak lengths suggest that streak information is not used in coherent motion detection.

A34 134 Effect of motion smear on perceived speed in low luminance

Maryam Vaziri Pashkam[1] (mvaziri@fas.harvard.edu), Patrick Cavanagh[1]; [1]Vision Sciences Laboratory, Department of Psychology, Harvard University

Surprisingly, perceived speed increases as luminance decreases (Vaziri-Pashkam & Cavanagh, VSS 2006; Thompson et al, Vision Research 2006). Here we propose that the visible trail that follows a moving object is the cue to speed that causes the overestimation at low luminance. Motion smear lengthens at higher speeds, hence its value as a cue to speed, but smear must also lengthen with increased persistence – as is found at low luminance (Di Lollo & Bischof, Psychological Bulletin 1995). To demonstrate this with a moving stimulus, we presented a dot on a rotating disc viewed in continuous light (incandescent DC source) at two difference luminance levels. Subjects increased the rotation speed of the disc until the dot appeared to trace out a continuous circle (Ptolemy, 150). As expected, the criterion speed was slower (indicating greater persistence) at the lower luminance. In the second experiment, the subjects matched the perceived speed of two computer generated, rotating dot patterns, one at high luminance (1000 cd/m2) and one at low (1 cd/m2), while fixating between the two. When the rotating dots had long lifetimes, the low luminance pattern appeared to move faster than the high luminance pattern. However, when the dots had short life times, the speed difference was greatly reduced. Decreasing the dot lifetime decreases the possible length of the motion smear (the persisting trace cannot be longer than the dot's path), removing this cue from the display. The results of these two experiments suggest a direct link between the amount of speed overestimation in dim light and the perceived motion smear.

A35 135 Speed perception across variations in spatiotemporal frequencies in apparent motion stimuli

Murthy Bhavaraju[1] (bvsm@cns.bu.edu), Ennio Mingolla[1]; [1]Department of Cognitive & Neural Systems, Boston University

Many pairs of spatial and temporal frequencies in a motion display that result in the same stimulus speed for a moving object can produce different speed percepts (Priebe NJ et al., J Neurosci. 2003, 23(13): 5650-61). We previously reported that judgments of the speed of an object depend on the spatiotemporal frequency of the moving pattern in an inverted-U function, peaking at a specific spatial and temporal frequency combination [http://www.journalofvision.org/4/8/84/]. The location of this peak is largely independent of the size and shape of the object. In the present series of experiments, with the use of high coherence dot motion stimuli, we investigated the dependence of perceived speed on both spatial and temporal frequencies. The perceived speed of the stimulus was estimated using a 2AFC paradigm with interleaved QUEST staircases; subjects were asked to pick the faster of the two spatially separated [6 deg eccentricity] patches of dots moving in opposite directions. We systematically varied the speed of the dots from 2 to 32 deg/sec such that there was an overlap of the spatial and temporal frequency components across trials with different speeds. Results indicate that observers are less sensitive to biases in speed estimation caused by variations of spatial frequency at moderate velocities than at the extremes. Also, as the actual speed increases, the stimulus that appears faster tends to move toward lower spatial and higher temporal frequencies. Moreover this shift is gradual over a range of speeds. These results are in line with speed and spatial frequency correlation of MT neuron responses (Priebe NJ et al., J Neurosci. 2004, 24(8): 1907-16) and predictions from multi-channel models of speed estimation, where larger cells with bigger receptive fields encode higher velocities (Chey J et al, Vision Res. 1998, 38(18): 2769-86).

Acknowledgement: Supported in part by the National Institutes of Health (NIH F32-DC006782) the National Science Foundation (NSF EIA-01-30851, NSF BCS-0235398, and NSF SBE-0354378) Office of Naval Research (ONR N00014-01-1-0624)

A36 136 **Frames of reference for perceiving motion direction in the human visual system**

Mario L. Ruiz-Ruiz[1] (mario.ruizruiz@mcgill.ca), Julio C. Martinez-Trujillo[1]; [1]Cognitive Neurophysiology Laboratory, Department of Physiology, Faculty of Medicine, McGill University, Montreal, Canada

The problem of reference frame coding for visual-to-motor transformations has been widely investigated using a variety of stationary stimuli and visuomotor tasks. Here we investigate the reference frame(s) for motion direction perception in human subjects. We recorded behavioral responses in 4 subjects while they performed a direction 'perception' + saccade (experiment 1) and a direction discrimination + key-press-2AFC (experiment 2) tasks. In experiment 1 a random dot pattern (RDP) moving in one of 10 possible directions (from 0° in steps of 10° to 90°) was presented to the subjects during 400ms. After stimulus offset, subjects rotated their heads 30° to the left around the anterior posterior axis and made a saccade in the perceived direction. When comparing to a control condition, in which the head remained stationary, we found that saccade trajectories, mean saccade landing positions and saccade directional errors were not affected by head rotations. In experiment 2 subjects compared the direction of two RDPs presented during 400ms each and separated by a 2000ms time interval. We obtained psychometric curves in two conditions, a) when subjects kept the head straight during the 2000ms interval, and b) when subjects rotated the head 300 to the left during that interval. We found that on average the curves point of subjective equality in the latter condition was slightly displaced in the direction of the head tilt (from -1.78° with the head straight to -2.76° with the head rotated). However, this displacement was considerably smaller than the one predicted by a head/eye-centered model of motion direction perception and much closer to the predictions of a body/space centered model. These results argue against the hypothesis that visual motion is encoded in a head/eye-centered frame of reference. On the other hand, they suggest that motion direction is encoded in a body/space-centered reference frame.

A37 137 **Transparent-motion detection requires bimodal population activity**

John A. Greenwood[1] (john.greenwood@anu.edu.au), Mark Edwards[1]; [1]School of Psychology, The Australian National University, Canberra, Australia

Transparent motion presents a major challenge for the motion-processing system, as multiple global directions must be detected within the same region of space. Some computational models have resolved this by extracting the perceived directions from multiple activity peaks across the global-motion population. However, recent electrophysiological evidence suggests that population activity becomes unimodal when the angular separation between component directions is below 90º (Treue et al., 2000). Were this the case, more complex operations would be required to detect transparency with acute angular separations. Alternately, the averaged population response may not reflect the specific activity used in transparent-motion detection, particularly if the visual system relies on a subset of detectors with narrow direction-tuning bandwidths. We thus sought to determine the population activity produced by near-threshold transparent-motion stimuli using psychophysical techniques. Following adaptation to transparent motion, population activity was assessed through the elevation of unidirectional detection thresholds for several test directions. Adaptation to suprathreshold and threshold-level angular separations produced a bimodal pattern of elevation in detection thresholds, with higher elevation for test stimuli moving in the component directions than the mean direction. These peaks were lost at subthreshold angular separations, with equivalent threshold elevation for detection of the mean and component directions. To quantify the height of these population activity peaks, transparent-motion adaptation was also compared with unidirectional adaptation at various coherence levels. With suprathreshold angular separations, threshold elevation for the component directions was equivalent to unidirectional adaptation with 50% coherence. Threshold elevation for subthreshold angular separations approached that produced by 100% coherent unidirectional motion. Thus, subthreshold angular separations produce population activity resembling unidirectional motion in both shape and magnitude. Together, this suggests that bimodality is an essential requirement for transparent-motion detection, with peaks determined by global-motion signal-to-noise processes.

Acknowledgement: Supported by an Australian Research Council grant (#S6505064).

A38 138 **The Development of Sensitivity to First- and Second-order Pattern versus Motion**

Vickie Armstrong[1] (armstrvl@mcmaster.ca), Terri Lewis[1], Daphne Maurer[1]; [1]McMaster University, Hamilton, Ontario, Canada

We measured sensitivity to first- and second-order pattern and motion in 5-, 7-, and 10-year-old children and in adults. Luminance (FO) and contrast (SO) were modulated over trials to measure the minimum modulation yielding 82% correct responses. We measured thresholds for four different conditions: the discrimination of the orientation (horizontal vs. vertical) of a stationary pattern and the discrimination of direction of motion (left vs. right) for three different combinations of temporal frequency (TF) and velocity (V): TF = 6 Hz, V=6 d/s; TF = 1.5 Hz, V = 6 d/s; TF = 1.5 Hz, V = 1.5 d/s. Adults and children (n=56/age grp) provided individual thresholds for one of the four conditions and for both types of stimuli (FO & SO). At all ages, observers were more sensitive to SO pattern than to SO motion, but showed the opposite for FO stimuli (ps<0.001). This suggests that information about pattern is necessary to discriminate the direction of SO but not FO motion, as would be expected if SO motion, but not FO motion, is processed using a feature tracking mechanism (Seiffert & Cavanagh, 1998). For SO stimuli, children achieved adult-like thresholds by 7 years of age for all four conditions. Surprisingly, for FO motion, their thresholds for pattern discrimination were not adult-like until 10 years of age and even at that age, they were still immature at discriminating the direction of motion in one condition: TF =1.5 Hz, V=6 d/s (p<0.001). The finding of earlier maturity for some conditions of SO than FO stimuli is consistent with recent findings in monkeys (Kiorpes, Gavlin, & El-Shamayleh, 2006).

A39 139 **Effects of Flicker on Perceived Object Velocity**

Michael Disch[1] (disch@socrates.berkeley.edu), Karen De Valois[2]; [1]Psychology, Holy Names University, [2]Psychology, University of California, Berkeley

Purpose: To examine perceived speed for objects which flicker as they move. Methods: Stimuli were luminance defined spots (0.45 deg, 30 cd/m2 time-averaged luminance) on a dark background. Test stimuli flickered and moved at a constant velocity. Chromatic conditions included isoluminant flicker along either the LM or S axes. Chromatic contrasts were 8%, 15.3%, and 80% for the L, M, and S cones respectively. Luminance flicker conditions included Michelson contrasts of 10.5%, 20%, 40%, and 80%. Angular velocity of test stimuli ranged from 4 deg/sec to 32 deg/sec at octave intervals. Test stimuli flickered at 2, 4, 8, or 16 Hz as square wave alternations. Comparison stimuli moved at a constant velocity without flickering. Subjects compared the forward speeds of translation of the two stimuli. An interleaved 2AFC staircase method determined the comparison stimulus speed that appeared to match the translational speed of the flickering spot. Direction of motion (left/right) and spatial position (upper/lower) of the two stimuli were randomized on each trial. Stimulus travel distance and starting location varied pseudorandomly. Results: Perceived speed was minimally affected by chromatic flicker. S axis flicker led to greater speed biases than did LM axis flicker, however, overestimations never exceeded 4%, and were generally lower or non-existent. Overestimation was maximal for slowly moving objects with low flicker rates and quickly moving objects with high flicker rates. Luminance flicker at 8 and 16 Hz produced small speed overestimations, no greater than 6%, for quickly moving objects in the 80% contrast condition only. Underestimation was not found. Conclusion: Object based flicker for a constantly visible object has small effects on perceived speed. The greatest bias was seen for quickly moving objects with high flicker rates. However, research we conducted previously found more substantial perceived speed biases for luminance defined objects whose visibility was spatially sampled.

Acknowledgement: Supported by grants from the National Science Foundation (IBN-01111059), the University of California Committee on Research, and the University of California Transportation Center.

A40 140 Time-to-passage judgments reflect naive physics: The cases of representational gravity and friction

Yuki Yamada[1] (yy@psycho.hes.kyushu-u.ac.jp), Mai Yamaguchi[1], Kayo Miura[1]; [1]Kyushu University

Naive physics is one's own implicit knowledge about a universal physical law. We measure the naive physics by introducing time-to-passage (TTP) paradigm. In the TTP task, observers were asked to estimate the time distance for a moving target to pass behind a pre-determined landmark. In Experiments 1 and 2, a circular target smoothly moved in a linear path and on the way, was gradually occluded by a static screen rectangle. Additionally, a luminance border parallel to the motion path was presented as a pictorial cue evoking a ground surface. Since the motion path was oblique (+45 or -45 deg) or horizontal, the target appeared as if it descended, ascended or translated on the ground. As a result, when the target always contacted the solid line, TTP was significantly shorter in the descending condition than in the ascending condition. On the other hand, when the target was slightly away from the border, no significant effect of the slope of the motion path on the TTP was obtained. Therefore, the effect depends on whether or not the target appeared to move on the ground. Next, in Experiment 3, a black line was drawn on a diameter of the target stimulus and expressed the spin of the target by the direction of its rotation. We employed three types of spin, forward, backward, and no spin. The results showed that only when the target attached on the ground the target with backward spin led larger TTP than that with forward spin and with no spin, and we concluded this effect was attributable to representational friction. Moreover, Experiment 4 suggested this friction effect was triggered not only by visual cues but also by auditory cues. Our findings revealed that TTP judgment can reflect motion impressions evoked by the naive physics, representational gravity and friction.

Acknowledgement: This study was supported by Japan Society for the Promotion of Science.

Perceptual Learning I

Author Presents: 5:45 - 7:15 pm

A41 141 Action video game playing alters early visual processing

Renjie Li[1] (rli@bcs.rochester.edu), Uri Polat[2], Daphne Bavelier[1]; [1]Brain and Cognitive Sciences, U. of Rochester, [2]Goldschleger Eye Research Institute, Tel Aviv University, Tel Hashomer

Our past work indicates that action video game playing alters visual attention. Here, we investigate whether action video game playing may also alter early visual processing.

The effects of action gaming on the organization of early vision were first tested by characterizing the dynamics of lateral interactions using the paradigm of Polat & Sagi (2006). Contrast detection of a central Gabor Patch (GP) flanked by lateral GPs was measured, as the timing between flankers and target was varied to separately assess forward and backward masking. Reduced masking was noted in gamers (VGPs), especially in the case of backward masking. The size of the masking effect varied as the orientation of the flankers shifted from collinear to orthogonal, indicating that the changes observed indeed arise from visual areas that are early enough in the visual hierarchy that orientation information still influences lateral interactions.

Changes in sensitivity of the visual system were then more directly assessed by comparing the contrast sensitivity function of VGPs and non-VGPs (GP for 60ms at spatial frequencies of 1,3,6,9,12 cycle/deg). VGPs showed higher contrast sensitivity than non-VGPs, especially at medium and high frequencies. Finally, the critical duration, or the exposure duration needed for contrast sensitivity to plateau, was found to be shorter in VGPs than non-VGPs. Together these studies indicate enhanced contrast sensitivity in VGPs.

The causal role of action game playing was established through a 50 hours training study. As predicted, the action game trained group showed reduced backward masking and shorter critical duration time than the control trained group. Hence, the very act of playing action video games improves visual sensitivity. This effect may be mediated through faster processing time of local mechanisms and/or faster excitatory lateral interactions after action gaming.

A42 142 Action videogame playing improves Bayesian inference for perceptual decision-making

C. Shawn Green[1,2,3] (csgreen@bcs.rochester.edu), Alexandre Pouget[1,2,3], Daphne Bavelier[1,2,3]; [1]Brain and Cognitive Sciences, [2]Center for Visual Sciences, [3]University of Rochester

Perhaps the most striking and consistently observed performance change that occurs as a result of video game experience is a dramatic reduction in reaction time. This result holds across a wide range of visual tasks, with on average, action game experience resulting in a 15% reduction in reaction time. Importantly, this reduction occurs without a concomitant reduction in accuracy. We propose that this effect is due to improved Bayesian inference for perceptual decision-making in gamers.

To test this idea, we used a motion direction task in which subjects accumulate evidence over time about the direction of motion of many simultaneously moving dots with the goal of making the proper decision for that particular sensory stimulus. Typically in this task subjects take less time to decide the direction of motion and do so more accurately when all the dots move in the same direction (high coherence) than when some of the dots move in different directions (low coherence). Reaction time and accuracy can therefore be modeled as reflecting the quality of the information that is accumulated until the subject makes a decision and executes a motor response.

Using such a motion coherence paradigm in combination with models developed by Palmer et al. (2005) and Ma et al. (2006), we show that the performance improvement following action game playing can be captured by more efficient integration of the sensory information on which the decision is based, or in other words a more faithful Bayesian inference step, along with a reduction in decision criteria. The same approach, applied to an auditory localization task, demonstrates that this enhancement generalizes beyond the visual modality. Together, these results suggest that action video game playing results in better Bayesian inference for perceptual decision-making.

A43 143 Multidimensional Visual Statistical Learning

Phillip Isola[1] (phillip.isola@yale.edu), Nicholas Turk-Browne[1], Brian Scholl[1]; [1]Department of Psychology, Yale University

Statistical relationships between objects in space and time are automatically extracted via visual statistical learning (VSL). Such processing has traditionally been thought to operate over visual objects, but visual input is also highly structured at the level of individual surface features. Here we studied VSL in temporal sequences of colored shapes, exploring how features are combined into objects. Observers were familiarized to sequences of colored shapes that appeared one at a time, with statistical regularities present in the order of repeated shape subsequences. In Experiment 1, half of these were bound-color subsequences, in which each shape was always presented in its own unique color; the other half were random-color subsequences, with colors randomly drawn upon each presentation from a different set of possible values. During a later test phase, observers repeatedly judged which of two shape subsequences -- now presented all in black -- was more familiar: one previously encountered during familiarization vs. a misordered foil subsequence constructed from the same shapes. Observers reliably chose the previously encountered subsequences for both bound-color and random-color conditions. Since each shape had been encountered equally often, this performance must reflect learning of the shapes' statistical ordering. Moreover, performance in these conditions did not differ, suggesting that the covariance between individual feature values did not affect the expression of VSL for black shapes. In Experiment 2, however, familiarization consisted of only bound-color subsequences, and performance at test with black shapes was significantly (and surprisingly) lower. Thus, color appears to have been more integral for the learned representations of the bound-color subsequences in Experiment 2 -- compared to those same subsequences in Experiment 1, which were encountered in the context of additional random-color subsequences. In sum, what determines the input to VSL is the diagnosticity of feature dimensions, not only of individual feature values.

URL: http://www.yale.edu/perception/

A44 144 Subliminal visual feature is learned better when spatially closer to attended task

Shigeaki Nishina[1] (nishina@bu.edu), Aaron Seitz[1], Mitsuo Kawato[2], Takeo Watanabe[1]; [1]Department of Psychology, Boston University, [2]ATR Computational Neuroscience Laboratories

It has been previously shown that task-irrelevant perceptual learning (TIPL) can occur for stimuli that are presented at a different spatial location from the attended task (Seitz and Watanabe, 2003). However, TIPL was found to be restricted to the same visual hemifield as that in which the attended task stimulus was presented (Nishina et al., VSS05). Here, we further investigated the spatial profile of the task-irrelevant learning around the attended location. During the training period, the participants performed an attentionally demanded letter identification task (rapid serial visual presentation, with SOA = 300 ms) presented at a single location, while subthreshold static Gabor patches with noise were presented at three different locations in the same visual hemifield. The orientations of the Gabor patches were temporally paired with the target or distractor letters in the letter task. The detection performance of Gabors was tested before and after a seven days of training in which a different stimulus was exposed at each location and orientation. The largest improvement was found for the Gabors presented in closest proximity to the letter task. The improvement was smaller at the intermediate location, and the smallest at the most distal location. Our data indicate that the learning of the unattended task-irrelevant visual feature strongly depends on the attended location, with a gradual attenuation according to the spatial distance between them. These results suggest that a learning signal that is spatially tuned to the attended task incidentally facilitates the learning of nearby-presented unattended visual features.

Acknowledgement: This research was supported by NSF BCS-0549036 and the National Institute of Information and Communications Technology (NICT).

A45 145 While V1 activity enhancement that occurs immediately after PL training is nullified due to consolidation, the performance enhancement sustains.

Yuko Yotsumoto[1,2] (yuko@nmr.mgh.harvard.edu), Takeo Watanabe[2], Yuka Sasaki[1]; [1]Martinos Center for Biomedical Imaging, Massachusetts General Hospital, [2]Boston University

Perceptual learning (PL) is a manifestation of neural plasticity and is known to last for months. Some studies have shown that PL increased activity in the human primary visual cortex (V1) shortly after the behavioral training. However, it is not clear how activity changes through/after the consolidation period. We measured BOLD activity at four different phases in 3 weeks of time course of PL. Six volunteers participated in a series of sessions with visual texture discrimination task (Karni & Sagi, 1991). In training sessions, the target texture was presented only at the upper left visual field and only behavioral performance was measured. In fMRI sessions, the target texture was presented either at the trained visual quadrant (trained condition) or at the untrained visual quadrant (control condition). Four fMRI sessions were scheduled (1) before the first training session (pre-training), (2) on the next day of the first training session (post-1), (3) on the next day of the 7th training session (post-2), and (4) approximately 2 weeks after the post-2 scan (post-3). We compared BOLD activity in V1 between the trained and control conditions. First, no significant difference between these conditions was found at the pre-training scan. Second, consistent with the previous studies, in the trained condition V1 activity was significantly higher at the earlier phase of PL (post-1 and post-2). However, to our surprise, while the behavioral performance sustained after post-2 scan, at post-3 scan, V1 activity decreased to the same level as in the pre-training sessions. The parietal region showed no significant difference in the time course, ruling out the possibility of attentional artifact. Our results suggest that the increased BOLD activity caused by PL is just a transient state of neural plasticity and that downscaling neural activity occurs with reorganization of visual cortex for consolidation of PL.

Acknowledgement: This study is funded by National Institutes of Health (R01 EY015980, R21 EY017737) to TW the ERATO Shimojo Implicit Brain Function Project to YS. MRI was supported by National Center for Research Resources P41RR14075, the Mental Illness and Neuroscience Discovery Institute, the Athinoula A. Martinos Center for Biomedical Imaging.

A46 146 Tracking changes in cortical responses as a function of perceptual practice

Michael Wenger[1] (mjw19@psu.edu), Christine Kapelewski[1], Justin Eroh[1]; [1]Psychology, The Pennsylvania State University

We have previously documented that reliable reductions in contrast detection thresholds (as a function of practice) are accompanied by reliable increases in false alarm rates. These increases in false alarm rates occur with and without the presence of trial-by-trial feedback, and also occur when observers practice the contrast detection task without the requirement of making explicit present/absent judgments. These patterns suggest a liberal shift in response criterion in perceptual learning. However, the lack of effects due to feedback call into question the extent to which these shifts reflect decisional ("top-down") influences in a form of learning that has typically been interpreted as reflecting changes at low levels of a feed-forward system. The present study examines the relative responsiveness of cortical regions (including V1-V2) to varying levels of contrast, before and after practice with a contrast detection task. A twelve-day protocol was used. On day 1, a multifocal visual evoked potential (mfVEP, Slotnick et al. 1999) procedure was used to localize neural regions responsive to contrast onsets at known retinal locations. On days 2-11, observers practiced the contrast detection task, using a 2I-2AFC staircase procedure, with stimuli presented at a single, invariant location throughout practice. On day 12, the mfVEP procedure was used, with variations in contrast at both trained and untrained locations, and in the presence of valid and invalid cues for spatial attention. The design allows examination of the responsiveness of low levels of the visual system, at trained and untrained locations, and in the presence and absence of directed spatial attention.

A47 147 The effect of age on perceptual learning of subthreshold stimuli

Rui Ni[1] (ruini@ucr.edu), Takeo Watanabe[2], George J. Andersen[1]; [1]Department of Psychology, University of California, Riverside, [2]Department of Psychology, Boston University

Previous studies have found that detection of near-threshold stimuli can be improved with training (perceptual learning) (Karni & Sagi, 1991, PNAS). The goal of the present study was to determine whether perceptual learning of near/sub-threshold stimuli can occur with older observers. In the present study, we used a commonly used texture discrimination task (TDT) to assess perceptual learning. On each trial, observers were presented with a target item embedded in noise for 100msec, followed by a blank interstimulus interval, followed by a mask display for 10msec. The threshold of interest was SOA between target and mask. 15 older (mean age of 73) and 9 younger (mean age of 23) subjects participated in the study. Each subject was run through four blocks of training on two consecutive days (a total of 1152 trials). To assess learning the SOA threshold (85% accuracy) was assessed using a BEST-PEST procedure at the beginning (pre-test) and end (post-test) of each day. The SOA used in the training sessions was the 60% accuracy level based on each subject's psychometric function. The results showed that significantly greater perceptual learning occurred for older as compared to younger subjects. The results from a group of control subjects (who were not presented subthreshold SOA conditions) indicated that the learning found for older subjects was not the result of repeatedly performing the discrimination task. These results suggest that perceptual learning can be used to improve perceptual performance of older subjects. The importance of these results to issues regarding the recovery of age-related declines in vision will be discussed.

Acknowledgement: This work was supported by NIH AG13419-06, NIH EY015980

A48 148 Sleep dependent learning in contour integration

Patricia Gerván[1] (pgervan@cogsci.bme.hu), Ilona Kovács[1]; [1]Department of Cognitive Science Budapest University of Technology and Economics

Aim. A large body of evidence supports the involvement of sleep dependent mechanisms in perceptual learning (Karni et al, 1994; Stickgold et al, 2000). However, sleep dependence has only been studied extensively in the texture discrimination paradigm. We have indicated earlier (Kozma & Kovacs, 2002) that improvement in a contour integration task might also depend on sleep, but our design did not make a clear distinction between time vs. sleep dependent learning. Here we clarify the role of sleep in the contour integration task.

Method. The contour integration task consisted of an egg-shaped, closed contour of Gabor patches on a background of randomly positioned and oriented Gabor patches. Subjects had to determine the direction where the egg-shape was pointing to at various levels of difficulty. 40 subjects practiced in the contour integration task over five 15 min sessions (240 trials/session) with 12 hours between sessions. We introduced a circadian phase shift between two groups of subjects. One group of subjects started the 1st session at 8 a.m. (Morning Group/MG), while the second group started at 8 p.m. on the same day (Evening Group/EG).

Result. By the 4th session (2 nights of sleep for EG subjects, and only 1 night of sleep for MG subjects), EG performance was significantly better than MG performance.

Conclusion. The 'circadian shift' design (see also Walker, 2002) allowed us to dissociate the impact of time vs. sleep on perceptual learning. We can now safely say that learning in the contour integration task is dependent on sleep.

Acknowledgement: Supported by OTKA NF60806 to IK.

A49 149 Covert attention strengthens, speeds and maintains perceptual learning

Anna Marie Giordano[1] (amg223@nyu.edu), Marisa Carrasco[1,2], Abby Rosenbaum[1]; [1]New York University, Department of Psychology, [2]New York University, Center for Neural Science

Goal: Covert attention improves discriminability and accelerates the rate of visual information processing (Carrasco & McElree, 2001). In a perceptual learning task in which observers trained with neutral and attention trials simultaneously, we observed that exogenous attention initially led to higher discriminability and faster processing. In addition to this benefit, attention showed stronger perceptual learning (Carrasco, Giordano & Looser, VSS). Here, we ask: Is perceptual learning enhanced when observers train in a new task with or without attention? To isolate and compare these effects we trained observers either in an attention or in a neutral condition and assessed the effects using a speed-accuracy trade-off (SAT) procedure.

Methods: Observers performed a conjunction (orientation x spatial frequency) discrimination task in which a cue preceded a target presented with 7 distracters at 8 isoeccentric locations. Half the observers were exposed to a neutral cue condition, which provided no information regarding the target location, whereas the other observers participated in the attention cue condition, which indicated the target location. A response tone prompted observers to respond after various lags (40–1500 ms). Observers completed 5 consecutive sessions (1/day), then completed 3 sessions of a transfer task in which the identity of the target and one of the distracters was switched. Finally, observers performed the original task for 2 more sessions (target and distracter were switched back).

Results & Conclusion: For both discriminability and processing speed, attention showed greater perceptual learning than the neutral condition in all stages: the initial original task, transfer task, and return-to-original task. When switching from original to transfer and then back to the original task, attention exhibits a reduced cost in temporal dynamics, and learning continues to increase in discriminability. These results indicate that attention strengthens, speeds and maintains the effects of perceptual learning.

Acknowledgement: NIH EY016200-01A2

A50 150 Can stimulus-induced affective states influence the rate of PL?

Noah Sulman[1] (sulman@mail.usf.edu), Thomas Sanocki[1]; [1]Department of Psychology, College of Arts and Sciences, University of South Florida

Perceptual learning (PL) has been characterized as improvements in perceptual ability as a function of experience. Based on evidence that negative stimuli can enhance perceptual processing in across a wide variety of domains, we sought to evaluate the possibility that observers primed with negative images would learn the acuity discrimination faster than subjects primed with control images.

The influence of emotion on PL was tested utilizing a primed PL paradigm. Observers were presented with a peripheral vernier stimulus over 350 trials with feedback on each trial. The magnitude of the offset was adjusted over the first 50 trials. Over the final 300 trials, 20 subjects were primed with photographs containing negatively valenced images, 20 were primed with neutral images, and 20 were primed with positively valenced images selected from the International Affective Picture System (Lang, Bradley, & Cuthbert 2005). Negatively and positively valenced primes were matched for arousal. Immediately following the prime, subjects were presented with a centrally presented character and peripherally presented acuity stimulus followed by a mask. Participants were instructed to indicate both the identity of the central character and the direction of the offset.

Relative to the initial unprimed 50 trials, performance declined when the picture primes were presented, and most so for negatively primed subjects.However, the observers primed with negative images demonstrated a faster rate of learning than observers in either of the other two prime conditions, eventually demonstrating higher accuracy than either of the other two control conditions. These results are consistent with the conclusion that negative stimuli can enhance perceptual processing in general.

Rivalry and Bi-stability I

Author Presents: 7:15 - 8:45 pm

A51 151 Attenuation of the pupillary response during interocular suppression

Eiji Kimura[1] (kimura@L.chiba-u.ac.jp), Satoru Abe[2], Ken Goryo[3]; [1]Department of Psychology, Faculty of Letters, Chiba University, [2]Graduate School of Humanities and Social Sciences, Chiba University, [3]Faculty of Human Development and Education, Kyoto Women's University

[Purpose] By presenting a high-contrast grating to one eye and a spatially homogeneous field to the other eye, stable interocular suppression can be produced (permanent suppression). The present study investigated the pupillary response to color and luminance changes during permanent suppression and explored a possibility that the pupillary response can be an objective probe of interocular suppression. [Methods] The pupillary response was recorded under both permanent- and no-suppression condition. Permanent suppression was produced by presenting a 3° high-contrast square-wave grating of 2 c/deg to the right eye. During continuous dominance of the grating, a 2.5° test flash was presented to the left eye. The test duration was 100 ms and the flash was ramped on and off over a 100-ms period to eliminate sharp transients. The test direction was defined in the DKL color space (Derrington et al., 1984). During the measurement, a 9.8° white background field of 4 cd/m2 was always presented to each eye. Under the no-suppression condition, the test flash was presented to the left eye while the background field was presented alone. [Results and Discussion] The pupillary responses to luminance as well as color changes were clearly attenuated during permanent suppression. The amount of attenuation was comparable to that determined psychophysically, but the attenuation was observed over a wider range of test contrast extending to well-above the threshold level. However, additional experiments revealed that, in contrast to psychophysical findings, the pupillary response was also attenuated in a similar fashion when the test flash was superimposed on the suppressing grating in the same eye. These findings suggest that the pupillary response can be used to evaluate the interocular suppression but the pupillary suppression would be mediated by a distinct visual mechanism such as the subcortical pupillomotor pathway where visual signals from two eyes are also converged.

Acknowledgement: Supported by JSPS grant

A52 152 Increase of perceived speed accompanying onset of interocular suppression

Tomas Knapen[1] (t.h.j.knapen@phys.uu.nl), Joel Pearson[2], Randolph Blake[2], Raymond van Ee[1]; [1]Physics of Man, Helmholtz institute, [2]Department of psychology, Vanderbilt University

While viewing binocular rivalry between two annular shaped rival targets -- a stationary concentric grating and a rotating, radial grating -- we noticed a novel, compelling illusion: during transitions from dominance to suppression of the radial grating, its perceived speed of rotation appeared to accelerate markedly. Intrigued by this transient illusion, we devised a matching procedure to measure the magnitude of perceived acceleration and used interocular flash suppression to control the onset of suppression of the radial grating.

Results from both experienced and naïve observers show that the magnitude of illusory acceleration increases with the contrast of the stationary pattern that suppresses the rotating radial grating. Acceleration was not experienced, however, when the contours of the radial grating were isoluminant. Nor was acceleration seen when the two dissimilar patterns were physically superimposed and viewed dioptically; interocular rival stimulation is essential to experience the illusion. By varying the duration of the interocular stimulation, we confirmed that illusory acceleration is associated with the transition from dominance to suppression, not with the state of suppression itself. Using an adaptation procedure we confirmed that illusory acceleration is not attributable to contrast or motion adaptation. Moreover, the reported acceleration is opposite to the effects of lowering the contrast of a moving stimulus, a maneuver that strongly decelerates perceived speed as we verified in a control experiment.

Motion perception, it is commonly thought, represents the culmination of neural activity arising in multiple cortical areas within the visual hierarchy. During normal viewing, that distributed activity is seamlessly coordinated, but the illusion described here implies that the onset of interocular suppression can temporarily disrupt that coordination.

Acknowledgement: This work was supported by NIH grant EY13358

A53 153 Sequential dependency in percept durations for binocular rivalry

Loes van Dam[1] (l.c.j.vandam@phys.uu.nl), Rene Mulder[1], Andre Noest[1], Jan Brascamp[1], Bert van den Berg[1], Raymond van Ee[1]; [1]Helmholtz Institute, Utrecht University

When the two eyes are presented with different images, perception cycles through a sequence of dominance durations for either image: binocular rivalry. Generally, the dominance durations are assumed to be sequentially independent. However, a moderate but consistently positive sequential dependency of up to 20% has been reported across studies that took the step to analyze sequential dependency. This dependency is not only consistently present but also consistently ignored for interpretation. Here we investigated this sequential dependency in dominance durations both experimentally and theoretically. We presented orthogonal gratings and subjects reported the experienced percept (taking the durations of mixed percepts into account). We found a positive sequential duration dependency consistent with existing literature, underscoring the reproducibility of this effect. Furthermore, we found, by varying the contrast of the gratings across trials, that this sequential dependency increased with increasing contrast of the gratings. Statistical data simulations showed that this correlation between stimulus content and sequential dependency do not naturally result from the decrease in average percept durations with increasing contrast. It is clear that the sequential dependency and its correlation with stimulus content provide important information on the mechanism underlying binocular rivalry. We found that our results are an emergent property of a neural model by our group (Noest et al, VSS 2006), originally designed to explain perceptual memory for interrupted ambiguous stimuli.

A54 154 Identical rivalry dynamics for monocular, stimulus and binocular rivalry

Jeroen J.A. van Boxtel[1] (j.j.a.vanboxtel@phys.uu.nl), Tomas Knapen[1], Raymond van Ee[1], Casper J. Erkelens[1]; [1]Helmholtz Institute, Utrecht University

Research on visual awareness often employs rivalrous stimuli. It remains unknown why rivalry manifests itself in various distinct ways. A widely supported view is that monocular rivalry, binocular rivalry and stimulus rivalry depend on different rivalry mechanisms, because their instigation depends on different temporal and spatial stimulus characteristics, and their evoked perceptual alternation dynamics are distinctly different.

We used orthogonal sine-wave gratings that were repetitively presented with a certain on- and off-period duration. To produce stimulus rivalry or monocular rivalry the patterns were swapped between or within the eyes, respectively, at each successive cycle. First we show that with these stimulus and monocular rivalry stimuli we could induce rivalry for spatial frequencies and contrast values that are generally thought to preclude rivalry.

We then looked into the perceptual dynamics. Generally, binocular rivalry is found to have rapid alternations of percepts, and short transition periods between two dominant percepts, whereas monocular rivalry has slow alternations and long transitions periods. We observed the same dynamics when presenting the stimuli without a blank: binocular rivalry showed average percept durations around 2 seconds, and monocular rivalry around 8 seconds. However, with relatively long blank periods and relatively short repetition cycles, the perceptual dynamics for stimulus rivalry and monocular rivalry are identical to those of binocular rivalry: transition periods between successive dominance periods are short, and perceptual alternations rapid (around 0.5/s). Our data—on both the dependence on spatial parameters, and on the perceptual dynamics of rivalry—strongly suggest a single mechanism underlying multiple types of grating rivalry.

A55 155 Aging and the depth of binocular rivalry suppression

J. Farley Norman[1] (Farley.Norman@wku.edu), Hideko F. Norman[1], Kristina Pattison[1], M. Jett Taylor[1], Katherine Goforth[1]; [1]Western Kentucky University

Two experiments were designed to examine the effect of aging upon the strength of binocular rivalry suppression. To initiate the onset of rivalry, orthogonally-oriented sine-wave luminance gratings were presented dichoptically to the observers' two eyes. The observers were then required to either discriminate the spatial location of a probe spot presented to the dominant or suppressed eye's view or to detect the presence or absence of the probe. The observers in the younger and older age groups exhibited typical rivalry suppression for both tasks (i.e., the probe was more difficult to detect or discriminate when presented to the suppressed eye), but the magnitude of the suppression was significantly larger in the older observers. This increased suppression that accompanies aging can be explained by a reduction in the inhibition produced by the binocular matching circuitry of the Lehky and Blake (1991) model.

A56 156 Predicting the spatial origin of a dominance wave in binocular rivalry

Chris Paffen[1] (c.paffen@fss.uu.nl), Marnix Naber[1], Frans Verstraten[1]; [1]Helmholtz Institute, Experimental Psychology, Universiteit Utrecht

During binocular rivalry, incompatible images compete for perceptual dominance. The alternation between dominant percepts generally occurs gradually: the suppressed image gradually 'washes in' and becomes the dominant percept (also dubbed a traveling or dominance wave). Here we investigate what determines at what location the suppressed image starts washing in.

We used a concentric and a radial grating to initiate binocular rivalry. In experiment 1, we varied the contrast within the radial grating (between 20 and 80%), keeping that of the concentric grating constant at 50%. In experiment 2, we varied the spatial frequency within the radial grating (between .75 and 3 cpd, or between 3 and 12 cpd), keeping that of the concentric grating constant at the mean frequency of the radial grating. Observers indicated at what part of the stimulus the suppressed grating started becoming perceptually dominant.

In experiment 1, a perceptual alternation was most likely to start at the location where the contrast of the suppressed grating was higher than that of the dominant grating. In experiment 2, a perceptual alternation was most likely to start at the location where the spatial frequency of the suppressed grating was lower than that of the dominant grating. The results indicate that the spatial origin of a perceptual alternation is related to stimulus strength, but not necessarily to sensitivity: if the local strength of the suppressed grating is higher than that of the dominant one – because of a higher contrast – the probability of a perceptual alternation is increased at that location. For stimuli defined by spatial frequency, the probability of a perceptual alternation is highest at the location where the frequency of the suppressed grating is lowest, not where sensitivity to spatial frequency is highest (which, for our observers, was around 3 cpd).

A57 157 Perceptual and mnemonic contents of mental imagery revealed by binocular rivalry

Joel Pearson[1,2] (Joel.pearson@vanderbilt.edu), Colin Clifford[2], Frank Tong[1]; [1]Department of Psychology, Vanderbilt Vision Research Center, Vanderbilt University, [2]School of Psychology, The University of Sydney

Mental imagery refers to people's ability to reconstruct perceptual experiences from memory. Controversy surrounds whether imagery relies on the same sensory representations as perception. Here, we report a collection of experiments in which we utilized binocular rivalry as a tool to reveal the perceptual and mnemonic contents of mental imagery. Observers were either shown or instructed to imagine one of two oriented patterns, several seconds prior to the presentation of an ambiguous rivalry display consisting of both competing patterns. The presentation of low luminance patterns strongly biased the perception of subsequent rivalry displays, in favor of the previously seen pattern. Remarkably, mental imagery of a specific pattern led to equally potent bias effects. Further experiments revealed that the effects of both imagery and perception were highly orientation-specific, with bias effects showing peak tuning for matching orientations. Longer periods of mental imagery led to progressively stronger bias effects, mimicking the effects of prolonged viewing of a physical pattern. These bias effects were observed even when subjects had to perform an intervening visual task prior to presentation of the rivalry display, which required attending to rapidly presented letters at central fixation. This suggests that prolonged mental imagery leads to the build-up of a short-term trace, which can endure for brief periods when observers are engaged in other tasks. Other experiments indicated that the top-down effects of imagery could be distinguished from manipulations of visual attention. Our results suggest that imagery mimics the effects of direct visual stimulation, leading to the formation of a short-term sensory trace lasting several seconds. This sensory trace can strongly bias an observer's future perceptual state under ambiguous conditions. It appears that top-down endogenous phenomena such as imagery can alter the balance of neural competition in binocular rivalry, commonly thought to transpire in early visual areas.

Acknowledgement: Research support: NEI R01-EY14202 to FT and Discovery Project Grant CC.

A58 158 Temporal frequency and contrast tagging bias the type of competition in interocular switch rivalry

Michael Silver[1,2] (masilver@berkeley.edu), Nikos Logothetis[1]; [1]Max Planck Institute for Biological Cybernetics, Spemannstrasse 38, 72076 Tübingen, Germany, [2]School of Optometry and Helen Wills Neuroscience Institute, University of California, Berkeley

The nature of competition underlying perceptual alternations in binocular rivalry remains controversial. Interocular switching (IOS) of orthogonal gratings at a rate of 3 Hz can result in slow irregular perceptual alternations that persist over multiple stimulus switches (Logothetis et al., 1996). That is, subjects experience periods of perception of a particular orientation and phenomenal suppression of the other orientation, even though both orientations are presented to both eyes during each of these periods of stable perception. This result argues against competition based on eye-of-origin signals for IOS rivalry and is more consistent with competition between stimulus representations. However, changes to low-level stimulus features such as contrast, spatial frequency, and/or interocular switch rates in IOS rivalry can generate a different percept in which the perceived orientation changes with every stimulus switch (Lee and Blake, 1999). Because this fast regular alternation is identical to the stimulus sequence presented to a single eye, the underlying competition has been postulated to be between the two monocular pathways. We have employed temporal frequency and contrast tagging to label either eye-of-origin or stimulus orientation in IOS rivalry between orthogonal gratings. The relative amounts of fast regular and slow irregular perceptual alternations were measured for human observers using a subjective rating scale. Tagging of eye-of-origin enhanced fast regular alternations (characteristic of eye rivalry), while orientation tagging enhanced slow irregular alternations (characteristic of stimulus rivalry). These results suggest that when the visual system is presented with two different perceptual ambiguities (interocular and orientation incompatibility), additional information in the stimuli biases the type of perceptual alternation. The results are consistent with a model in which the brain combines information across multiple visual features to resolve ambiguities in visual inputs.

A59 159 The speed and spreading of binocular rivalry dominance from boundary contours

Yong Su[1] (y0su0002@louisville.edu), Teng Leng Ooi[2], Zijiang J. He[1]; [1]University of Louisville, [2]Pennsylvania College of Optometry

The visual system endows an image region that owns the boundary contour as the modal/occluding surface, and in binocular rivalry, such a region tends to dominate over another with a weaker boundary contour. In this study, we investigated the proposal that the process of representing the dominant surface begins and spreads from its boundary contours. We used a rivalry stimulus with a common vertical grating in both half-images, and an additional quasi-rectangular area (3 lateral widths: 1.50, 2.00, 2.66deg) with horizontal grating placed in the center of the vertical grating background in one half-image (SF=4cpd; contrast=29.1%; luminance=40.3cd/m2). Since the monocular area with the horizontal grating surface owns the boundary contours, it tends to dominate almost continuously. To test the prediction that the global dominance of the horizontal grating is reached by the spreading of the horizontal grating surface from the monocular boundary contours at both (vertical) sides of the quasi-rectangle, we varied the rivalry display duration (30-500msec) for each rectangular width. Confirming the prediction, at short duration (<250msec), the

Friday Posters

observer perceived the horizontal grating pattern at the right and left sides of the quasi-rectangular area, with the central area having no horizontal grating (filled instead with vertical grating, piecemeal, and/or checkerboard percepts). As the stimulus duration increased, the horizontal grating percept increased from both ends of the quasi-rectangle, indicating a spread toward the center. To measure the spread of the horizontal grating surface, observers rated the relative size of the center of the quasi-rectangle (gap) that had no horizontal grating percept. We found that the reported gap size decreased as the stimulus duration increased up to approximately 250msec. From these data, we estimated the average spreading speed of the horizontal grating surface from the two ends of the quasi-rectangle, i.e., from the monocular boundary contours, to be about 1.5-3 deg/sec.

Acknowledgement: Supported by a grant from NIH (R01 EY 015804)

A60 160 Illusory boundary contours affect binocular rivalry and depth perception

Eric Van Bogaert[1] (vanbogaert.eric@gmail.com), Teng Leng Ooi[2], Zijiang J. He[1]; [1]University of Louisville, [2]Pennsylvania College of Optometry

An image with boundary contours defined by abutting gratings has precedence in the competition for dominance in binocular rivalry (Ooi & He, 2006). Do illusory contours behave similarly, as well as obey the occlusion constraint in binocular rivalry? To answer this, we manipulated the pattern and shape of the inducing elements (pac-men) of the illusory Kanizsa-square. The left-eye's half-image consisted of two discs on the left side and two aligned pac-men on the right side (forming a vertical illusory contour). The right-eye's half-image consisted of two pac-men on the left side (also forming a vertical illusory contour) and two discs on the right side. The four elements in each half-image spatially corresponded, and were filled with 135deg grating. These elements were placed against a 45deg grating background. (The grating orientation was counterbalanced in the experiment.) When fused, observers experienced a strong predominance (>80%) of perceiving a 45deg grating-square in front of four discs (135deg grating), with the perceived depth of the square increasing with the horizontal widths of the pac-men. This percept is remarkable, considering that when viewed in isolation from the context of the Kanizsa display, a 135deg grating disc versus a 45deg grating segment (quadrant of the pac-man) ordinarily induces strong rivalry alternations. Supporting the notion that the strong dominance is caused by the vertical illusory contours (formed by the vertically aligned pac-men), observers experienced strong rivalry alternations when the two pac-men in each half-image were placed diagonally (eliminating each monocular illusory contour). Furthermore, strong rivalry alternations were experienced when the two half-images were exchanged between eyes, and when the pac-men in each half-image were relocated to form horizontal illusory contours. Altogether, our findings indicate that vertical illusory contours can act as occluding boundary contours (to partially occlude the discs) in resolving binocular correspondence and assigning 3D depth.

Acknowledgement: Supported by a grant from NIH (R01 EY 015804)

A61 161 The roles of boundary contour and stimulus onset asynchrony in triggering binocular rivalry alternation

Jingping Xu[1] (j0xu0007@louisville.edu), Zijiang J. He[1], Teng Leng Ooi[2]; [1]University of Louisville, [2]Pennsylvania College of Optometry

The perceptual alternation of binocular rivalry is often experienced as a relatively abrupt change from one dominant percept to another. This switch in dominance could be caused by either a sudden change, or a gradual change, in the relative signal strength between the two eyes. In the latter, the signal strength changes gradually until it reaches a threshold that triggers the perceptual switch. To psychophysically test the sudden change hypothesis vs. gradual change hypothesis, we capitalized on a rivalry display (Ooi & He, 2006) where an image having the monocular boundary contour (MBC) has prolonged dominance duration. In the experiment, the MBC display consisted of a 1deg monocular vertical grating disk in the center of a 7.5x7.5deg binocular horizontal grating background (SF=5cpd; contrast=86%). At a predetermined stimulus onset asynchrony (SOA=0.15-4.5sec) following the onset of the MBC display, a horizontal grating disk whose spatial phase was shifted (22-72deg) relative to the larger horizontal grating background was introduced into the horizontal-grating-only half-image (suppressed eye), at a location corresponding to that of the vertical grating disk in the dominant eye. We found that when the spatial phase shift (i.e., the boundary contour) of the horizontal grating disk was sufficiently large, it disrupted the continued dominance of the vertical grating disk. To reveal the "latency-to-alternation", we measured observers' reaction times to experiencing the change in percept from vertical to either horizontal or piecemeal/checkerboard. We found: (i) The larger the spatial phase shift of the horizontal grating disk (yielding a stronger boundary contour), the faster it was to suppress the vertical grating disk (shorter reaction time); (ii) For SOA durations between 0.15-1sec, the reaction times reduced significantly with increasing SOA. This finding supports the prediction of the gradual change hypothesis, and reveals the interplay between boundary contour strength and SOA in triggering binocular rivalry alternation.

Acknowledgement: Supported by a grant from NIH (R01 EY 015804)

A62 162 Staying Focussed: The function ofsuppression during binocular rivalry?

Thomas Wallis[1] (t.wallis@psy.uq.edu.au), Derek Arnold[1]; [1]School of Psychology, The University of Queensland

A central issue in contemporary binocular rivalry literature concerns whether suppression is driven by selections of a particular stimulus or by information from a specific eye. We propose an alternative - that suppression is controlled by an independent process which facilitates visibility near the point of fixation. This predicts that suppression should be governed by cues signalling distance from fixation, even when suppression is unambiguously related to a particular stimulus rather than to a specific eye. To explore this possibility, we used two presentation styles: classical rivalry, in which different images were shown to either eye for a period of 30 seconds, and stimulus rivalry, in which images were flickered (20 Hz) and swapped between the eyes (2 Hz). During stimulus rivalry suppression is evidently related to stimulus selections as average periods of exclusive perceptual dominance exceed the durations for which images are shown to either eye. We manipulated image blur across trials, such that as one image became progressively blurred the other became better focussed. For both classical and stimulus rivalry, focused images were persistently experienced whereas relatively blurred images were suppressed. Alternating dominance, for approximately equal periods, tended only to occur when images were equally focussed (e.g. both focussed or both blurred). Our data showed a smooth transition from the near total suppression to the near complete perceptual dominance of an image as blur difference changed – suggesting that blur is influential even when there is little or no blur difference. Image blur was found to be a stronger suppression determinant than either luminance contrast or colour. Our findings suggest that optics can determine suppression selectivity, even during stimulus rivalry. This is consistent with our proposal that suppression, during binocular rivalry, is an evolutionary adaptation which facilitates visibility near the point of fixation.

A63 163 Binocular rivalry and head-worn displays

Marc Winterbottom[1] (marc.winterbottom@mesa.afmc.af.mil), Robert Patterson[2], Byron Pierce[1]; [1]Air Force Research Laboratory, [2]Washington State University

When wearing a monocular head-worn display (HWD), such as in an Air Force simulation and training environment, one eye views the HWD symbology while both eyes view a simulated out-the-window (OTW) scene. This may create interocular differences in image characteristics that could disrupt binocular vision by provoking visual suppression (i.e., binocular rivalry), thus reducing visibility of the OTW scene, monocular symbology, or both. However, binocular fusion of the OTW scene may mitigate against the occurrence of visual suppression, a hypothesis that was investigated in this study. Across two experiments the effects of optic flow rate and target contrast on visual suppression were also investigated. For each experiment, observers viewed a simulated OTW scene and HWD symbology while performing a target recognition task under three viewing conditions. In a partial-fusion condition, observers viewed the OTW scene with both eyes and the symbology with only one eye. In a no-fusion (dichoptic) condition, observers viewed the OTW scene and symbology with different eyes. In a full-fusion control condition, both the OTW scene and symbology were viewed with both eyes. Elevation in duration threshold for a briefly-presented target served as a measure of suppression. The results revealed that, compared to the full-fusion condition, thresholds were elevated for the partial-fusion condition, but to a lesser extent than the no-fusion condition. Increasing target contrast produced less suppression while increasing optic flow rate produced greater suppression. We conclude that under conditions that simulate a semi-transparent monocular HWD, binocular rivalry is present.

Acknowledgement: This work was supported by U.S. Air Force contract FA8650-05-D6502 to Link Simulation and Training (a division of L3 Communications Corp.).

A64 164 Processing of Fearful Faces Outside of Awareness

Eunice Yang[1] (eunice.yang@vanderbilt.edu), David Zald[1], Randolph Blake[1]; [1]Psychology Department, Vanderbilt University

Being able rapidly to register the presence of potentially threatening objects or events is obviously highly adaptive. It is no surprise, therefore, that sensory processing of affectively charged stimuli can occur automatically and, at least initially, outside of conscious awareness (Wiens, 2006). Results from neuroimaging studies and from lesion studies implicate amygdala responsivity to fearful faces in the absence of awareness (Pasley et al., 2004; Williams et al., 2004, Jiang & He, 2006). Intrigued by those observations, we have investigated whether fearful faces rendered invisible by continuous flash suppression (CFS: Tsuchiya et al, JOV, 2006) emerge from suppression into awareness more quickly than do pictures of faces with neutral or happy expressions. With the aid of a mirror stereoscope, naïve observers (n = 7) dichoptically viewed dissimilar images displayed on the two halves of a calibrated video monitor. On each trial, one eye initially viewed a high contrast CFS display (dynamic Mondrian), and on most but not all trials the other eye viewed a face image ramped up in contrast to a fixed value (thereby avoiding abrupt transients). The contrast of the CFS target then gradually decreased until the observers indicated by button press the detection of the face; if no face was seen, observers withheld their response. Reaction times for detecting fearful faces were reliably shorter than those for detecting neutral faces, happy faces or inverted fearful faces (thus ruling out low-level features as the salient quality of the fearful faces); false alarm rate (response on trials when no face was presented) was negligible. These results point to some degree of processing of the affective content of a visual image presented outside of awareness. We are now exploring the involvement of limbic structures in this processing by administering this task to patients with amygdala damage.

Acknowledgement: Supported by NIH EY1335

3D Perception: Cue Integration

Author Presents: 7:15 - 8:45 pm

A65 165 Newly recruited cue trades against pre-existing cues during the construction of visual appearance

Qi Haijiang[2] (haijiang@seas.upenn.edu), Benjamin Backus[1]; [1]Psychology Department, University of Pennsylvania, [2]Bioengineering Department, University of Pennsylvania

During visual perception multiple relevant cues are often combined together as in a weighted average. Recent cue recruitment experiments show that the visual system can be conditioned to use artificial visual cues in perceiving a bistable stimulus (Haijiang et al., 2006). Is the newly recruited cue treated as an independent source of information even in presence of the trusted cues that were used to train it? Specifically, we conducted an experiment in which a newly recruited cue (stimulus location) and a pre-existing cue (binocular disparity) were put into conflict: they favored opposite directions in resolving the ambiguity of a rotating Necker Cube. The data demonstrate that both the new cue and the pre-existing one contribute, simultaneously, to the perceived 3D rotation direction. This result suggests the visual system uses the newly recruited cue in a fashion similar to a pre-existing cue, treating it as an independent source of information despite correlation was maintained during training. We also show that the new position cue was based primarily on retinal position, so early visual areas may mediate its effect.

A66 166 Bayesian model of cue combination for ambiguous stimuli

Benjamin Backus[1,2] (backus@psych.upenn.edu); [1]Department of Psychology, University of Pennsylvania, [2]Institute for Neurological Sciences, University of Pennsylvania

Perceptually ambiguous stimuli have the property that observers can accurately report how they look, which makes them useful for studying the construction of visual percepts (appearance, qualia, or "how things look"). Recent work on cue recruitment (Haijiang et al., 2006) makes clear the need for theory to quantify the effectiveness of factors that influence a dichotomous perceptual decision. Here we propose a simple Bayesian model for dichotomous perceptual decisions in the tradition of Brunswik's probabilistic functionalism and Savage's personalistic view of probability: the Mixture of Bernoulli Experts or MBE model. The MBE equation describes the system's reliance on each factor as being equivalent to having observed a certain number trials in a binomial experiment. Biasing factors include a noise term, an overall bias (the prior), and a term for each cue. The MBE equation distinguishes between the system's reliance on a given expert and the expert's estimate of the Bernoulli probability. If this distinction is not made, then the equation simplifies to a form that resembles a log odds decomposition or the linear weighting of evidence. Previous work supports such a model: several cues can exert independent effects that bias the apparent direction of rotation of a Necker Cube (Dosher, Sperling and Wurst, 1986). MBE provides a method for measuring the effectiveness of cues in the special situation where the perceptual system makes a probabilistic choice between exactly two representations. MBE is not a model to explain bistability. Instead, it presupposes bistability. MBE is model only for the effects that weak cues have on the appearance of a stimulus, causing it to appear in one or the other of its two possible forms.

Acknowledgement: R01 EY 013988 and the Human Frontier Science Program

URL: http://psych.upenn.edu/backuslab

A67 167 Visuo-haptic adaptation: the role of relative reliability

Johannes Burge[1] (jburge@berkeley.edu), Ahna R. Girshick[1], Martin S. Banks[1,2,3]; [1]Vision Science Program, UC Berkeley, [2]Psychology, UC Berkeley, [3]Helen Wills Neuroscience Program, UC Berkeley

When two estimators capable of measuring the same environmental property are put into constant conflict, recalibration occurs and the apparent conflict is reduced. The prevailing wisdom in the adaptation literature is that vision is the 'gold standard'; i.e. the non-visual estimator changes to match vision. However, recent theoretical models suggest that both estimators should adapt by amounts and at rates determined by their relative reliability. Related findings have been made in the cue-combination literature- i.e. 'visual capture' has been rejected in favor of a Bayesian probabilistic approach (Ernst & Banks, 2002; see Girshick, Burge, and Banks, VSS07). We examined visuo-haptic adaptation by manipulating the reliability of visually and haptically specified stimuli. The stimulus was a 3D hinge specified visually by random-dot stereograms and haptically by PHANToM force-feedback devices. The task was to indicate whether the hinge angle was greater than or less than 90 degrees. In a pre-adaptation phase we first measured uni-modal (vision-alone and haptic-alone) percepts. Then, in the adaptation phase we exposed subjects to a visuo-haptic conflict for an extended period. Finally, in a post-adaptation phase we measured uni-modal percepts again. Adaptation was assessed by comparing uni-modal percepts in the pre and post-adaptation phases. We found a role for relative reliability in adaptation, a result suggesting that traditional thinking should be re-examined.

Acknowledgement: AOF William C. Ezell Fellowship

A68 168 Bayesian cue combination: coupling of disparity-texture information compared to coupling of visual-haptic information

Ahna R. Girshick[1] (ahna@berkeley.edu), Johannes Burge[1], Martin S. Banks[1,2,3]; [1]Vision Science Program, UC Berkeley, [2]Psychology, UC Berkeley, [3]Helen Wills Neuroscience, UC Berkeley

The combination of sensory cues is statistically optimal in several cases (Ernst & Banks, 2002; Alais & Burr, 2004) in the sense of reducing the variance of the resulting combined percept. Previously, these studies have assumed that sensory estimates are combined fully into a unified percept and access to single-cue estimates is lost. Here we examine a more general Bayesian view of cue combination, in which a "coupling prior" (Ernst, 2005) can probabilistically characterize both the potential for optimal improvements in perceptual accuracy as well as the possibility of partial cue combination. The variance of the coupling prior for two cues is presumably determined by their natural co-variation statistics and their degree of consistency over time. As the variance of the coupling between two cues increases, there should be greater access to single-cue information, less improvement in discriminability, and a faster rate of adaptation (see Burge, Girshick, Banks, VSS2007). We tested the first two predictions for each of two situations: disparity and texture slant cues and visual and haptic size cues. In one experiment, observers matched a two-cue conflict stimulus to a single-cue stimulus. We varied the single-cue reliability and the conflict magnitude between the cues. This allowed us to determine the extent to which the two cues were combined into a unified percept and thereby to estimate the variance of the coupling prior. In another experiment, we measured discrimination thresholds as observers matched a two-cue conflict stimulus to a two-cue, no-conflict stimulus under similar conditions. The extent of improvement in thresholds also yields a constraint on the coupling prior variance estimate. The results of both experiments suggested that the variance of the coupling prior is smaller for disparity and texture slant than for visual and haptic size.

Acknowledgement: NIH RO1 EY012851, AOF William C. Ezell Fellowship for JB

A69 169 Grasping for cues: Visual cue integration for object manipulation

Hal S. Greenwald[1] (hgreenwald@bcs.rochester.edu), David C. Knill[1]; [1]Center for Visual Science, University of Rochester

Purpose. We measured the separate influences of monocular and binocular cues on planning and executing arm movements aimed at picking up an object. Method. Subjects viewed a large coin (7 cm diameter, 0.95 cm thickness) that was suspended in a virtual environment binocularly under central fixation. A robot arm positioned an unseen physical coin so that it was co-aligned with the virtual coin in the workspace. The coin's slant (orientation in depth) varied randomly across trials, and we introduced cue conflicts of 0-10° between the monocular cues (contour and texture) and binocular information (disparity) that defined the coin's orientation either at the beginning of each trial or following a mask that appeared upon movement initiation to prevent subjects from becoming aware of changes. Subjects reached for and picked up the real coin by the edges and from the side using a precision grip, and we optically tracked the positions of each subject's thumb and index finger throughout each trial. We used the vector between these fingers as an indicator of the subject's estimate of the coin's orientation. No visual feedback about the positions of the fingers was available until the fingertips made contact with the coin. Results. Subjects were very accurate about how they positioned their fingers to pick up the coin since the mean orientation of the vector between the fingers typically matched the orientation of the coin with a standard deviation of 3-4° on cue-consistent, unperturbed trials. As in a previous study involving object placement (Greenwald et al., 2005), binocular information dominated the execution phase of the movements (the normalized binocular weight was 0.6-0.7). Conclusion. The cue weights we measured during this grasping task were similar to those found for object placement, suggesting that our previous findings generalize to other visuomotor tasks.

A70 170 Manual control is effective in disambiguating in kinetic depth effect

Masahiro Ishii[1] (ishii@eng.u-toyama.ac.jp), Masaaki Todo[1], Kazuya Yamashita[1]; [1]Graduate School of Innovative Life Science, University of Toyama

A 3D object such as plural points distributed in 3D space appears flat when rear projected onto a translucent screen. Its 3D shape becomes apparent when it is rotated about an axis parallel to the screen. The effect is called kinetic depth effect (KDE). With parallel projection, depth information is given by the relative motion of the points but perspective information is not present. Without perspective, the relative depth of points can be perceived but not their depth order. It is impossible to tell which is the front and which is the back of the objects. The 3D object is ambiguous with respect to its reflection in the plane of the projection. As a result the object periodically appears to reverse in depth as well as direction of rotation. The sign of depth in a motion parallax display produced by parallel projection, however, is unambiguous when the motion of the display is coupled to side-to-side self-produced motion of the observer's head. Proprioceptive and vestibular information produced by self-motion is effective in disambiguating the depth structure. This study investigated if observers' manual control of the stimulus change removes ambiguity of KDE. In the experiment, the stimulus change could be controlled by the rotation of a computer trackball that the observer manually rotates rightward or leftward. As the result, manual control could remove the ambiguity in a part of our subjects: the perceived direction of rotation from KDE united the manual control. Prolonged viewing, however, made reverse the perceived direction of rotation. We measured duration from the beginning of stimulus change (i.e. rotation) until reverse. The mean duration in the case of manual control is almost equal to that of conventional KDE. Manual control had no effect in the rest of our subject. They always perceived unidirectional rotation from conventional KDE.

A71 171 Joint effects of height-in-the-picture-plane and distance-relative-to-the-horizon in pictorial depth perception

Jonathan Gardner[1] (jonathansgardner@gmail.com), Stephen Palmer[1]; [1]Psychology Department, University of California, Berkeley

Height in the picture plane (or height in the field) is known as a powerful and salient depth cue (Dunn, 1965). Rock (1975) found that the distance to the horizon also affects judgments of depth: objects that are located closer to the horizon line are seen as more distant. Height in the picture plane can work independently of distance to the horizon: the horizon itself can be placed at different heights in the frame, affecting the depth of objects, even if distance to the horizon is held constant. Additionally, distance to the horizon can vary if the horizon line changes but the object position in the frame stays the same. However, when the object is located on the ceiling plane, these two depth cues can be seen to conflict – an object on the ceiling plane may be high in the picture plane but far from the horizon. Using a 2AFC paradigm, we examined the depth cues of height in the picture plane and distance to the horizon to determine the way in which information from these depth cues is obtained and combined.

A72 172 Dynamics of Registered Convergence

Glen McCormack[1] (mccormackg@neco.edu), Tyler Lowe[1], Li Deng[1]; [1]Vision Science, New England College of Optometry

Purpose: This study tested whether registered convergence - the ability to sense convergence distance - has a temporal tuning function, and if so, whether that function changes when registered convergence interacts with the visual angle motion-in-depth cue.

Methods: Informed consent was obtained from fifteen normally binocular subjects prior to experimentation. Subjects fixated haploscopic luminous targets, in dark surrounds, oscillating in depth at frequencies of 0.06, 0.12, 0.25, and 0.5Hz at a mean distance of 33cm. Three targets manipulated registered vergence and visual angle: "harmonious" (a 25mm maltese cross with congruently changing visual angle and binocular disparity), "conflict" (a 25mm maltese cross of changing disparity but fixed visual angle), and "isolated" (a 0.7mm dot with changing binocular disparity). Perceived motion-in-depth was judged by continuous kinesthetic matching of the unseen hand to target distance. Convergence was measured by infrared oculography. Differences were analyzed by two-way ANOVA with repeated measures.

Results: "Isolated" responses were 47% of the size of "harmonious" responses ($p<0.001$) while "conflict" responses were 37% of the size of "isolated" responses ($p<0.001$). During isolated stimulation there was a 54% reduction of motion-in-depth perception at the 0.06Hz rate compared to the 0.25Hz rate ($p<0.005$). This low frequency loss of response was also evident in conflict stimulation ($p<0.005$), but cue conflict did not appear to alter the temporal tuning function. The rate effect was not significant in harmonious stimulation.

Conclusion: Registered convergence has a low frequency gain reduction which is most evident in isolated cue and cue conflict situations. These findings may help explain some of the differing conclusions drawn previously regarding the role of registered convergence in depth perception. The reduced low frequency response of registered convergence is consistent with the argument that registered convergence may be more useful for directing visually-guided behavior than supporting depth perception.

Acknowledgement: Supported by The New England College of Optometry research fund, and NEI Infrastructure Development Grant #R24 EY014817 (L. Deng)

A73 173 Curvature Contrast Occurs After Cue Combination

Katinka van der Kooij[1] (k.vanderkooij@fss.uu.nl), Susan te Pas[1]; [1]Experimental Psychology, Helmholtz Institute, Utrecht University

Introduction: The general lay out of a scene influences shape perception, as is shown in shape contrast effects where the perception of one shape is distorted in the direction opposite to another shape. So-called cue combination models describe the perception of 3-D shape accurately. Such models are based on the assumption that the overall shape estimate is a weighted linear combination of the estimates derived from the individual cues and explain shape contrast on the cue level, before cue integration. However, curvature contrast effects for motion-, shading-and-texture and stereoscopically defined stimuli are all of the same order and magnitude. This suggests that these contrast effects are shape-based, not cue-based. In this study we investigated whether curvature contrast effects are cue-based or shape-based.

Methods: In one condition, both central and flanking paraboloids were defined in stereo. In another condition the flankers were defined by structure-from-motion, whereas the central test paraboloid was defined in stereo. We varied the curvature difference between the flanker paraboloids in the reference and test interval. Observers had to decide which of the two intervals contained the central paraboloid with the highest curvature. In this way we could determine the curvature contrast effect in all conditions.

Results: We found a consistent contrast effect in the stereo-stereo condition, in the motion-stereo condition it varied in strength for individual observers. In addition, we found that half of the observers that performed normally on the stereo-stereo condition barely perceived stereo depth when the flanker shapes were defined by structure-from-motion. This might have been due to conflicting binocular flatness cues in the structure-from-motion defined flankers.

Conclusion: Curvature contrast effects are at least partly shape-based, however, in some cases strong cue-conflict seems to prevent influence from other cues.

Cortical Receptive Fields and Perception

Author Presents: 7:15 - 8:45 pm

A74 Abstract moved to Early Visual Processing: Receptive Fields

A75 175 Voltage-sensitive dye imaging of collinear patterns in the visual cortex of a behaving monkey

Elhanan Meirovithz[1] (elhanan.me@gmail.com), Yoram Bonneh[2], Uri Werner-Reiss[1], Inbal Ayzenshtat[1], Guy Saban[1], Hamutal Slovin[1]; [1]The Leslie and Susan Gonda (Goldschmied) Multidisciplinary Brain Research Center, Mina & Everard Goodman Faculty of Life Sciences, Bar Ilan University, Israel, [2]Neurobiology Dept. Weizmann Institute of Science, Rehovot Israel

Accumulating psychophysical and physiological evidence suggest the involvement of early visual areas in the process of visual integration and specifically in local facilitation of proximal and collinear stimuli. However, the physiological evidence is primarily based on single cell recording and much less is known about the population level processing. To investigate the early integration mechanisms at the population level, we performed voltage-sensitive dye imaging that is highly sensitive to subthreshold population activity, and imaged from the primary visual cortex (V1) and extrastriate cortex (V2) of a behaving monkey. The animal was trained on a simple fixation task while presented with collinear or non-collinear patterns of small gratings, Gabors or short oriented bars. Following the presentation of a single small visual stimulus (target), cortical response showed increased local activation at the corresponding retinotopic site over V1 area, as expected. The evoked response spread laterally over several mm within area V1. When the animal was presented with an additional high-contrast flanking visual stimulus, activation spread also to the gap between the corresponding patches of activation. Facilitation in terms of increased activity at the corresponding retinotopic site of the target as well as reduced latency of its response were observed for low contrast target bars, while almost no facilitation was observed for high contrast targets. The facilitation effect and its time course depended on the target flanker separation distance, suggesting the role of lateral spread of activity. Finally, the observed facilitation was smaller then the expected linear sum of the separate responses to the target and flanker at the target location. These results suggest that neuronal population activity in area V1 is involved in local visual integration processes, and specifically in the increased sensitivity for low-contrast visual stimuli surrounded by high contrast flankers.

A76 176 TimeCourse of Surround Suppression in V2 Neurons of Macaque Monkeys

Jianliang Tong[1] (jtong@optometry.uh.edu), Bin Zhang[1], Jianghe Zheng[1], Earl. L Smith III[1], Yuzo. M Chino[1]; [1]College of Optometry, University of Houston

In macaque V1, stimulation of the receptive field (RF) surround of a neuron strongly suppresses the responses initiated by stimulation of its classical RF (CRF). Although the exact nature of circuits responsible for surround suppression is still a matter of considerable debate, investigating the time course of surround suppression is a useful means to reveal underlying cortical circuits for suppression (Bair et al, 2003). The previous investigators found that latency of suppression depends on its strength. We previously reported that V2 neurons have similar center/surround organization but exhibit stronger surround suppression than V1 neurons (Zhang et al, 2005). In this study using dynamic center-surround stimuli similar to those developed by Bair et al (2003), we examined the time course of surround suppression in 180 V2 neurons and compared to that in 125 V1 neurons in order to determine whether latency of surround suppression is shorter in V2 than in V1 and also how the timing of center/surround responses are different between V1 and V2. We found that the relative latencies of surround suppression and release in V2 were not significantly different from those in V1, and that suppression latency in V2 was generally longer for those units with weaker surround suppression with some notable exceptions. This relationship between suppression latency and the strength of suppression was stronger in V2 than in V1. Other aspects of the timing of center/surround responses were remarkably similar between V1 and V2. These results suggest that circuits in V2 for surround suppression are likely to be similar to those in V1 except that the functional connections supporting surround suppression in V2 are functionally more robust than those in V1.

Acknowledgement: NIH Grant EY-08128 EY-03611 RR-07146

A77 177 Mature Transient Responses of V2 Neurons in 2-Week-Old Infant Monkeys

Bin Zhang[1] (binzhi@yahoo.com), jianghe Zheng[1], Earl Smith[1], Yuzo Chino[1]; [1]College of Optometry, University of Houston

Previous studies reported that the onset firing of V1 neurons during the first 150-200 msec of stationary stimulus presentation, carry as much information, if not more, as the sustained component (e.g., Muller et al, 2001). In this study, we investigated the normal maturation of response properties in V1 and V2 neurons by comparing the relative development of transient versus sustained components of cell's responses. In 13 infant and 4 adult anesthetized and paralyzed macaque monkeys, microelectrode recording methods were employed to examine the responses of V1 and V2 neurons to stationary sine wave gratings of high contrast (80%) optimized for orientation, spatial frequency and size. All receptive fields were located within 6° of the center of the fovea. At 2 weeks of age the transient components of neuronal responses in V1 and V2 to high-contrast, stationary gratings were as strong as in adults. However, the sustained responses of these neurons were abnormally suppressed or absent in infant monkeys largely due to robust contrast adaptation. Maximum detectability (d') in infant monkeys, achieved during the first 200 msec of stimulus presentation, was as strong as those in adult monkeys, while maximum detectability (d'), achieved during the last 100 msec of stimulus presentation, was significantly lower in 2-week-old infants than those in adults. As early as 2 weeks of age, most V1 and V2 neurons achieved maximum detectability (d') to high contrast stationary stimuli during the first 200 milliseconds stimulus presentation. These results suggest that neonates and young infants may perform better than previously thought for the visual tasks where prolonged fixation on targets is not required, but instead, the direction of saccades is used for detection of spatially simple, high contrast targets.

Acknowledgement: NIH Grant EY-08218, EY-03611, RR-07146

A78 178 The development of local connections in V1 and V2 of macaque monkeys

Peter Kaskan[1] (peter.m.kaskan@vanderbilt.edu), Mary Baldwin[1], Bin Zhang[2], Yuzo Chino[2], Jon Kaas[1]; [1]Department of Psychology, Vanderbilt University, Nashville TN, [2]College of Optometry, University of Houston, Houston, TX

Previously, we reported that the receptive-field (RF) center/surround organization of V1 and V2 neurons in macaques is immature during the first postnatal 8 weeks (Zhang et al, 2005). To gain insight into such functional immaturity, we examined the development of intrinsic and cortico-cortical connections in some of these infant monkeys. In 2-, 4- and 16-week-old infants and adults, we placed pressure injections of the tracers CTB and WGA-HRP along the posterior bank of the lunate sulcus. Following two to four days of transport, each animal was perfused. The brain was artificially flattened, cut, and stained for cytochrome oxidase (CO) or either tracer. CO sections were used to identify the V1/V2 border, stripe types, and blobs within V1. In some respects connection patterns were relatively mature even after two weeks of postnatal development. At two weeks, thin stripe injections showed strong connections with V1 blobs, thin stripes and other stripes in V2. Thick stripe injections did not preferentially label cells associated with blob or interblob regions. The label found within stripes was patchy at two weeks of age, as in older monkeys. V1 injections in two week old monkeys resulted in patches of labeled cells near the injection site. These connectional features were also observed in older monkeys. Thus, the presence of aspects of 'adult-like' connections at two weeks of age suggests that the basic pattern of intrinsic connections is present in V1 and V2 near birth. However, the RF surround mechanisms of V1 and V2 neurons are very immature at this age and adult-like responses emerge much later (Zhang et al, PNAS, 2005). The RF surround mechanisms of V2 (and V1) neurons likely depend more on the developmental elaboration of long-range horizontal connections, and/or the maturation of feedback connections from higher-order visual areas.

A79 179 Estimation of voxel receptive fields in human visual cortex using natural images

Kendrick Kay[1] (kendrick@post.harvard.edu), Thomas Naselaris[2], Jack Gallant[1,2]; [1]Department of Psychology, UC-Berkeley, [2]Program in Neuroscience, UC-Berkeley

A central goal of sensory neuroscience is to discover what stimulus features are represented by the visual system. Previous fMRI studies of this issue have been limited by signal averaging across entire visual areas (lack of precision) and by evaluating only a few stimulus conditions (lack of generality). We circumvented these problems by adopting a system identification approach. In brief, system identification provides a functional model (the 'receptive field') that describes how each voxel transforms visual stimuli into BOLD signals.

We recorded BOLD signals from human visual cortex (4 T, gradient-echo EPI, 2 × 2 × 2.5 mm, 1 Hz) during passive viewing of full-field, grayscale natural photos (~2000 distinct photos). We then estimated the receptive field (RF) of each voxel in terms of the Berkeley Wavelet Transform (BWT). The BWT expresses each RF in terms of wavelets that are tuned along several dimensions: position, orientation, spatial frequency, and phase. Each RF consists of a collection of excitatory wavelets (representing features that increase the BOLD signal) and suppressive wavelets (representing features that decrease the BOLD signal).

The RF of a typical voxel from area V1 consists of many excitatory wavelets that are confined to a small region of the visual field, and that span a broad range of orientations, spatial frequencies, and phases. This diversity is expected since each voxel pools the activities of many different neurons. The quality of the RFs was assessed by quantifying how well each RF predicted responses to novel photos. Predictive power is remarkably high in area V1 (median correlation between observed and predicted responses ~0.6). However, predictive power declines markedly in areas V2, V3, and V4. This decline likely reflects the fact that higher visual areas represent more complex features that are not described efficiently by the BWT.

Acknowledgement: NDSEG Fellowship, NIMH, and NEI.

A80 180 BOLD fMRI Response to Local Neural Inhibition

Jennifer F. Schumacher[1] (jfschumacher@gmail.com), Cheryl A. Olman[2]; [1]Department of Neuroscience, University of Minnesota, [2]Departments of Psychology and Radiology, University of Minnesota

Lateral inhibition is an important neural process for vision, however the BOLD fMRI response to this type of neural activity is not thoroughly understood. Primary visual cortex (V1) neural activity to a parafoveal target Gabor patch is inhibited when neighboring Gabor patches of the same orientation surround the target, while the activity is facilitated by Gabor patch flankers oriented perpendicular to the target Gabor patch. Psychophysical measurements confirm the inhibitory and facilitatory relationships between flanker and target via determination of contrast response functions inferred from the contrast discrimination thresholds. The inferred contrast response functions for target Gabor stimuli predict that local inhibitory processes decrease the V1 neural response to a 35% contrast target by approximately 30% when high contrast parallel flankers are present. The functional imaging data show that the 3T GE BOLD response to the targets is not reduced in the presence of parallel flankers. Furthermore, principal components analysis of the response to the target stimuli alone (with neither flanking nor facilitatory surround) reveals a heterogeneity in the hemodynamic response that has not been observed before. The close juxtaposition of target and flanker cortical representations presents a significant challenge for BOLD fMRI studies of contextual modulation. In this case, the hemodynamic responses to target and flanker stimuli overlap, and the failure of BOLD to accurately reflect local neural inhibition may simply be a consequence of hemodynamic blurring, rather than an indication of a more basic aspect of neuro-hemodynamic coupling. Further experiments at high field using perfusion and spin-echo fMRI will reveal whether, in the absence of hemodynamic blurring, the BOLD response is reduced by local neural inhibition.

Acknowledgement: NIH-NPCS Graduate Student Training Fellowship and Keck Foundation and BTRR P41 RR008079

A81 181 **Learning simple and complex cells-like receptive fields from natural images: a plausibility proof**

Timothée Masquelier[1] (timothee.masquelier@alum.mit.edu), Thomas Serre[2], Simon Thorpe[1], Tomaso Poggio[2]; [1]CERCO, UMR 5549, CNRS-Université Paul Sabatier Toulouse 3, [2]Dept. of Brain and Cognitive Sciences and McGovern Institute for Brain Research, MIT

The ventral stream of the primate's visual system, involved in object recognition, is mostly hierarchically organised. Along the hierarchy (from V1, to V2, V4, and IT) the complexity of the preferred stimulus of the neurons increases, while, at the same time, responses are more and more invariant to shift, scale, and finally viewpoint. Several feedforward networks have been proposed to model this hierarchy by alternating simple cells, which increase selectivity, with complex cells, which increase invariance (Fukushima 1980; Le Cun & Bengio 1998; Riesenhuber & Poggio 1999; Serre et al 2005). The issue of learning is perhaps the least well understood, and many authors use hard-wired connectivity and/or weight-sharing. Several algorithms have been proposed for complex cell learning based on a trace rule to exploit the temporal continuity of the world (for e.g., Foldiak 1991; Wallis & Rolls, 1997; Wiskott & Sejnowski, 2002; Einhaüser et al 2002; Spratling 2005), but very few can learn from natural cluttered image sequences.

Here we propose a new variant of the trace rule that only reinforces the synapses between the most active cells, and therefore can handle cluttered environments. The algorithm has so far been developed and tested through the level of V1-like simple and complex cells: we showed how Gabor-like simple cell selectivity could emerge from competitive hebbian learning, and how the modified trace rule allow the subsequent complex cells to pool over simple cells with the same preferred orientation, but with shifted receptive fields. Development of the V2, V4, and IT layers is ongoing.

A82 182 **Responses of single neurones in the middle temporal area (MT) to kinetic contours: implications for understanding the physiological basis of form cue invariance**

Leo Lui[1] (Leo.Lui@med.monash.edu.au), Anouska Dobiecki[1], James Bourne[1], Marcello Rosa[1]; [1]Department of Physiology, Monash University

In order to understand the physiological correlates of form-cue-invariance, we investigated the visual response properties of single neurones in area MT of marmosets anaesthetised with sufentanil (6mg.kg-1.hr-1) and nitrous oxide/ oxygen (7:3). The visual stimuli were bars of different lengths, directions of motion and speeds, presented against a background consisting of dynamic visual noise. Specifically, we compared the responses of MT cells to luminance-defined ("solid") bars, which were uniformly darker than the background, and kinetic ("camouflaged") bars, which were filled with the same noise pattern as the background, hence becoming visible only due to the coherent motion of its component elements. We found that the vast majority of MT cells (63/ 82, 77%) had cue-invariant responses, whereby the tuning curves for direction of motion were similar irrespective of the type of stimulus (solid or camouflaged). This contrasts with the smaller proportions (approximately 1/3) of cue-invariant units observed in caudal visual areas (V1 and V2). The responses of MT cells to camouflaged bars were typically as strong as those to solid bars of similar length, direction and speed. Moreover, while in V1 and V2 the responses to camouflaged bars were significantly delayed by relative to the responses to solid bars (by 30-40 ms), in MT we found a large population of cells that responded to the two classes of stimulus with similar time-courses. These results are compatible with the notion that cue-invariant responses involving luminance-defined and motion-defined figures emerge in "early" visual cortex as result of feedback interactions from MT, and perhaps other dorsal stream areas (JA Bourne et al., 2002, Cereb Cortex 12: 1132-1145).

Saturday Talk Sessions

Saturday, May 12, 2007

Perceptual Learning II

Saturday, May 12, 8:30 - 10:00 am, Hyatt Ballroom South
Moderator: Aaron Seitz

8:30 183 **A test of the sensorimotor theory of visual calibration**

Bruce Bridgeman[1] (bruceb@ucsc.edu); [1]Department of Psychology, University of California, Santa Cruz

Two theories define the relationship between sensory experience and perception of location. The doctrine of specific nerve energies relies on hard-wired, genetically specified relationships between stimulation and perception, modifiable only within limits by adaptation. In a newer sensorimotor account (O'Regan & Noë, BBS 2001), experience tunes the relationship between stimulation and perception and even the modality of experience. Vision for example is characterized by changes in input that correlate with eye and head movements, while audition requires change by head but not eye movements. Eye movements along a straight line result in no change in the retinal elements stimulated by the line, while movements along curved lines change the elements stimulated. Perception of pressure phosphenes can differentiate the two theories, because the phosphene appears at a location predicted by physiological optics and in a modality predicted by specific nerve energies. Moving a finger vertically along the eye's outer orbit while pressing on it through the lid during nasally directed gaze results in apparent motion of the phosphene out of phase with the finger, therefore contradicting information from motor efference to the finger, tactile sense at the fingertip, eyelid and bulb, joint receptors, and proprioception of muscles driving the finger. The contradiction between these observations and the sensorimotor account might occur because of limited time of the phosphene observation and simultantous contradictory information from the rest of the visual field. A test of the sensorimotor theory giving it every advantage had six observers in complete darkness moving their fingers along the eye, observing phosphenes for one hour and 2400 motion cycles; this extent of exposure is more than adequate for other sensory adjustments such as prism adaptation. The phosphene always obeyed the doctrine of specific nerve energies, and never adapted as the sensorimotor account predicts.

8:45 184 **Transfer (vs. specificity) following different amounts of perceptual learning in tasks differing in stimulus orientation and position.**

Pamela E. Jeter[1] (pjeter@uci.edu), Barbara Anne Dosher[1,2], Shiau-Hua Liu[1]; [1]Memory, Attention, and Perception (MAP) Laboratory, Dept. of Cognitive Sciences, University of California, Irvine, [2]Institute of Mathematical Behavioral Sciences, University of California, Irvine

Perceptual learning refers to the improvement in performance in perceptual tasks through learning or practice. Often, this learning is partially or wholly specific to stimulus features of the task, such as rotation of the stimulus or change of visual position. In this study, we investigated transfer (or conversely specificity) as a function of the extent of initial practice for tasks that differed in stimulus orientation and position. We chose to test a moderate-precision orientation discrimination task known to exhibit partial transfer (Jeter et al., VSS, 2004) so that the extent of transfer after different amounts of initial learning could be assessed. Subjects discriminated the orientation (clockwise or counter-clockwise of a base angle) of a peripheral Gabor in initial training (i.e., -35°±5° or 55°±5°) with locations such as the NW and SE positions and in a 90° rotated transfer task in the NE and SW positions. Discrimination was trained and tested in the presence and absence of white external noise. Staircase methods measured contrast thresholds as a function of practice. As expected, the results show improvements in initial performance for the transfer task following 4 blocks (2 days) and 8 blocks (4 days) of initial training compared to 0 (no) initial training. Initial training and training after transfer had approximately equal power function rates. Additional blocks of initial training yielded little improvement in the transfer task. These results were not consistent with a simple model in which each initial training block yielded a (fractional) benefit at transfer ($p < 0.001$), but may suggest saturating benefits with additional practice. These results are considered in the context of previous examples of perceptual learning in the literature.

Acknowledgement: Research supported by the National Eye Institute

9:00 185 **Effect of reward on perceptual learning**

Dongho Kim[1] (kimdh@bu.edu), Aaron Seitz[1], Takeo Watanabe[1]; [1]Department of Psychology, Boston University.

It has been proposed that visual cortical processing is improved for stimuli that are consistently paired with reinforcement, which might be a mechanism underlying perceptual learning (Seitz and Watanabe, Nature, 2003; TICS, 2005). To test this, we examined whether paring stimuli with a liquid reward (in humans) results in a sensitivity improvement to that stimulus. Using a classical conditioning paradigm, we presented every 500 msecs a different sinusoidal noise background that filled the display. At random intervals, a sinusoidal grating that was spatially masked by sinusoidal noise (20% signal; 2 c/deg; 2 deg diameter) and was presented for 500 msecs, superimposed on the noise background. For each subject, one of 112.5 deg or 22.5 deg grating was paired liquid-delivery (C+) and the other orientations was presented without reward (C-). Subjects were asked to restrain from eating or drinking for five hours previous to each experimental session. The liquid reward was provided 400 msecs after presentation of the grating pattern and thus partially overlapped with the grating presentation. Pre and post test was done before and after training to see the learning effect. In the tests, performance was evaluated for the C+ and C- orientations (112.5 deg or 22.5 deg). After the training significant sensitivity improvement occurred in low signal level (55.8% vs. 75.9% in 5% signal) in paired orientation with the reward, however no significant improvement in unpaired orientation (51.3% vs. 53.1% in 5% signal). The pre and post test result of D-prime (0.18 vs. 0.79) and beta (0.97 vs. 0.69) in paired orientation also showed that our result is not a response bias but perceptual learning. These results support the proposal that stimulus reinforcement pairing enhances visual cortical responses selectively for the paired stimulus in human.

Acknowledgement: This study is funded by National Institutes of Health (R21 EY017737), the Human Frontier Science Program Organization (RGP18/2004).

9:15 186 Brain activity related to consolidation of perceptual learning during sleep

Yuka Sasaki[1,2] (yuka@nmr.mgh.harvard.edu), Yuko Yotsumoto[1,4], Shinsuke Shimojo[2,3], Takeo Watanabe[4]; [1]Martinos Center, Massachusetts General Hospital, [2]ERATO , Shimojo Implicit Brain Function Project, [3]California Institute of technology, [4]Boston University

Recently, a large number of studies have suggested that sleep plays an important role in learning consolidation, although it is still controversial. In the present study, we examined consolidation–related brain activity during sleep after perceptual training. We measured brain activity in sleep for about an hour using simultaneous EEG and fMRI technique. First, subjects underwent the adaptation protocol in which they slept inside the MRI scanner with electrode attached so that they familiarized themselves to fall asleep inside the scanner. Then, we measured BOLD signals in the visual cortex before and after training of a texture discrimination task. Perceptual learning of this task is known to be locationally specific and may involve the primary visual cortex (V1) (Karni & Sagi, 1991). Stimulus targets were presented only in the upper left visual field. The post learning sleep session was conducted at the same night as the training. Relative BOLD changes in brain activity in both the trained and untrained regions in V1 during sleep compared to that in the wake period before the sleep onset were calculated. Sleep stages were determined by EEG signals using a standard method. Visual areas in each subject's brain had been localized in advance in a separate fMRI session. Results indicate that in the post learning sleep period, the relative brain change for the trained region in V1 was significantly different from the untrained region and for the trained region during the sleep before the learning. In addition, before the training, there was no significant difference between relative brain changes in the untrained and trained regions in V1. These results indicate that sleep consolidation process occurs in a highly localized circuit specific to the location of a trained stimulus.

Acknowledgement: This study is funded by National Institutes of Health (R01 EY015980, R21 EY017737), and National Science Foundation (BCS-0549036) to TW the ERATO Shimojo Implicit Brain Function Project to YS. MRI was supported by National Center for Research Resources P41RR14075, the Mental Illness and Neuroscience Discovery Institute, the Athinoula A. Martinos Center for Biomedical Imaging.

9:30 187 Location specificity in perceptual learning: A revisit

Cong Yu[1] (yucong@bnu.edu.cn), Stanley Klein[2], Dennis Levi[2]; [1]Institute of Cognitive Neuroscience and Learning, Beijing Normal University, [2]School of Optometry, UC Berkeley

Perceptual learning (PL) is specific to the practiced retinal location, a signature property in many PL tasks. We investigated this signature with a contrast discrimination learning task. Contrast learning for a V-Gabor in the lower-right quadrant (Lower-Loc) of the visual field was not transferred to the upper-right quadrant (Upper-Loc) for the same V-Gabor, replicating location specificity. However, simultaneous training of a V-Gabor in Lower-Loc and a H-Gabor in Upper-Loc greatly improved contrast discrimination of a V-Gabor in Upper-Loc. To separate the contributions of Lower-Loc V-Gabor training and Upper-Loc H-Gabor training, we conducted (a) Lower-Loc V-Gabor training followed by Upper-Loc H-Gabor training and (b) same training in a reversed order. In (a) initial Lower-Loc V-Gabor training had little effect on Upper-Loc V-Gabor discrimination, but later Upper-Loc H-Gabor training greatly improved Upper-Loc V-Gabor discrimination. In (b) initial Upper-Loc H-Gabor training also greatly improved Upper-Loc V-Gabor discrimination, but later Lower-Loc V-Gabor training further improved Upper-Loc V-Gabor discrimination. These data indicated that improved Upper-Loc V-Gabor discrimination mainly depended on training in the same retinal location, even with an orthogonal stimulus. However, after a location had been trained or sensitized, learning of the same stimulus in a different location could then be transferred to the sensitized location. A control experiment demonstrated that even simultaneous training of V-Gabor contrast discrimination in Lower-Loc and 45o-Gabor orientation discrimination, which was a completely different task, in Upper-Loc also greatly improved Upper-Loc V-Gabor contrast discrimination, indicating that training-induced location sensitization might be task unspecific. We conclude that PL might include a location-specific but stimulus-or-task-unspecific process, and a stimulus-specific but location-unspecific process. Contrast learning in the periphery is mainly determined by location specific training of probably any task. In a less degree it is also affected by location-unspecific stimulus training, provided that the target location has been sensitized.

9:45 188 Transient attention potentiates perceptual learning

Marisa Carrasco[1,2] (marisa.carrasco@nyu.edu), Anna Marie Giordano[1], Christine Looser[2]; [1]New York University, Department of Psychology, [2]New York University, Center for Neural Science

Goal: It is known that covert attention improves discriminability and accelerates the rate of visual information processing (Carrasco & McElree, 2001). In this study we used the speed-accuracy tradeoff (SAT) procedure to examine: (1) effects of perceptual learning in visual search, and (2) effects of transient attention on perceptual learning in visual search, by assessing discriminability and speed of information processing.

Methods: Naive observers performed a discrimination conjunction task (orientation x spatial frequency) in which either a peripheral cue, indicating the target location and onset, or a neutral cue, indicating only target onset, preceded the display. The target (2-cpd tilted Gabor) was presented amid distracters (4-cpd tilted and 2-cpd vertical Gabors), and appeared in one of 8 iso-eccentric locations. A response tone prompted observers to respond after various lags (40-1500 ms). To assess perceptual learning, at the end of 10 consecutive sessions (1/day), observers performed a transfer task in which the identity of the target and one type of distracter was switched (3-cpd tilted target among 2-cpd tilted and 3-cpd vertical Gabors).

Results & Conclusion: In both the neutral and attentional conditions, both discriminability and processing speed improved over time for visual search. This improvement was due to perceptual learning: In the transfer task, performance was impaired when compared to the initial performance levels in the original task. Exogenous attention leads to an initial benefit in discriminability and faster processing speed. Despite this initial advantage, over the course of experimental sessions, attention continues to improve performance more than the neutral condition. These findings suggest that observers' perceptual learning occurred because they processed the target preferentially while inhibiting the distracters, particularly in the attended condition.

Acknowledgement: NIH Ey016200-01A2

3D Perception

Saturday, May 12, 8:30 - 10:00 am, Hyatt Ballroom North
Moderator: Marc Ernst

8:30 189 Kinesthetic Feedback Helps Disambiguate 3D Structure-from-motion

Bo Hu[1] (bh@cs.rochester.edu), David Knill[1]; [1]Center for Visual Science, University of Rochester

Visual motion provides information about the 3D shapes of surfaces, but is confounded with information about the 3D movement of surfaces. We tested whether the brain uses kinesthetic information about object motion produced when actively manipulating objects to disambiguate 3D structure-from-motion. Five naïve subjects monocularly viewed computer-rendered folded cards through a 4-degree aperture. The virtual surfaces were covered with random dots and shown in a mirrored view of a computer monitor, making the virtual surface appear behind the mirror. In active conditions, subjects rotated the virtual surfaces themselves by rotating a rod mounted behind the mirror in the same location as the virtual surface. The rotation was fed back into the computer to generate the rotation of the surface. In passive conditions, subjects were shown movies of the rotating cards sampled from the recorded rotation sequences from their active sessions. Subjects viewed surfaces with different dihedral angles and were asked to judge whether the angle was greater or less than 90 degrees. We built a Bayesian model for estimating dihedral angle from visual motion information that was parameterized by known noise parameters on sensed velocity and acceleration and was supplemented by noisy kinesthetic feedback when available. Under passive viewing, the model has a large bias toward acute angles. The bias is reduced by kinesthetic feedback from active rotation. Kinesthetic feedback also significantly reduces the variance of the estimator. Consistent with these predictions, subjects showed significantly lower biases toward acute angles in the active conditions than in the passive conditions (by ~24 degrees). The std. deviations of their estimates, indicated by the slopes of their psychometric functions, were also significantly lower in active conditions than in passive conditions (average: 17 degrees vs. 28 degrees). The results provide strong evidence that humans use kinesthetic information to disambiguate 3D structure from visual motion.

8:45 190 Integration of alternating cues to slant

Massimiliano Di Luca[1] (max@brown.edu), Marc Ernst[1]; [1]Max Planck Institute for Biological Cybernetics

Several studies showed that cue integration is close to optimal when two or more cues are available simultaneously. However, most of these studies consider only constant cues. Here we investigate how different depth cues interact when they are not presented simultaneously but they are alternating. We ask whether there is fusion of cues in time and how the interaction between cues depends on the frequency of alternation.

To study this, we presented two surfaces in alternation at six different frequencies (from 0.8 to 15 Hz). One surface was defined by a random-dot pattern displayed in stereo (disparity-defined surface); the other was defined by a monocularly viewed regular texture (texture-defined surface). The angle between the two surfaces was always +20 or -20 degrees. Participants had to indicate whether the texture-defined surface was slanted to the left or to the right. The orientation of the two surfaces was varied jointly using a double staircase procedure to find the orientation at which the texture-defined surface appeared frontoparallel.

Results indicate that there is a significant interaction between the cues depending on frequency. That is, the orientation of the stimulus needed to see the texture-defined surface as frontoparallel depended on the sign of conflict and the frequency of alternation. At high frequencies (above 6 Hz) there was a perceptual bias of the texture-defined surface in the direction of the disparity-defined surface, indicating integration of the signals. At low frequency (0.8 Hz), however, this interaction did not only disappear, it reversed in the opposite direction, indicating a contrast effect. This contrast may be explained as an aftereffect resulting from adaptation to the disparity-cue slant. We conclude that simultaneity between cues is not necessary for integration to occur. There seems to be a temporal window for integration in the order of 150 ms.

Acknowledgement: EC project IMMERSENCE, IST-2006-027141

9:00 191 Does the visual system extract "keyframes" from dynamic object sequences?

Benjamin Balas[1] (bjbalas@mit.edu), Pawan Sinha[1]; [1]Department of Brain and Cognitive Sciences, MIT

In natural settings, we encounter complex 3-D objects as dynamic sequences resulting either from ego motion or object motion. How does the visual system represent object appearance following these dynamic experiences? Specifically, does it extract privileged or canonical views of an object from a dynamic sequence? This is a fundamental question that has implications not only for theories of object representation, but also for the broader issue of how our continuous experience of the visual world may be encoded in memory. We presented naïve observers with short image sequences depicting novel objects either rigidly rotating through space, or scrambled sequences that did not depict coherent motion. Following this brief exposure period, we measured response time and accuracy for old/new judgments of frames from the training sequence and novel distracter images. We report two main results. First, performance following the observation of coherent object motion is far superior to performance following random presentation. This is evident even when the same set of images is used following both coherent and scrambled sequences, indicating that target/distracter dissimilarity is not driving recognition judgments. Second, we find evidence that even after very little experience, certain object views from coherent sequences are correctly identified faster than others. These views might serve as "keyframes" for efficiently encoding the full spatiotemporal input. We compare our RT data to explicit ratings obtained for each view, and discuss various models by which keyframe position might be predicted from spatial and temporal factors. We conclude that locally canonical views are indeed determined from coherent dynamic experience and that explicit judgments of canonicity do not necessarily predict the results obtained from implicit measures.

Acknowledgement: National Defense Science and Engineering Graduate Fellowship

9:15 192 How long does it take to adjust a weight?

Marc Ernst[1] (marc.ernst@tuebingen.mpg.de), Massimiliano Di Luca[1], Divid Knill[2]; [1]Max Planck Institute for Biological Cybernetics, Tübingen, Germany, [2]University of Rochester, NY

Cue integration has been demonstrated to be close to optimal under temporally constant stimulus conditions. That is, cues are assigned different weights according to their relative reliabilities. In real-world situations, however, stimulus conditions constantly change. For example, depending on the viewing situation the reliability of cues may change over time. Here we ask whether the system takes such continuous changes in reliability into account by adjusting the cue weights online. Subjects were binocularly presented with a spinning disk slanted in depth. Thus one cue was disparity, the other motion. There was a ±30 deg conflict between the slants defined by the two cues. We varied the reliability of the motion cue by sinusoidally changing the speed of rotation at different frequencies (0.067, 0.1, 0.2 Hz). Decreasing the speed of rotation decreases the reliability of the motion cue. However, it does not affect the magnitude of slant specified by the motion cue. Subjects task was to continuously adjust the angle of a two-lines probe according to the perceived slant. We found that increasing the motion cue reliability with faster rotations biased perceived slant towards the slant defined by the motion cue. The surface was therefore perceived to oscillate in depth according to the modulation of speed. The oscillation amplitude decreased with higher modulation frequency. The phase shift between rotation modulation and perceived oscillation increased with frequency. As a control, we repeated the task in order to estimate subject's reaction time for adjusting the probe. In this control the slant of the surface was actually oscillating in depth. By subtracting the reaction time from the phase shifts obtained in the experimental conditions we estimated that the time it takes to update the weights is less then a second.

Acknowledgement: FP6 EC project ImmerSence (IST-2006-02714)

9:30 193 **Perceived curvature in depth: a test of cue combination models using motion and binocular disparity.**

Kevin J. MacKenzie[1] (kjmacken@yorku.ca), Richard F. Murray[1], Laurie M. Wilcox[1]; [1]Centre for Vision Research and Department of Psychology, York University

We elucidate two properties of the intersection of constraints (IC) model of depth cue combination (Domini et al., 2006, Vision Research, 46, 1707-1723). First we show that, like the modified weak fusion (MWF) model (Landy et al., 1995, Vision Research, 35, 389-412), IC combines depth cues in a weighted sum that maximizes the signal-to-noise ratio of the combined cue. Thus, IC is more similar to MWF than may at first appear. Second, we show that IC measures perceived depth in terms of just-noticeable differences (JND's), and hence predicts that the perceived depth difference between two stimuli is proportional to the number of JND's separating them, regardless of what combination of disparity and motion cues are in play. We tested this prediction.

Method We created two motion-defined random dot cylinders, mC and mE, with circular and elliptical cross-sections, respectively. We also created two disparity-defined random dot cylinders, dC and dE, and we measured points of subjective equality to match the perceived depth of dC to mC, and of dE to mE. Using a 2AFC method of constants design, we then measured depth JND's for motion-defined cylinders, using mC as a baseline, and calculated the number of JND's separating mC and mE. Similarly, we measured depth JND's for disparity-defined cylinders, using dC as a baseline, and calculated the number of JND's separating dC and dE.

Results The number of JND's separating mC and mE was significantly different from the number of JND's separating dC and dE, even though the the perceived depth difference between mC and mE was the same as that between dC and dE.

Conclusions The perceived depth difference between two stimuli is not proportional to the number of JND's separating them. This finding poses no challenge to MWF, but contradicts a key prediction of the IC model.

Acknowledgement: Natural Sciences and Engineering Council of Canada (LMW)

9:45 194 **3-D curvature aftereffects invariant to texture pattern**

Andrea Li[1] (Andrea.Li@qc.cuny.edu), Qasim Zaidi[2]; [1]Department of Psychology, Queens College, CUNY, [2]Department of Vision Sciences, SUNY College of Optometry

Are there neural mechanisms that are selective for 3-D curvatures, and are they invariant to the patterns that form the curvature? We test for such mechanisms by adapting to curvatures defined by plaids differing in spatial frequency by a factor of three. Gratings differing by frequency octaves do not raise contrast thresholds for each other, indicating that they are detected by independent mechanisms. Observers adapted monocularly to perspective images of carved, sinusoidal surfaces textured with horizontal-vertical plaids at either 2 or 6 cpd. Each adapting image spanned 1.5 cycles and was concave or convex at the central fixation. Shape aftereffects were measured using 1 flat, 4 concave, and 4 convex test images varying in amplitude between the concave and convex adapting stimuli, and textured with either the 2 or 6 cpd plaid. Observers were presented with a 2 minute initial adaptation, followed by 200 msec test images each preceded by a 5 second top-off adaptation. They were asked to judge the shape of the test as concave or convex. The perceived flat point was estimated as the curvature that was perceived as convex 50% of the time, and was extracted from psychometric fits. To examine frequency selectivity, we measured shape aftereffects with test stimuli of the same or different frequencies as the adaptation stimulus. Results from six observers show significant shape aftereffects: adapting to a convex surface causes a flat test to appear concave, and thus the perceived flat point is shifted to convex values, and vice versa for concave adaptation. Aftereffects were obtained in both within and across frequency conditions, but were larger for the within-frequency conditions. Pattern adaptation cannot account for aftereffects in the across frequency conditions. These results thus show that there are neural mechanisms selective for 3-D curvatures whose responses are invariant to the texture pattern.

Acknowledgement: NIH R01 EY13312 to Q. Zaidi and PSC-CUNY 60066-35 36 to A. Li.

Global Motion and Motion Integration

Saturday, May 12, 10:30 am - 12:15 pm, Hyatt Ballroom South
Moderator: Constance Royden

10:30 195 **Binocular integration of pattern motion signals by MT neurons and by human observers**

Chris Tailby[1] (ct@cns.nyu.edu), Najib Majaj[1], Tony Movshon[1]; [1]Center for Neural Science, New York University

When two moving gratings that differ only in orientation are superimposed, the resulting plaid is perceived as a coherently moving pattern. When the same two gratings are presented separately to either eye (a dichoptic plaid), the perceived direction of motion remains that perceived monocularly, even in the presence of binocular rivalry. In recordings from binocular neurons in MT of anesthetized macaque we measured direction-tuning curves for monocularly presented gratings, and for monoptic and dichoptic plaids (component gratings separated in orientation by 120°). We calculated a pattern index to quantify the degree of pattern selectivity for each plaid type. Pattern indices in each eye were strongly correlated in individual MT neurons ($r^2 = 0.66$, $n = 67$). In all cells the value of the pattern index decreased for dichoptic plaids. Of 18 cells classified as pattern selective with monoptic plaids, only 3 remained pattern selective using dichoptic plaids. We asked human subjects to identify the direction of motion of monocularly and dichoptically presented plaids, using similar stimulus conditions to the physiology. For monoptic plaids, histograms of the absolute angular separation ("delta dir") between the perceived and the pattern direction of motion were unimodal, clustered tightly around 0°. For dichoptic plaids the histogram of "delta dir" was bimodal, with a prominent peak near 0° and a smaller one near 60°: on average, subjects perceived the pattern direction of motion on ~70% of dichoptic trials. Thus, while the vast majority of cells in MT (including those cells that are monoptically pattern selective) show no evidence of pattern selectivity when stimulated with dichoptic plaids, the dominant motion percept evoked by dichoptic plaids is of pattern motion. We conclude that the perceptual experience of visual motion does not always correspond to the direction of motion signaled by individual neurons in MT.

10:45 196 **Motion opponency in area MT of the macaque is mostly monocular**

Najib J Majaj[1] (najib@cns.nyu.edu), Chris Tailby[1], J Anthony Movshon[1]; [1]Center for Neural Science, New York University

When added, two identical sinusoidal gratings moving in opposite directions appear as a single grating that is flickering in place with no net motion. This is taken as evidence for the existence of motion opponent mechanisms. Single neurons in MT are often inhibited by motion in the anti-preferred direction, indicative of motion opponency.

Most neurons in MT can be driven strongly through either eye. We wondered whether the motion opponency expressed so strongly under monocular conditions still occurs under dichoptic conditions. We recorded from MT neurons in anesthetized, paralyzed macaques. For each neuron, we measured the contrast response function to a preferred grating presented alone, and in the presence of a high contrast grating moving in the opposite direction. The two gratings were either presented in the same eye (monocular) or one to each eye (dichoptic). The anti-preferred stimulus caused the contrast response function to shift rightward on a log-contrast axis, with the effect being largest in the monocular condition. To characterize this effect we fit each contrast response function with a Naka-Rushton equation in order to identify the contrast at which the response of the neuron was half-maximum (c50). In the monocular condition, the anti-preferred grating increased the c50 by a factor of 4, in the dichoptic condition it increased the c50 by a factor of 1.5. Control experiments confirmed that this dichoptic effect represents genuine opponency and not just a dichoptically exerted contrast gain change.

This distinction between dichoptic and monocular motion opponency mirrors recent results obtained psychophysically (Gorea et al. 2001, Vision Res.). Taken together, the psychophysical and physiological results suggest that motion opponency is for the most part generated prior to binocular combination.

11:00 197 Both simple and choice reaction times reveal suppressive center-surround interactions in motion perception

Duje Tadin[1,2] (duje.tadin@vanderbilt.edu), Kristin K. Grdinovac[1], Bjorn P. Hubert-Wallander[1], Randolph Blake[1,2]; [1]Department of Psychology, Vanderbilt University, [2]Vanderbilt Vision Research Center

Increasing the size of a high-contrast moving object can make its motion substantially more difficult to perceive (Tadin et al., Nature, 424, 312-5, 2003). Based on converging lines of evidence, we attributed this counterintuitive finding to the involvement of motion-sensitive neurons with suppressive center-surround receptive fields. Here we used reaction times (RTs) to reveal the effects of center-surround interactions on neural processing speed of moving stimuli.

As expected, at low contrast (2.3%), RTs to a motion onset decreased as stimulus size increased from 2.4deg to 12deg. This was true for both simple (369ms to 306ms) and choice (439ms to 399ms) RTs. At high contrast (93%), however, as the stimulus size increased, choice RTs increased from 350ms to 384ms. Interestingly, increasing the size of a moving stimulus almost completely eliminates the well-established contrast-dependency of RTs. This paradoxical increase in RT, found in both naïve and experienced observers, is consistent with impaired motion processing resulting from surround suppression. Moreover, we found a parallel result for simple RTs; increasing the size of a high-contrast stimulus significantly increased simple RTs, a remarkably different result from simple RTs to stationary stimuli of varying size. Thus, even a task for which motion direction is irrelevant yields performance changes consistent with center-surround suppression. This same overall pattern of results was observed regardless of whether the motion stimulus abruptly appeared or if the stimulus was a stationary grating that abruptly moved.

These increases in both choice and simple RTs with increasing size extend the effect of center-surround interactions to the neural processing speed of motion. Additionally, we found that these effects were dependent on the predictability of the stimulus event evoking RTs, with a paradoxical RT improvement for large, unpredictable stimuli. This counterintuitive finding may reflect attentional modulation of center-surround interactions; a hypothesis that we are currently investigating.

11:15 198 Interaction of the On and Off pathways in motion processing with motion-defined-form signals.

Mark Edwards[1] (mark.edwards@anu.edu.au); [1]School of Psychology, Australian National University, Canberra, ACT, 0200, Australia.

The interaction of the On and Off pathways in motion processing with motion-defined-form (common-fate) signals was investigated. A modified version of the global dot-motion stimulus was used. Signal dot number was fixed at 4 and the number of noise dots was varied to establish the threshold S/N ratio required to determine the direction of the signal dots (up/down). The same dots remained signal dots over the 3-frame motion sequence and two spatial arrangements for them were used: a square pattern and a random pattern that changed from trial to trial. To minimise the possibility of attentional tracking of the signal dots, the first motion frame contained 12 distracter patterns, i.e. noise dots arranged into the same pattern as the signal dots. Three luminance-polarity conditions were used: 1) same polarity for all the dots; 2) mixed polarity for the signal and noise dots (half light, half dark); and 3) same polarity for the signal and mixed for the noise dots. In the same-polarity condition, performance for the square pattern was better than for the random pattern, e.g. threshold of 1.7% versus 5.3%. This advantage was lost when the polarity of the signal and noise dots were mixed. However, when only the noise dots had mixed polarity, performance for the square pattern was markedly better, 0.9%. To further rule out attentional tracking, the number of motion frames was reduced to two, and the same pattern of results was obtained. CONCLUSION: These results show that the On and Off pathways are kept separate in the motion processing of motion-defined-form signals. This is different to the situation with standard global-motion processing, in which they are pooled, suggesting that this form-based motion task is processed in a different area, possibly in the ventral pathway.

Acknowledgement: ARC grant S65050

11:30 199 Contrast and assimilation in visual motion processing for perception and smooth pursuit eye movements

Miriam Spering[1] (miriam.spering@psychol.uni-giessen.de), Karl R. Gegenfurtner[1]; [1]Experimental Psychology, Justus-Liebig University Giessen, Germany

In order to track an object of interest that moves across a dynamic visual context, motion signals from target and context have to be processed. Physiological and behavioral studies provide evidence for at least two different strategies for motion processing that are reflected in the neuronal or behavioral response: averaging absolute target and context motion signals (motion assimilation), or calculating relative motion between target and context (motion contrast). Here, we show that perceived velocity and pursuit velocity can follow different motion cues. Eye movements were recorded from seven naïve human observers to a medium contrast Gaussian dot that moved horizontally at 11.3 deg/s. A peripheral context, consisting of two vertically oriented sinusoidal gratings, one above and one below the stimulus trajectory, drifted into the same direction as the target at the same speed. During the steady-state phase of the pursuit eye movement, target and context moved continuously at 11.3 deg/s, or were independently perturbed for 250 ms to move slower (5.6, 8.5 deg/s) or faster (14.1, 16.9 deg/s). Observers were asked to smoothly track the target, and to indicate whether the target velocity had increased or decreased. In all observers, eye velocity transiently increased or decreased to the velocity vector average for an increase or decrease in context velocity, time-locked to perturbation onset. In contrast, psychophysical responses followed relative motion between target and context. When the context was perturbed to move slower, target velocity was overestimated, and when the context moved faster during perturbation, target velocity was underestimated. We conclude that motion signals are processed in different ways for perception and pursuit. In the presence of a moving context, perceived velocity is driven by relative motion, and pursuit velocity is driven by a motion average.

11:45 200 The effect of object speed and angle on the perceived rigidity of an optic flow field.

Constance Royden[1] (croyden@mathcs.holycross.edu), Michael Holloway[1]; [1]Department of Mathematics and Computer Science, College of the Holy Cross

When an observer moves straight through a stationary scene, the images of objects move in a radial pattern. One can detect a moving object in the scene if its image moves in a different direction from this pattern. However, a speed difference is ambiguous. It could be due to distance variation or to object motion. We examined how the angle or speed of object motion influences whether people perceive the scene as rigid or non-rigid. Observers viewed a 38x38 deg window within which a field of 500 random dots moved to simulate observer motion toward two transparent planes. The object consisted of a 10x10 deg square of 30 dots initially located 8 deg to the right of center. To test the effect of object angle we kept the object speed constant and varied the angle of object motion between 0 and 360

Saturday Talks

deg. To test speed, we kept the angle constant and varied the speed by a factor between 0.25 to 2.75 times the speed of dots in the nearest plane. Subjects indicated by a keypress whether the scene appeared rigid or non-rigid. Results for 5 observers show that perception of rigidity decreased from 90% rigid responses to 30% as the angle increased from 0 to 157.5 deg. Perceived rigidity rose slightly for an angle of 180 deg. Perception of rigidity also fell as the speed factor deviated from 1.0, although these displays were all consistent with a rigid interpretation, with the object placed at different distances from the observer. Speed factors of .25, 1.0 and 2.75 resulted in 38%, 98% and 4% rigid responses, respectively. Thus, in the absence of other cues, a moving observer may perceive an object located sufficiently closer or farther from the other items in the scene as a moving object.

Acknowledgement: Supported by NSF grant #IBN-0343825.

12:00 201 Disambiguation of optic flow with vestibular signals

Paul MacNeilage[1] (pogen@berkeley.edu), John Butler[2], Heinrich Buelthoff[2], Martin Banks[1]; [1]Vision Science Program, UC Berkeley, [2]Max Planck Institute for Biological Cybernetics

Optic flow is generated by observer motion relative to stationary objects, by movement of objects relative to a stationary observer, and by combinations of those situations. To determine the relative contributions of object and self motion to the observed optic flow, the nervous system can use vestibular signals. An object's speed relative to earth is given by the difference between its speed relative to the head and the head's speed relative to the earth. The variance of the difference is the sum of the component variances: ó2obj=ó2vis+ó2vest. In contrast, if observers estimate self-motion from optic flow and vestibular signals, and assume a stationary visual scene, visual and vestibular estimates may be combined in a weighted average to yield more precise self-motion estimates: ó2self=(ó2visó2vest)/(ó2vis+ó2vest). So depending on whether the subject reports object motion or self-motion, the two-modality variance is predicted to be respectively higher or lower than the component variances. To test these predictions, we measured speed-discrimination thresholds for fore-aft translations and roll rotations. There were two single-modality conditions, Visual and Vestibular, and two multi-modality conditions, Self-motion and Object-motion. In the Visual, Vestibular, and Self-motion conditions, observers indicated if the movement was faster or slower than a standard. In the Object-motion condition, observers indicated if the object appeared to move with or against the self-motion. Experiments were conducted on a rotating chair and translating motion platform. The stereoscopic projection system was mounted on the apparatus. Stimuli were random-dot planes that rotated clockwise or anti-clockwise or translated forwards or backwards. In the translation conditions, multi-modal object-motion thresholds were, as predicted, higher than single-modality thresholds, and multi-modal self-motion thresholds were, as predicted, generally lower than single-modality thresholds. Results from the rotation conditions were less clear. Possible causes of differing results for translations and rotations will be discussed.

Acknowledgement: NIH EY014194

The Many Functions of the Ventral Stream

Saturday, May 12, 10:30 am - 12:15 pm, Hyatt Ballroom North
Moderator: David Sheinberg

10:30 202 Neural Dynamics of Visual Scene Segmentation

Lawrence Appelbaum[1] (greg@duke.edu), Vladimir Vildavski[2], Mark Pettet[2], Alex Wade[2], Anthony Norcia[2]; [1]Duke University, Durham, NC 27708, [2]Smith-Kettlewell Eye Research Inst. San Francisco, CA, 94115

Visual scene segmentation represents one of the fundamental functions accomplished by the early visual system. Figure-ground assignment, object perception, and attentional allocation all rely upon the ability to rapidly and accurately segment the visual scene into coherent objects and their surrounds. Using synthetic images portraying simple texture-defined figures and an electrophysiological paradigm that allows us to separately monitor cortical responses to figure and background regions, as well as interactions between them, we found distinct neuronal networks responsible for the processing of each. Figure activity was distributed over a network of ventral stream visual areas including the lateral occipital cortex. A separate network, extending from primary visual cortex through the dorsal visual pathway was observed in response to the background region. The activated sites and temporal sequence of these networks was largely invariant with respect to the cues used to define the figure, did not depend on its spatial location or size, and were largely unaffected by attentional instructions. To evaluate border-specific activity, tagged stimuli were presented with figure and background regions composed of different one-dimensional textures such that the figure region remained segmented throughout the duration of the stimulus presentation. Reponses occurring at nonlinear interaction terms resulted in distinct source distributions relative to the figure or background region responses, indicating unique mechanisms that signal border discontinuities. These responses were greatly diminished when the figure region was constructed such that it was continuously segmented, as well as, by the introduction of gaps between the two regions. These non-linear interactions therefore reflect finely tuned pooling activity occurring at the region borders that is highly sensitive to the global segmentation state of the scene. Collectively, these data reflect unique aspects of the object processing hierarchy in which low-level features of the retinal image are abstracted forming the neural basis of visual scene segmentation.

Acknowledgement: EY014536, EY06579 and the Pacific Vision Foundation.

10:45 203 Object recognition in ventral temporal cortex is category-graded rather than specific: Neuropsychological evidence

Marlene Behrmann[1, 2] (behrmann@cnbc.cmu.edu), Stephanie Manchin[1]; [1]Department of Psychology, Carnegie Mellon University, [2]Department of Psychology, University of Toronto

The study of brain-behavior relations continues to be plagued by controversy regarding the extent to which localized and circumscribed brain regions are content-selective. On the one hand, much neuropsychological and neuroimaging data have argued for a narrow localization of cortical regions and have suggested that domain-specificity is a natural distinction in cortex. On the other hand, there is strong empirical support for the claim that the psychological and neural mechanisms are more general-purpose and that differences in processing certain stimulus classes emerge from differential experience and/or processing demands. To assess the selectivity of two brain regions, one responsive to faces (fusiform face area; FFA) and the other responsive to words (visual word form area; VWFA), we examined the visual performance of adults with profound deficits in either face (prosopagnosia) or word (pure alexia) recognition following lesions to the critical cortical area. Both populations completed several experiments designed to elucidate their ability to do perceptual discriminations between morphed faces and to match faces across vantage point. They also named and performed lexical decisions on words and letter strings. Although each group was maximally impaired in recognition of its own 'primary' stimulus class (prosopagnosics on faces and pure alexics on alphanumeric stimuli), both groups also showed a significant decrement, relative to controls, in the other domain too, although the deficit was not as severe as in the primary domain. Thus, a lesion to each area produces a graded rather than a binary outcome, indicating that neither face nor word regions are entirely content-selective. Rather, the data are compatible with an account in which cortical organization is graded and distributed, with words primarily, but not exclusively, represented in the left hemisphere (presumably to constrain proximity to language-related areas) and faces primarily, but not exclusively, represented in the right hemisphere.

Acknowledgement: This work is supported by a grant from NIH (MH54246) to MB.

11:00 204 **Cortical fMRI maps in response to 3D morphs between head and house.**

Roger B. H. Tootell[1, 2] (tootell@nmr.mgh.harvard.edu), Kathryn J. Devaney[1], Gheorghe M. Postelnicu[1], Leslie G. Ungerleider[2]; [1]Martinos Center for Biomedical Imaging, Charlestown, MA, [2]Laboratory for Brain and Cognition, NIMH, Bethesda MD

As in early visual cortex, accurate functional maps should clarify the fundamental information processing steps in inferotemporal (IT) cortex. Tanaka's group suggested that macaque IT is organized based on continuously-varying cortical columns, optimized for specific geometrical features (the 'feature map' hypothesis). More recently, human fMRI described larger IT areas responding selectively to specific objects (FFA and PPA for faces and places, respectively), general object categories (animate, tool), or expertise.

Different hypotheses predict correspondingly distinct fMRI maps in IT, in response to virtual 3D objects that were morphed systematically between two shape extremes. These extremes (head and house) were easily recognizable; the intermediate shapes were less (or un-) recognizable. All objects had identical lighting and surface reflectance; other properties (retinotopic extent, position and viewpoint) were equated wherever possible. FMRI data were acquired in response to selected shapes along the morph continuum, using extensive signal averaging. The response to each single shape was resolved independently ('single stimulus' imaging).

The feature map hypothesis predicts a continuous shift in the topography of cortical activity, as stimulus shapes changed along the morph continuum. In contrast, the FFA-PPA hypothesis predicts changes in response amplitude in each presumptive area, without any topographic shift. Preliminary results (n = 5) suggest that: 1) recognizable and unrecognizable shapes produce equivalent levels of fMRI activity throughout IT; 2) these virtual shapes (lacking surface reflectance variation) nevertheless activate FFA and PPA selectively, like real-life objects; 3) intermediate shapes may produce higher activity than either head or house, in specific cortical regions; 4) intermediate shapes produce systematic variations in fMRI amplitude in FFA and PPA - but no topographic shifts. Collectively, this evidence suggests that FFA and PPA are classical cortical areas, with differing functional selectivity. However the ultimate functional selectivity may only be approximated by 'faces' or 'places'.

11:15 205 **Joint object and motion selectivity in the temporal cortex**

Jedediah Singer[1] (Jedediah_Singer@brown.edu), David Sheinberg[1,2]; [1]Brain Science Program, Brown University, [2]Dept. of Neuroscience, Brown University

The dorsal and ventral streams of visual processing are known to be interconnected, but there has been surprisingly little investigation of how these systems interact on a cellular level. To explore this issue, we trained two monkeys to perform a discrimination task using animated, visually rich stimuli, and recorded from cells in inferior temporal cortex and the superior temporal sulcus while they performed this task. We presented the monkeys with eight rendered bipedal figures that could perform eight animated motions. The monkeys were required to respond according to the action being performed, regardless of the model's identity. Each action sequence lasted about 1.5 seconds, and started and ended with the same neutral pose. Learning curves indicated that the monkeys understood the task and were able to transfer their knowledge to new models performing the same actions. Using mutual information measures, we found that many of the recorded cells were selective with regard to which model was visible, while another large set of neurons conveyed information about the action being performed; these two sets had moderate overlap. Action-selective neural responses might arise from sensitivity to one or more the following: individual still images that form the action sequences, particular collections of images appearing within a short period of time, or the actions' trajectories. Model-selectivity did not increase after actions began, which suggests that selective responses to actions were not driven solely by single views. Further work is needed to determine whether and how much each mechanism contributes. We have shown that single temporal neurons can carry information about the visual objects that populate our world and about what they are doing.

Acknowledgement: James S. McDonnell Foundation and NIH R01-EY014681

11:30 206 **Decoding of ITC Cell Activity Closely Predicts Human Visual Similarity Judgments**

Ethan Meyers[1] (emeyers@mit.edu), Chou Hung[2], David Freedman[3], Earl Miller[1], Gabriel Kreiman[4]; [1]Department of Brain and Cognitive Sciences , MIT, [2]Institute of Neuroscience, National Yang Ming University, [3]Department of Neurobiology, Harvard Medical School, [4]Department of Ophthalmology, Harvard Medical School

Recent work has shown that the identity and category of a stimulus can be "read out" from the spiking activity of populations of neurons in monkey inferior temporal cortex (Hung, Kreiman, et al., 2005). Here we extend these decoding techniques to create a neural similarity score for visual objects. In particular, we train a linear support vector machine to discriminate between pairs of objects based on feature vectors that consist of the firing rates of 256 monkey ITC cells, and we define the similarity score to be the average classification accuracy over 100 bootstrap samples of the neurons. We compare these neural similarity scores to human judgments of similarity from a simple delayed match to sample discrimination task. Results show a high level of agreement between human similarity judgments and neural readout similarity, even though the neural readout results are only using a small fraction of the cells in ITC.

11:45 207 **Retinotopy versus category specificity throughout primate cerebral cortex**

Reza Rajimehr[1] (reza@nmr.mgh.harvard.edu), Wim Vanduffel[1], Roger Tootell[1]; [1]NMR Athinoula A. Martinos Center, Massachusetts General Hospital (MGH), Charlestown, MA

In initial stages of the visual hierarchy, stimuli are represented in point-to-point (retinotopic) maps. However at higher stages in the ventral stream, it has been proposed that the retinotopic map is converted into a category-selective cortical architecture (e.g. face representations in IT cortex of humans and macaques). To independently map and compare these two dimensions, we acquired fMRI from two awake monkeys and six human subjects, while presenting stimuli consisting of face- or place-based images, confined to retinotopically-specific apertures, during continuous central fixation. This common data was analyzed in two different ways: 1) based on category (faces vs. places), and 2) based on retinotopic location (e.g. foveal vs. peripheral stimuli). In macaques, the category comparison revealed face-selective regions in the posterior IT/STS, anterior IT, lateral parietal and inferior frontal cortex, consistent with previous studies. In human subjects, analogous face-selective regions were revealed in two major areas described previously: the fusiform gyrus (including FFA), and lateral occipital cortex (~V4d) - plus a smaller region in anterior temporal lobe, perhaps homologous to the anterior temporal face patch in macaques. The retinotopy analysis demonstrated a surprising degree of retinotopic organization in IT cortex. In both human and macaque subjects, each face-selective region typically contained subdivisions selective for either foveal or peripheral stimuli, or both. Retinotopic maps (polar and eccentricity) were also revealed in more than 20 additional areas in macaques, including frontal and parietal cortex, association cortex, and ventral occipital regions not described previously. The overall findings suggest a conjoined representation of object and space selectivity in the ventral pathway - not a 'pure' representation of object category.

12:00 208 **Increased Structural Connectivity in Grapheme-Color Synesthesia**

Romke Rouw[1] (r.rouw@uva.nl), Steven Scholte[1]; [1]Psychology Department, University of Amsterdam

We studied grapheme-color synesthetes, who experience particular colors while viewing particular graphemes (e.g. the A is red). While it is now clear that synesthesia is a genuine sensory phenomenon, no consensus exists on the cause of synesthetic experiences. Models diverge mainly on two issues. The first issue is whether anatomical brain differences exist between synesthetes as compared with non-synesthetes. For example, grapheme-color synesthesia may be caused by additional cross-connections between the visual word form area in inferior temporal cortex and the adjacently located color processing region. The second issue concerns the cognitive and neurological mechanisms involved in synesthesia. We studied 18 grapheme-color synesthetes by means of fMRI, questionnaires, and diffusion tensor imaging (DTI). DTI measurements showed increased diffusion anisotropy in synesthetes as compared with non-synesthetes. Increased anisotropic diffusion indicates more coherent white matter structures. This finding validates for the first time the hypothesis that differences in brain structure differentiate synesthetes from non-synesthetes. Of particular interest is a cluster of increased anisotropy in inferior temporal cortex. Synesthetes, as compared with non-synesthetes, also show increased brain activation in inferior temporal cortex while viewing graphemes that elicit synesthetic color. Next, individual differences in grapheme-color synesthesia were studied. In particular, a different cognitive and neurological architecture might underlie the degree to which the synesthetic color is experienced in the outside world ('projectors') as compared with seeing the synesthetic color in the mind's eye only ('associators'). Indeed, we found differences in brain activation and brain structure between these subtypes of grapheme-color synesthesia. Importantly, increased connectivity in inferior temporal cortex is particularly strong for grapheme-color synesthetes who see synesthetic color in the outside world. In conclusion, we found evidence that increased structural connectivity is associated with the presence of grapheme-color synesthesia, and furthermore plays a role in the subjective nature of synesthetic color experience.

Perception and Action I

Saturday, May 12, 2:00 - 3:30 pm, Hyatt Ballroom South
Moderator: Barbara Gillam

2:00 209 Visual selection of multiple goal positions before rapid hand movement sequences

Daniel Baldauf[1] (baldauf@psy.uni-muenchen.de), Heiner Deubel[2]; [1]California Institute of Technology, [2]Ludwig-Maximilian-University, Munich

In this ERP study a dot probe paradigm was used to provide physiological evidence for the parallel selection of multiple movement goals. Participants executed a sequence of manual pointing movements to two out of three possible goal positions. During movement preparation, a task-irrelevant visual transient (dot probe) was flashed either at one of the movement goals or at the third position that was movement-irrelevant in the current trial. The data reveal that the N1-component induced by the dot probe is enhanced if the dot is flashed at any of the movement goals, indicating that both target positions are attended well before the initialization of the movement sequence. Therefore, the preparation of a double reach to both goals leads to enhanced sensory processing of visual stimuli at both target locations. Additional behavioral studies using a secondary letter discrimination task show that this selection-for-action of multiple goal locations occurs in parallel and leads to a splitting of visual attention into spatially distinct foci. Comparison with the preparation of double-saccade sequences shows that the observed pre-movement facilitations at multiple goal positions occur independent of the effector system used.

2:15 210 Perceiving Changing Affordances for Action: Pregnant Women Walking Through Doorways

John Franchak[1] (franchak@nyu.edu), Karen Adolph[1]; [1]New York University

Affordances for action depend on the characteristics of the environment relative to people's body dimensions and physical abilities. Thus, adaptive motor control requires that people perceive variations in both the environment and their own bodies, and scale their actions accordingly. The current study addressed this issue in a situation where affordances for action undergo dramatic change: We observed pregnant women longitudinally as they decided whether they could fit their bodies through wide and narrow doorways.

Women were tested on a monthly basis, from their third month of pregnancy to one month post-partum. Facing an adjustable doorway from 3 m, women decided whether they could walk through without becoming wedged. The size of the doorway aperture varied from 0 to 74 cm in .5 cm increments. Women provided verbal reports as they approached the doorway, and either attempted passage or refused by turning away. An adaptive psychophysical procedure was used to estimate affordance thresholds (the doorway width that allowed passage on 50% of attempts) and decision thresholds (the doorway width that participants attempted passage on 50% of trials) for each participant at each session.

As expected, affordance thresholds increased over months of pregnancy and decreased sharply following childbirth. Affordance thresholds were highly correlated with body dimensions (abdomen, breast, and hip circumferences). Overall, participants successfully tracked changes in their body size – changes in decision thresholds paralleled changes in affordance thresholds, indicating that pregnant women scale their motor decisions to the relationship between the dimensions of their rapidly changing bodies and small variations in doorway width. On average, however, women overestimated their ability to fit through apertures, by attempting apertures slightly smaller than their affordance thresholds. In addition, participants' visual exploration was determined using a head-mounted eye-tracker.

2:30 211 Steering performance is influenced by road width, road curvature and gaze behaviour.

Richard Wilkie[1] (r.m.wilkie@leeds.ac.uk), Katherine Robertshaw[1], John Wann[2]; [1]Institute of Psychological Sciences, University of Leeds, UK, [2]Department of Psychology, Royal Holloway University of London, UK

Control of steering is an essential component of successful high speed locomotion. Land & Lee (1994) recorded gaze behaviour during driving and observed extensive use of the tangent point of upcoming bends. In Wilkie & Wann (2003), however, we observed that gaze exploration of the centre of the road 1-2 seconds ahead was associated with accurate steering. Here we examine the relationship between gaze and steering behaviour by simulating locomotion along roads of varying width and curvature. Nine participants were asked to steer as close as possible to the centre of a computer-simulated roadway when traveling at 13.8m/s (50km/h). Two road widths (3m or 6m) and two bend curvatures (constant radii of 60m or 120m) were used. Each participant steered initially down 24 roads with randomly interleaved width and curvature (6 trials of each) and were free to look wherever they like in the scene. We then added a fixation requirement to the task and repeated these conditions. A fixation cross could either be on the tangent point of the bend, or on the centre of the road the same distance ahead as the tangent point. We also ran conditions with fixation on the outside edge of the road, or in the space between the centre and the road edges, or 3m beyond the road edges. Throughout trials we recorded position relative to the road centre and gaze behaviour. The results show that steering performance was influenced by both road curvature and width (the largest errors occurring on tight wide roads). The point of fixation also influenced steering, causing systematic biases in the direction of gaze. We conclude that the tangent point of the road does not provide information which is uniquely useful, but rather that looking to the point you wish to pass through contributes to successful steering.

Acknowledgement: Research supported by the UK EPSRC GR/R14644 & EP/D055342/1
URL: http://www.personal.leeds.ac.uk/~pscrmw/

2:45 212 Human and Robot Ball Catching on a Hill: Is the Control Geometry on the Level or Atilt?

Michael K. McBeath[1] (m.m@asu.edu), Thomas G. Sugar[2], Abhay Paranjape[3], Igor Dolgov[1], Wei Wang[1]; [1]Department of Psychology, Arizona State University,

[2]Department of Engineering, Arizona State University Polytechnic, [3]Department of Mechanical and Aerospace Engineering, Arizona State University

Past research supports that humans, animals, and robots navigate to intercept moving airborne or ground-based targets by using a small set of simple, angular control heuristics. Pursuers navigate to keep the target image moving at a constant optical speed and direction. For fly balls the tangent of the vertical optical angle increases at a constant rate, while for grounders the cotangent decreases at a constant rate. Past research typically assumes that these optical control functions are based on a universal, level, world-based geometry, but this may only be true with level terrains. The present study examines human and mobile-robot fielders intercepting ground balls rolling up or down hills. We tested if navigational behavior is more consistent with optical-angle functions that are based on level, world-coordinate geometry, or on a reference frame rotated parallel to hill-slope. Both human and robot fielders pursued ground balls on a 4° slope. Measurements were made using an 8-camera Vicon motion-capture system with 60 Hz, 1 cm position resolution. Experiment conditions followed a 2-by-2 design with both uphill and downhill directions of ball-movement and locomotion. In the human experiment, three skilled fielders caught five grounders in each of the four conditions. The findings confirmed the optical control model was significantly more linear when based on a reference frame tilted with the hill slope. Results of the robot study exhibited the same pattern, with the robot catastrophically failing when programmed to use a level-geometry control mechanism in the ball-rolling-down, fielder-running-up condition in which humans also had the least variance explained. Overall, the tilted geometry model accounted for an average of over 98% variance in the vertical optical-angle function. The findings support that interceptive human action utilizes a geometry recalibrated to tilt with hill-slope, and that robotic control models are greatly improved by adopting this same strategy.

Acknowledgement: National Science Foundation Grants #BCS-0318313 and NSF #0403428
URL: http://robotics.eas.asu.edu/movies/catchingBallMain.wmv

3:00 213 The role of binocular vision in navigating obstacles

Kelly Chajka[1] (kchajka@cvs.rochester.edu), Elia Vecellio[2], Mary Hayhoe[1], Barbara Gillam[2]; [1]Center for Perceptual Systems, University of Texas at Austin, [2]School of Psychology, University of New South Wales

Despite a wealth of knowledge about stereoscopic vision, little is known about the role of stereopsis in the control of everyday actions. Work by Patla et al. (Exp Brain Res, 2002) has shown that when stepping over obstacles, foot position is elevated when only monocular vision is available. Our investigation compared monocular and binocular vision when walking over and around obstacles, and also tracked eye movements during the task. Eye movements were recorded from 8 subjects using an RIT wearable eye tracker (ETRA, Babcock & Pelz, 2004). Subjects stepped over two boxes, walked around a table, and returned to the starting point. Subjects performed two monocular and two binocular trials, with the order counterbalanced across subjects. Subjects were overall 11% slower in the monocular condition (600 ms slower around the table, 500 ms slower stepping over obstacles), and elevated the foot approximately 2 cm higher when stepping over obstacles. Fixations on the obstacles accounted for 30% of total gaze duration in each trial, with remaining fixations falling on the floor or wall. However, eye movement patterns were fundamentally different in monocular versus binocular trials. Subjects fixated longer on obstacles (approximately 150-200 ms per obstacle) in monocular vision. In the monocular condition, they also maintained fixation on the floor in order to guide foot placement between the boxes with high frequency (60%), but did this less often in the binocular case (15%). Thus both eye movements and obstacle avoidance are significantly altered when only monocular cues are available. These findings are consistent with increased uncertainty about spatial configuration in monocular vision, resulting from the loss of either stereopsis or other binocular cues.

Acknowledgement: Supported by ARC RM00362, NIH EY05729, NIH RR 06853

3:15 214 Using a Bayesian Model to measure the benefit of visual landmarks and layout topology on human navigation efficiencies

Brian J. Stankiewicz[1,2] (bstankie@psy.utexas.edu), Jane Pitts[1]; [1]Psychology, University of Texas, [2]Center for Perceptual Systems, University of Texas

Previously, Stankiewicz, et al. (2006) used an ideal navigator to measure human navigation efficiencies with varying sizes of layout and limited visual information. The current studies will use the same approach to investigate the benefit of visual landmarks and layout topology on human navigation efficiencies.

In the current studies, participants were trained and tested in large-scale, virtual, indoor environments. Three viewing conditions were used: No-Landmarks, Landmarks+Fog and Landmarks. In the No Landmarks condition, the environment was visually sparse such that multiple places in the environment could produce the identical visual image (similar to Stankiewicz et al., 2006). In the Landmarks condition, pictures were placed in the environment such that every state generated a unique view. In the "fog" conditions, fog prevented participants from observing distal hallway structure.

During testing, participants navigated to a goal state trying to make as few actions (rotations and translations) as possible. We calculated navigation efficiency (Number_of_Actions_Ideal/Number_of_Actions_Human). For the current analysis we also included results from Experiment 2 of Stankiewicz et al. (2006).

Landmarks 0.836(SEM=0.027)

Landmarks+Fog 0.724(SEM=0.037)

No-Landmarks 0.598(SEM=0.040)

Stankiewicz et al. (2006)

No-Landmarks 0.604(SEM=0.055)

No-Landmarks+Fog 0.485(SEM=0.038)

To evaluate the benefit of landmarks we calculated the difference in performance in the Landmarks vs. No-Landmarks and the Landmarks+Fog vs. No-Landmarks+Fog conditions. The benefit of landmarks was not significantly different in these conditions (0.239 (Fog); 0.235 (No Fog)). To evaluate the benefit of hallway topology we compared the No-Landmarks vs. No-Landmarks+Fog and the Landmarks vs. Landmarks+Fog conditions. Again, there was no significant difference (0.112 (Landmarks); 0.117 (No Landmarks)). These additive effects suggest that landmarks and hallway topology provide independent sources of information when navigating and orienting.

Acknowledgement: This research was supported by funding from: AFOSR (FA09550-04-1-0236), AFOSR MURI (FA09550-05-1-0321) and NIH (EY016089).

Perceptual Organization: Contours I

Saturday, May 12, 2:00 - 3:30 pm, Hyatt Ballroom North
Moderator: Manish Singh

2:00 215 Non-Bayesian Mechanisms of Contour Synthesis

Barton L Anderson[1] (bart.a@unsw.edu.au), John Cass[1], Judit O'Vari[1]; [1]School of Psychology, University of New South Wales, Australia

Vision science has experienced a recent surge in theories that model perceptual organization as a form of Bayesian inference. Following Helmholtz's principle of unconscious inference, an underlying assumption of such approaches is that perceptual organization is treated as the output of processes that derive the most likely interpretation of the image data. We report a class of illusory contours that seem impossible to explain within such probabilistic frameworks. Thin stationary contours were accreted and deleted by a visible moving surface. Although the image data were fully explained by the visible occluding surfaces in the image, vivid additional illusory contours (ICs) formed on the opposite side of the occluded contours. Matching experiments reveal that the strength of these ICs is a monotonic function of the contrast of the occluding surface and the occluded contours, suggesting that they originate in relatively early stages of cortical processing. In particular, when the contrast of the visible occluding surface increased, the strength of the ICs deceased; a similar decrease in IC strength was observed when the contrast of the occluded contour was reduced. We mapped out the shape of these moving ICs using a dot-probe method, and found evidence that, in opposition to a number of theories of contour interpolation, vivid inflection points and/or corners could be generated by the ICs in these displays. These experiments provide new insights into the mechanisms underlying the formation of ICs in moving images, and challenge Bayesian explanations of contour synthesis in particular, and of perceptual organization more broadly.

2:15 216 Local determinants of contour interpolation

Marianne Maertens[1] (marianne.maertens@gmail.com), Robert Shapley[2]; [1]University of Magdeburg, [2]Center for Neural Science, New York University

Object parts in the natural environment are often excluded from view due to occlusion. The visual system adapted to such degraded viewing conditions by developing a remarkable ability to interpolate linking contours between isolated object fragments. One factor that is believed to be of critical importance for the perceptual strength of interpolated (or "illusory") contours is the Support Ratio, the ratio between luminance-defined contour support and total contour length (Kellman & Shipley, 1991).

In Varin figures in which vivid illusory contours are interpolated between inducers (Lesher & Mingolla, 1993), solid Kanizsa inducers are replaced by a number of partially-occluded concentric arcs. Their luminance-defined contour support is dramatically reduced (compared with corresponding Kanizsa-type inducers) because the line ends amount to only a small proportion of the total contour length. Here we tested whether the crispness of the perceived illusory contour in Varin figures is a function of the luminance-defined contour support, or alternatively, depends on the distance between the line-endings of the inducers. We independently manipulated the line density and line width of the inducer circles, resulting in conditions with equal Support Ratio but different line density, and vice versa. We measured subject's performance in a probe localization task (Stanley & Rubin, 2001; Guttman & Kellman, 2004), where a small target is presented at different distances from a curvilinear illusory contour (Ringach & Shapley, 1996) and subjects have to indicate whether the target appeared inside or outside the illusory figure. Sensitivity, as indicated by the slopes of the psychometric functions for the accuracy of probe localization, increased with increasing line density – independent of Support Ratio. This is objective evidence that the perceived crispness of illusory contours in the Varin figures was determined by the separation between 2-d features, the inducers' line endings, and not by Support Ratio.

Acknowledgement: Marianne Maertens was supported by the German Academic Research Foundation

2:30 217 Breakdown of contour interpolation: Testing a multiple-contours hypothesis

Jacqueline M Fulvio[1] (jmf384@nyu.edu), Manish Singh[3], Laurence T Maloney[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University, [3]Department of Psychology and Center for Cognitive Science, Rutgers University

In previous work, we found that as the inducing edges of a partly-occluded contour become non-relatable (i.e., can be interpolated only with an inflected contour), observers' interpolation settings of position and orientation become mutually inconsistent: there is no single smooth contour that they all agree with (Fulvio, Singh, & Maloney, CVPR2006). We propose that this inconsistency arises from the presence of multiple contours generated within the region of interpolation. We test this hypothesis by asking whether observers' settings at a given location are influenced by the presence of their own setting at a nearby location.

Methods: The experiment was run in two parts. In Part I, observers made paired settings of position and orientation independently through four interpolation windows. In Part II, two interpolation windows were opened on each trial: one contained a fixed line segment determined by the observer's own settings in Part I. The second contained the adjustable probe. The vertical offset between the two inducing edges was manipulated so that they were either relatable (R), just-relatable (JR), or non-relatable (NR).

Results: To test whether observers' interpolation settings within a window are altered by the presence of their own setting in a nearby window, we compared observers' settings in Part I versus Part II of the experiment. For relatable inducers, the settings were not reliably different between Part I and Part II (only 2/32 tests were significant for position). For the JR and NR inducers, however, a large majority of the positional settings were reliably different between the two parts (23/32 for JR, 24/32 for NR). This suggests that no single contour is interpolated in the JR and NR cases. Rather, multiple contours are present and, depending on where a measurement is taken, it is influenced more by one inducing edge or the other.

Acknowledgement: NSF BCS-0216944 NIH EY08266

2:45 218 Illusory Contour Formation Modulates Competitive Interactions in Human Extrastriate Cortex

Stephanie McMains[1] (smcmains@princeton.edu), Sabine Kastner[1,2]; [1]CSBMB, Princeton University, [2]Dept. of Psychology, Princeton University

When multiple stimuli appear simultaneously in the visual field, they are not processed independently, but rather interact in a mutually suppressive way suggesting that they compete for neural representation. The biased competition model of selective attention suggests that both top-down and bottom-up processes can help resolve this competition by reducing suppressive interactions between competing stimuli. Both top-down attention and bottom-up visual salience (via pop-out visual stimuli) have been found to reduce competition in extrastriate cortex. Here we investigated whether the low- to intermediate-level visual cortical mechanisms that subserve illusory contour formation can reduce the competitive interactions between competing stimuli in a bottom-up fashion.

FMRI activity in visual cortex was investigated while subjects performed a target detection task at fixation. While subjects performed this central task, four illusory contour inducers were displayed at four nearby locations within the upper right visual quadrant. The four stimuli were either presented simultaneously (SIM) or sequentially (SEQ: each stimulus presented alone in one of the four locations). In addition, stimuli either formed an illusory contour (inducers rotated inward) or did not (inducers rotated outward).

Greater activity was observed in extrastriate cortex for the SEQ condition compared to the SIM condition, regardless of if the stimuli formed an illusory contour. This supports the biased competition model that predicts greater competition, and thus reduced activation, when the stimuli are presented simultaneously. Greater activity was also observed during the SIM condition in V3/V4 when the stimuli could be grouped together to form an illusory contour compared to when the stimuli did not form a perceptual group. This suggests that in the illusory contour condition the four inducers were grouped together into a single perceptual group, reducing competition among the simultaneously presented inducers.

These results suggest that early contour formation can influence neural competition in a bottom-up fashion.

Acknowledgement: NRSA, NIMH

3:00 219 Ladder contours are undetectable in the periphery

Keith May[1] (keith@keithmay.org), Robert Hess[1]; [1]McGill University

In many studies of contour integration, the task is to detect a contour consisting of spatially separated Gabor elements positioned along a smooth path (e.g., Field, Hayes, & Hess, 1993, Vision Research, 33, 173-193). The elements can be aligned with the path ("snakes") or perpendicular to it ("ladders"). With foveal viewing, ladders are generally harder to detect than snakes but, as long as they are fairly straight, ladders can still be detected quite easily. We found a striking deficit in detection of ladders in the periphery. Completely straight ladders were undetectable at an eccentricity of 6 degrees of visual angle, whereas performance on straight snakes at this eccentricity was at or close to 100%. This suggests that ladder detection is disproportionately impaired in the periphery, but an alternative explanation is that there is a general impairment of ladder detection that only shows up in the periphery, where performance falls away from ceiling. To address this issue, we brought performance away from ceiling in the fovea by jittering the orientations of the elements. For two subjects, foveal performance was matched for snakes and ladders with the same orientation jitter levels. In both cases, detection of ladders fell to chance at an eccentricity of 4 deg, whereas detection of snakes remained significantly above chance up to and including the largest eccentricity that we tested (8 deg). The failure to detect ladders at such small eccentricities may partly explain the relative difficulty in detecting ladders that has been reported in previous studies: in all of these studies, the position of the contour has been randomized to some extent. The difference in the effect of eccentric viewing on snakes and ladders means that any positional randomization would have caused a greater disruption to detection of ladders.

Acknowledgement: This work was supported by CIHR grant MT 108-18 to Robert F. Hess.

3:15 220 Evidence for synchrony using direct electrical stimulation of the human retina

Alan Horsager[1,2,3] (horsager@usc.edu), Ione Fine[1,2,3]; [1]Department of Ophthalmology, [2]Zilhka Neurogenetic Institute, [3]Doheny Retina Institute, Keck School of Medicine, USC, Los Angeles, CA

Purpose: The visual representation of objects and contours may involve binding related features through synchronous neural activity. While task and stimulus dependent synchronous activity on a fine temporal scale has been recorded in early visual cortex, it remains uncertain whether this activity actually has a perceptual role. Since 2002, 6 human subjects with severe retinitis pigmentosa have been implanted with 4x4 epiretinal electrode arrays (Humayun, 1999). In these subjects, visual percepts are mediated by directly stimulating the inner retina, rather than via temporally sluggish photoreceptors. This allowed us to test whether synchronous retinal activity was perceptually distinct from asynchronous activity at rates higher than the critical flicker fusion limit.

Methods: 500 ms biphasic pulse trains were presented on four neighboring electrodes with 800 µm center-to-center separation. Stimulation was suprathreshold at 80 Hz or above. Subjects performed a two-alternative same/different task in which each interval contained either synchronous or asynchronous stimulation. During synchronous stimulation all pulses all four electrodes were stimulated simultaneously. During asynchronous stimulation, the pulses on each of the four electrodes were temporally interleaved, but each individual electrode continued to be stimulated at a rate of 80Hz or above. Data was collected on 10 4-electrode sets across 2 human subjects.

Results and Conclusions: Subjects had no difficulty (85-100% accuracy) differentiating synchronous from asynchronous stimulation, even at frequencies above the critical flicker fusion limit. Synchronous stimulation generally appeared brighter. While it is possible that these results are due to retinal interactions, it is more plausible that the synchronous and asynchronous activity patterns elicited within the retina were transmitted to early visual cortex and produced distinguishable percepts. Our data therefore support the notion that synchronous activity enhances brightness or salience and plays an important role in perception.

Acknowledgement: This research funded by Second Sight Medical Products, Inc.

Face Perception

Saturday, May 12, 4:00 - 5:45 pm, Hyatt Ballroom South
Moderator: Pawan Sinha

4:00 221 Information distribution for face identificaiton and its relation to human strategies

Matthew Peterson[1] (peterson@psych.ucsb.edu), Craig Abbey[1], Miguel Eckstein[1]; [1]UC Santa Barbara, Dept. of Psychology

Introduction: Humans consistently use the visual information in the eye region of the face more than the information in the other gross features when identifying individuals (Schyns et. al., 2002; Barton et. al., 2006). Using ideal observer analysis, we previously reported that humans use the eye and mouth regions more efficiently than the nose and chin with a set of computer generated faces (Peterson et. al., 2006). However, it remains a question as to whether this disparity in efficiency is due to a recognition strategy developed through expertise of the eye region gained during years of social interaction or whether it is a result of the eye region containing better information. Here, we compare the information content of these four feature regions for identification of real faces using a Bayesian ideal observer. Methods: 70 frontal-view photographs were standardized for position, contrast and size. We then selectively masked everything except the feature region of interest. An ideal observer model compared a randomly selected template, embedded in white Gaussian noise, to all templates of the same feature and made an identification. The different feature regions were equated for area and features were aligned across templates. Results: Ideal observer performance for the eye images (71 %) was much greater than for the nose (22 %), mouth (21 %) and chin (6 %). Conclusion: The human face recognition strategy using the eye region is commensurate with the concentration of visual information in real world faces. In our previous study, this became apparent through human observers' bias to select faces based on the information in the eyes, even when there was better information in the other features. This bias, present when a novel face was displayed and the information distribution was not known, was attenuated rapidly as the observers learned which features were most informative.

Acknowledgement: NIH-EY-015925, NSF-DGE-0221713

4:15 222 What's lost in prosopagnosia? An investigation of familiar face processing in a single-case of pure prosopagnosia working in a kindergarten

Meike Ramon[1] (meike.ramon@psp.ucl.ac.be), Bruno Rossion[1]; [1]Universite catholique de Louvain

Prosopagnosia is a deficit in recognizing familiar faces following brain damage whose study offers invaluable clues to understand the neural and functional aspects of normal face processing. Most studies of prosopagnosia have focused on processing of unfamiliar faces. As processing of personally familiar faces is substantially different from unfamiliar or famous face processing, these approaches lack ecological and thus informative value with reference to the underlying cause(s) of prosopagnosia. Here we present the first systematic investigation of familiar face processing in PS, a well-known case of acquired prosopagnosia with a deficit restricted to faces (Rossion et al., 2003; Schiltz et al., 2006). Due to largely preserved perceptual functions and an excellent memory, PS has been able to compensate for her deficits and has been pursuing her profession in a kindergarten. We conducted an exhaustive set of behavioral experiments with photographs of the 26 children of 3 to 4 years old that were in contact with PS and her 2 colleagues during the whole year. Tasks included familiar/unfamiliar face decisions (whole or half face, or face parts), and forced choice matching to improve the patient's performance. In striking contrast to controls, PS was most efficient in recognizing familiar faces by using the mouth relative to the eyes of the face, in line with our previous observation using the Bubbles methods (Caldara et al., 2005). Moreover, despite being able to perceive metric distances between features, several experiments

Saturday Talks

(whole-part interference, face composite effect, assessment of ratio of face relations) showed that PS does not process individual faces holistically. These results suggest that the ability to integrate facial features into a holistic individual representation centered on the eyes of the face is a critical component of a normal face recognition system that can be selectively disrupted following brain damage.

URL: http://www.md.ucl.ac.be/nefy/Face_Categorisation_Lab.htm

4:30 223 The spatio-temporal correlates of holistic face perception

Christine Schiltz[1] (schiltz@nefy.ucl.ac.be), Corentin Jacques[1], Bruno Rossion[1]; [1]Université catholique de Louvain

It is well known that faces are perceived holistically: their parts are integrated into a global or so-called holistic individual representation. Here we clarify where and how early in time individual holistic representations are extracted from the visual stimulus, by means of an event-related identity adaptation paradigm in fMRI (study 1; 10 subjects) and ERPs (study 2; 16 subjects). During blocks, subjects were presented with trials made of two sequentially presented faces and performed a same/different judgement on the top parts of each pair of faces. Face parts were presented either aligned or misaligned. For each face pair, the identity of top and bottom parts could be (a) both identical, (b) both different, (c) different only for the bottom part. The latter manipulation resulted in a strong face composite illusion behaviourally, i.e. the perception of identical top parts as being different, only in the aligned format. In the face-sensitive area of the middle fusiform gyrus ('fusiform face area') we observed a stronger response to the top part perceived as being different (release from adaptation), but only when the top and the bottom parts were aligned. It is consistent with the illusion of viewing different top parts of faces, and this release from fMR-adaptation is similar to the one observed in the 'different' condition for both aligned and misaligned parts. The same observations were made in ERPs as early as 150 ms, the amplitude of the electrophysiological response at occipito-temporal sites to the second face stimulus being reduced for identical relative to different top face parts, and to identical top parts perceived as different (aligned - bottom different). With both methods, the effects were stronger in the right hemisphere. Altogether, these observations indicate that individual faces are perceived holistically as early as 150 ms in the occipito-temporal cortex.

URL: http://www.md.ucl.ac.be/nefy/Face_Categorisation_Lab.htm

4:45 224 Spatial Limits of Face Processing: Evidence from Face Aftereffects.

Seyed-Reza Afraz[1] (afraz@fas.harvard.edu), Patrick Cavanagh[1]; [1]Department of Psychology, Harvard University

We examined the spatial limits of face processing by measuring the spatial spread of the face aftereffect (FAE) following adaptation to a single face and following simultaneous adaptation to a face and its anti-face at different spatial separations. In the adaptation phase, one of the following sets of stimuli was presented with each stimulus placed at locations around a 3 deg circle centered at fixation: 1) a single face; 2) a face and its anti-face on opposite sides of fixation; 3) two faces and two anti-faces evenly spaced; and 4) one to four ellipses evenly spaced with the average size and color of face stimuli (non-adapted condition). In the test phase, a face stimulus with various morphing levels between the face and the anti-face was presented at a random location around the display circle and subjects had to report whether the test stimulus was seen as face or anti-face. The adaptation effect was determined from the PSE in the psychometric function for all angles between adapt location and test location to provide a spatial map of the spread of the FAE. Results show non-retinotopic adaptation – an FAE of similar strength at all locations -- following adaptation to a single face stimulus. Nevertheless, simultaneous adaptation to both the face and the anti-face, spaced at opposite locations across the fixation, did not cancel, producing instead two separate regions of opposite aftereffects. With the smaller separation of the 4 equally spaced stimuli, faces alternating with anti-faces, FAE was greatly reduced.

These results suggest: 1) the spatial extent of face analysis and subsequent FAE has a dynamic nature and depends on the number of objects presented in the visual field, 2) when spaced too closely (one per quadrant), the FAE from adjacent faces is pooled and cannot survive independently.

5:00 225 Face Space: Distinctiveness, Discrimination and Dippers

Steven Dakin[1] (s.dakin@ucl.ac.uk), Diana Omigie[2]; [1]UCL Institute of Ophthalmology, London, UK, [2]Department of Anatomy, University College London, London, UK

It is widely held that the neural representation of faces may be usefully viewed as a multi-dimensional "face-space" with the average at its origin. Under this view the distance between faces encodes their similarity, and distance from the origin encodes general "distinctiveness". Here we compare objective and subjective measures of distinctiveness to uncover the nature of the dimensions supporting it. To this end we measured key-points for 64 Caucasian (Scotch) male faces, to yield a 70-parameter "identity vector" (IV) for each. Our stimuli were average-faces morphed to shift them along IVs.

We estimated subjective distinctiviness by having observers rate 16-member subsets of the face-set. We then made two objective measures of distinctivness: IV-length (i.e. distance from average) and psychophysical discriminability of the face from the average. The latter was the smallest shift of an average face along the IV (estimated using QUEST) that supported a 3AFC odd-man-out judgment (i.e. the cued versus two averages). We report that subjective ratings correlate well (>85%) with discriminability of the face from average, but less so with IV-length, suggesting that such thresholds are a useful psychophysical measure of distinctiveness. We next measured discrimination thresholds for faces morphed along the IV that were presented not just amongst averages, but amongst averages containing varying "pedestal" levels of morphing along the IV. Results indicate first, broadly inverse Weber's law dependence of threshold on pedestal; subjects get better at spotting the odd-man-out as faces become more atypical. Second, some faces elicit shallow "dipper functions" indicating discrimination is based on a non-linear transduction of (IV-encoded) identity level. By contrast, performance with inverted faces was uniformly poorer and exhibits straightforward inverse Weber's law behaviour with no dips. Thus our findings are related to encoding of facial distinctiveness and not visibility of distortion.

Acknowledgement: Funded by the Wellcome Trust

5:15 226 Using computer vision to probe the neural correlates of categorical face perception

Ming Meng[1] (mmeng@mit.edu), Tharian Cherian[1], Susan Gabrieli[1], John Gabrieli[1], Pawan Sinha[1]; [1]Department of Brain and Cognitive Sciences, MIT

We present a novel methodology that exploits work in computer vision, for identifying the neural correlates of face perception. It involves creating a sequence of non-face natural images that, on the one hand, constitute a smoothly varying continuum in terms of image-level similarity to faces, and on the other hand yield categorical face/non-face responses from observers. We then determine which brain regions exhibit graded activity changes across the sequence and which are categorical.

The key challenge in operationalizing this approach lies in compiling the collection of natural images that would constitute a continuum in a face-similarity space. We have addressed this challenge by using a state of the art machine-based face detection system. Given any image, the system spots faces therein and, on rare occasions, generates false positives (FAs). We have collected several hundred such FAs and rank-ordered them in terms of their similarity to faces (using computational norms and also ratings from human observers). The final collection comprises 300 images, ranging smoothly from being very distinct from faces to genuine faces. Similarity ratings change almost linearly across this set, while the face/non-face labels change categorically.

Using fMRI, we investigated which brain regions correlate with categorical face/non-face judgments. As a preliminary test of the approach, an ROI analysis showed that fusiform face area exhibited perceptually congruent categorical responses. In contrast to high level activity induced by faces, all non-face images, irrespective of their similarity to faces led to low activations. These results illustrate of how the approach allows us to assess whether a given region's activity is involved in categorical judgments rather than just being correlated with low-level image structure. We shall describe the use of this approach with whole-brain responses to identify additional regions involved in face processing.

Acknowledgement: Research supported by The Simons Foundation

5:30 227 Apparent Motion of the Face

Songjoo Oh[1] (songjoo@psychology.rutgers.edu), Maggie Shiffrar[1]; [1]Rutgers University-Newark

The biomechanical limitations of the human body constrain the visual perception of apparent body motion (Shiffrar & Freyd, 1990). Numerous findings suggested that face processing is distinct from body processing. This raises the question of whether the structure of the human face influences the visual perception of apparent face motion. To answer this question, participants viewed two-frame apparent motion sequences that depicted photographs and drawings of human faces in which the two eyes blinked in alternation. Frame duration varied from 100 to 700 ms in 100 ms steps and the interstimulus interval was fixed at 0 ms. The stimuli were constructed so that two percepts were possible: (1) a physically possible motion in which the two eyes remained in their fixed locations and blinked in alternation, or (2) a physically impossible motion in which the visible eye appeared to translate back and forth between the two eye sockets. On each trial, subjects reported whether they perceived the possible or impossible apparent motion. Following a between subjects design, participants in Experiment 1, viewed chromatic and achromatic faces that were upright or inverted. Observers reported the perception of possible blinking motion with upright faces and the perception of impossible eye translation with inverted faces. Thus, holistic face processing changed apparent motion perception. In Experiment 2, the two alternately blinking eyes were presented in isolation, either upright or inverted. In this case, orientation had no effect on apparent motion perception. Thus, apparent motion differs for faces and isolated eyes. Taken together, these results suggest that the visual analysis of the face influences the visual perception of apparent motion. If so, then neural activity in area FFA might constrain activity in area MT.

Acknowledgement: NIH grant EY012300

Attention: Objects, Scenes, and Search

Saturday, May 12, 4:00 - 5:45 pm, Hyatt Ballroom North
Moderator: Todd Horowitz

4:00 228 Grouping determines object-based selection in human inferior intra-parietal sulcus

Yaoda Xu[1] (yaoda.xu@yale.edu), Marvin Chun[1]; [1]Yale University

Visual objects are important units in visual processing, and yet how the brain determines what constitutes as a discrete visual object remains largely unknown. Previously, in a visual short-term memory (VSTM) study, we showed that, regardless of object complexity, fMRI response in the inferior intra-parietal sulcus (IPS) increased as the number of objects at different spatial locations increased (up to about four objects) (Xu & Chun, 2006, Nature). This finding indicates that the inferior IPS may participate in visual object individuation and selection, and its activation may reflect the number of discrete visual objects represented in the brain. In the current VSTM study, we asked: If object locations are fixed, but the grouping between objects differs, would that change the number of discrete objects represented in the brain? Our display consisted of two filled black rectangles on either side of the central fixation, similar to Egly, Driver and Rafal (1994, JEP:G). Observers encoded in VSTM two gray shapes appeared on the black rectangles and decided whether a probe shape at test matched one of the remembered shapes. Although grouping by closure (rectangles) was irrelevant to the VSTM task and could be ignored, the inferior IPS activation was lower when the two shapes appeared on the two ends of the same rectangle than on the same end of both rectangles. With an increased VSTM load, this grouping by closure allowed more shape information to be retained in VSTM as reflected in behavioral VSTM performance and fMRI responses in the superior IPS, which correlate with VSTM capacity. Interestingly, grouping did not modulate responses in the lateral occipital complex, an area involved in shape processing. Thus, grouping changes the number of discrete objects represented, and the inferior IPS may play a key role in determining object-based visual processing in the brain.

Acknowledgement: Supported by NSF grant 0518138 and NIH grant EY014193.

4:15 229 The Representation of Ensemble Visual Features Outside the Focus of Attention

George Alvarez[1] (alvarez@mit.edu), Aude Oliva[1]; [1]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology

We present several experiments demonstrating that observers can represent precise visual information outside the focus of attention, but concerning objects as a group rather than as individuals. We call these group representations "ensembles," because they represent accurate statistical characteristics of the group of elements as a whole while lacking an accurate representation of local object information.

First we investigated a simple ensemble feature, the center of mass of a group of objects. We used an adapted multiple object-tracking task where observers had to attentively track a subset of moving objects while ignoring others. During each trial, some targets or distractors would randomly disappear. Observers could accurately report the local position of a single missing target item but performed at chance when judging the local position of a distractor item. However, when estimating the center of mass, observers were well above chance for both targets and distractors, suggesting they accurately represented the center of mass of the set of unattended items. A second series of experiments investigated the representation of complex ensemble statistics by manipulating the spatial layout of a background texture. When tracking moving objects, observers were more likely to notice local orientation changes when they altered the global structure of the background texture than when they did not change the global structure.

To account for these data, we propose three main claims: the visual system measures ensemble statistics, which consist of compact, global featural representations that abstract away from the local details of an image; focal attention creates an isolation field that provides access to the local feature values at a particular spatial location; information outside the focus of attention remains consciously accessible in the form of an ensemble representation which lacks local detail, but nevertheless carries a precise statistical summary representation of the visual scene.

Acknowledgement: Author GAA was supported by NIH/NEI Grant #F32 EY016982.

4:30 230 Category Selectivity in the Ventral Visual Pathway Confers Robustness to Clutter and Diverted Attention.

Leila Reddy[1] (lreddy@mit.edu), Nancy Kanwisher[1]; [1]Mc Govern Institute for Brain Research, Massachusetts Institute of Technology, Cambridge, MA 02138.

The pattern of fMRI responses across the ventral visual pathway to objects presented in isolation carries information about the category of object viewed. However, natural images usually contain multiple objects ("clutter"), a notorious challenge for distributed representations. Here we used pattern analysis methods to ask whether category information in the fMRI response is preserved under conditions of clutter and diverted attention, and whether the answer to these questions depends on the category of object viewed. We found that information in the spatial pattern of fMRI response about standard object categories (shoes and cars) is severely disrupted by clutter, and eliminated when attention is diverted. However, information about preferred categories in category-specific cortical regions (faces in the FFA and houses in the PPA) is undiminished by clutter, and partly preserved under diverted attention. These findings suggest that one function of category-selective cortical regions may be to preserve category information under conditions of clutter and diverted attention.

Acknowledgement: This work is supported by grant EY13455 to NK.

4:45 231 Dissociating task performance from neural repetition effects in ventral visual cortex

Nicholas B. Turk-Browne[1] (nicholas.turk-browne@yale.edu), Yaoda Xu[1], Marvin M. Chun[1]; [1]Yale University

Repeated visual stimuli elicit reduced neural responses compared to novel stimuli in various brain regions (repetition attenuation). This effect has become a powerful tool in functional magnetic resonance imaging (fMRI) studies, allowing researchers to investigate the stimulus-specific neuronal representations underlying perception and cognition. Repetition attenuation is also commonly associated with behavioral priming, whereby response accuracy and speed increase with repetition. This raises the possibility that repetition attenuation reflects decreased processing time, rather than (or in addition to) changes in the response properties of individual selective neurons. Here we report a full dissociation between repetition attenuation and behavioral performance by varying the task performed on identical visual stimuli. Observers were presented with pairs of scene photographs that overlapped either 83% (very similar) or 50% (less similar). Filler trials where the photographs overlapped 0% and 100% were also included. In the scene task, observers judged whether the two photographs came from the same scene, and in the image task, they judged whether the two photographs were identical pixel for pixel. The two tasks produced opposite patterns of behavioral performance: responses were faster and more accurate for the very similar pairs relative to the less similar pairs in the scene task, and vice versa in the image task. However, in the parahippocampal place area (PPA), a scene-selective region of ventral cortex, identical repetition attenuation was observed in both tasks: lower neural responses for the very similar pairs relative to the less similar pairs. While the PPA was impervious to task modulation, two frontal regions showed the same crossover interaction as behavior, consistent with their role in decision-making. Thus, even though repetition attenuation and priming are often correlated, they can be dissociated, suggesting that attenuation in ventral visual areas reflects stimulus-specific processing independent of task demands.

Acknowledgement: Supported by a foreign Natural Sciences and Engineering Research Council of Canada Post-Graduate Scholarship to NBTB, NSF grant 0518138 to YX, and NIH grant EY014193 to MMC.

5:00 232 Discovering the Target Bias Map: Learning which features guide visual search in natural scenes

Dirk Walther[1] (walther@uiuc.edu), Mazyar Fallah[2], John K. Tsotsos[2]; [1]Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, Urbana, [2]Centre for Vision Research, York University, Toronto, ON, Canada

There is widespread agreement that visual search for known targets is guided effectively by a small number of basic features, such as color, orientation, corner junctions etc. (Wolfe 1994). Typically, the suitability of a particular feature for guiding search is tested in experiments with highly simplified stimuli presented in search arrays in front of a blank background (e.g., He and Nakayama 1992; Wolfe and Horowitz 2004). But who gets to decide what is a feature and is hence eligible to undergo this initiation test? This decision is usually made ad-hoc by the investigator, sometimes, but not always, guided by neuro-physiological insights.

For our experiments, we chose a parameter-free statistical approach to discovering features that guide search for particular objects. Subjects searched for familiar real-world objects in complex natural scenes. By analyzing the multi-scale image properties at fixated locations during search, we found statistical patterns that are specific for each object. Using these properties, we can predict well above chance, which object a subject is looking for from the image properties at the attended locations. Moreover, our method allows us to create object-specific target bias maps akin to the concept of a saliency map.

Furthermore, statistical patterns that are common to all object searches (but not to non-attended image locations) give us an operational definition for stimulus-driven saliency as a property that leads to the discovery of likely object locations, which can then be verified to contain actual objects or the specific target object.

Acknowledgement: Funding for this project was provided by the Canada Research Chairs Program, a Beckman Postdoctoral fellowship to DW, and NSERC Discovery Grant 327355-06 to MF. JKT holds the Canada Research Chair in Computational Vision.

5:15 233 Getting Guidance Going

Evan M. Palmer[1,2] (palmer@search.bwh.harvard.edu), Michael J. Van Wert[1], Todd S. Horowitz[1,2], Jeremy M. Wolfe[1,2]; [1]Brigham & Women's Hospital, [2]Harvard Medical School

In visual search tasks, attention can be guided to items that share features (e.g. color) with the desired target. Is feature guidance available immediately from the onset of a stimulus? To address this question, observers reported whether the gap in a target C was on the left or right among distractor Cs with gaps facing up or down. Stimuli were presented within circular placeholders that changed color during the trial. Once colored, displays had 4 placeholders of one color and 12 of another. The target always appeared in the 4-item set. Performance was compared to two control conditions: 4 or 16 homogeneously colored items. We manipulated stimulus onset asynchrony (SOA) between the color cue and the Cs. If Cs appeared well before color, observers searched through 16 items at random. As SOA approached zero, color information became increasingly effective, as if observers searched initially through all 16 items before the color information made it possible to restrict search to just four items. Color guidance was not fully effective at zero SOA. Only when color preceded the Cs by 200-400 ms was guided search equivalent to search through just four items. This was true even when the target color was constant for an entire block. When different target colors were randomly intermixed during a block, guidance took up to 600 ms to become fully effective, suggesting a cost for changing guidance settings. When the target color became a distractor color on the next trial, RTs were slowed relative to the randomly intermixed condition at zero ms SOA, but these conditions became equivalent by 600 ms. This suggests that observers continued to guide by the previous color until guidance to the new color came online. Feature guidance is not available immediately.

Acknowledgement: NRSA grant #F32 EY016632 to EMP

5:30 234 Investigation of spontaneous saccades based on the saliency model in monkeys with unilateral lesion of primary visual cortex

Laurent Itti[1,2] (itti@usc.edu), Masatoshi Yoshida[3,4], David Berg[2], Takuro Ikeda[3,4], Rikako Kato[3,4], Kana Takaura[3,4], Tadashi Isa[3,4]; [1]Computer Science Department, University of Southern California (Los Angeles, California), [2]Neuroscience Graduate Program, University of Southern California (Los Angeles, California), [3]Deptartment of Developmental Physiology, National Institute for Physiological Sciences (Okazaki, Japan), [4]CREST, JST (Japan)

Primary visual cortex (area V1) is the entry point of visual processing into the primate cortex. Yet, human and animal studies of V1 lesions have demonstrated a ``blindsight'' phenomenon, whereby residual visually-guided behavior remains even when large portions of V1 are absent. However, little is known quantitatively of how this residual vision (possibly subcortically-mediated) differs from normal (cortically-mediated) vision. We analyzed eye movements of three macaque monkeys (one normal, two with complete unilateral V1 ablation) watching ~54 minutes of television (97,051 video frames). A computational model of bottom-up attention quantified how salient visual features may guide gaze into the normal vs. the lesioned hemifield. To eliminate stimulus biases, we randomly presented all video clips twice, original and horizontally flipped. We quantified the extent to which salient stimuli attracted gaze of each monkey by computing, for saccades tallied along the eight principal directions, a model-based bottom-up guidance score (chance level 0.5; ideal upper bound 1.0; practical inter-observer score previously measured as the extent to which three control monkeys predict gaze of a fourth monkey ~0.6). For the normal as well as both lesioned monkeys, we found that saccades in all eight principal directions were guided towards salient locations, significantly above chance (scores 0.585+/-0.006 to 0.662+/-0.004, t-tests $p<0.00003$, 909 to 3,537 saccades per monkey in each direction). However, although lesioned monkeys overall scored lower, there was little difference in bottom-up guidance with saccade direction (scores 2.2% to 3.6% lower for saccades directed into vs. away from the lesioned hemifield). Our preliminary results suggest that the extent to which monkey saccades are attracted towards salient locations during natural vision may be less affected by the absence of primary visual cortex than previously considered.

Acknowledgement: Supported by HFSP and NSF.

Poster Session B

Saturday, May 12, 8:30 am - 1:00 pm, Municipal Auditorium

Eye Movements: Saccades and Smooth Pursuit

Author Presents: 10:30 am - 12:15 pm

B1 235 **Sensory and motor contributions to smooth pursuit variability**

Karl R. Gegenfurtner[1] (gegenfurtner@psychol.uni-giessen.de), Christoph Rasche[1]; [1]Abteilung Allgemeine Psychologie, Justus-Liebig-Universität Giessen

Several studies have shown that the variability of smooth pursuit eye speed can match perceptual speed discrimination thresholds. While Kowler & McKee (Vision Research, 1987) and Gegenfurtner et al (Journal of Vision, 2003) have shown this to hold during steady state pursuit, Osborne et al (Nature, 2005) claimed that the eye speed variability during the initiation phase of pursuit is also due to sensory noise alone. They measured pursuit variability using an innovative new method, but they did not determine perceptual variability of their monkey observers. We therefore measured pursuit and perceptual variability using the same stimuli.

Subjects had to pursue a Gaussian dot in a step-ramp paradigm. The dot moved at one of 5 different speeds (5.5 to 16.4 deg/s) for 1 s. Individual traces were fitted against their average to estimate their variability in latency and amplitude. The analysis was performed for short intervals containing the initiation period only and for longer intervals including steady-state pursuit. In a different set of trials, subjects had to compare the speed of the stimuli to a memorized standard (11.3 deg/s) for presentation durations ranging from 150 ms to 1s. In a third set of trials, subjects performed both tasks, eye movements and psychophysical judgments, for stimuli presented for 1 s.

In agreement with published studies, we found Weber fractions of less than 10% in the psychophysical speed discrimination task, even for the shortest presentation duration of 150 ms. Pursuit variability was about four times as high for the shortest analysis interval (250 ms) containing the initiation phase only. Only for pursuit analysis intervals of 400-500 ms, pursuit variability approached perceptual variability.

Our results show that the motor system contributes significantly to the variability of smooth pursuit eye movements during the initiation phase.

Acknowledgement: Supported by DFG FOR 560

B2 236 **Frames of reference for eye-head gaze shifts evoked during stimulation of the primate frontal eye fieldS**

J.A. Monteon[1,2] (jachin@yorku.ca), J.C. Martinez-Trujillo[3], Hongying Wang[1,2], J.D. Crawford[1,2]; [1]Centre for Vision Research, York University, Toronto, Canada, [2]Department of Biology, York University, Toronto, Canada, [3]Department of Physiology, McGill University, Montreal, Canada

Electrical microstimulation of gaze control structures as the superior colliculus (SC) produces gaze shifts defined in an eye-centered reference frame (Klier et al. 2001). In contrast, the supplementary eye fields (SEF) appear to encode gaze commands in multiple reference frames (Martinez-Trujillo et al. 2004; Park et al. 2006). Previous single-unit recording experiments in head-restrained monkeys (Russo and Bruce 1996) suggest that the frontal eye field (FEF) encodes the location of visual targets in an eye-centered reference frame. However, there is reason to suspect that the input code (revealed by unit recording) and the output code (probably revealed by stimulation) should not always employ the same reference frame (Smith and Crawford 2005). Currently it is not known if electrical stimulation of the FEF in head-free animals produces gaze shifts toward an eye, head, or space-fixed goal. We implanted two macaques with recording chambers over the FEF and search coils to measure eye and head rotations. Stimulation trains were delivered at 80 µA, 300 Hz, 200 ms, with gaze oriented at a variety of positions. Gaze shifts were evoked from 114 FEF sites in two monkeys (M1 n= 70, M2 n=44). Evoked gaze trajectories were mathematically rotated trajectories into three coordinate systems (eye/ head/space). Then we examined gaze convergence in each of these frames. The distribution of gaze end-points had the lowest amount of convergence to a common point when plotted in gaze coordinates (M1 = 4639.82°2, M2 = 2485.60°2). In contrast, gaze end-points had greater convergence when plotted in head (M1 =1277.95°2, M2 = 423.23°2) or eye (M1 = 423.2°2, M2 = 170.21°2) coordinates. This suggest that the FEF stimulation output is characterized by an intermediate trend between an eye-centered reference frame as observed in the SC (Klier et al. 2001) and a multiple reference frame code used in the SEF (Martinez-Trujillo et al. 2004).

B3 237 **Psychophysical and oculomotor reference points for visual direction measured with the Adaptive Optics Scanning Laser Ophthalmoscope.**

Scott Stevenson[1] (SBStevenson@uh.edu), Girish Kumar[1], Austin Roorda[2]; [1]College of Optometry, University of Houston, Houston TX 77204, [2]School of Optometry, University of California-Berkeley

Background: The sense that one is "looking at" a target is associated with stimulation of the fovea, and eye movements position or keep targets in the fovea. With recent advances in retinal imaging, in particular the AOSLO, we can now determine the absolute retinal position of a target during eye movements and visual direction judgments, and compare the retinal loci for each. Method: Subjects were imaged with the UC Berkeley AOSLO over a 2 degree field centered on the fovea. Stimuli were 10 arcmin square targets made by modulating the scanning laser. For eye movements, the target jumped randomly (saccades), followed a circular trajectory (pursuits) or remained stationary (fixation) in the raster. Subjects were instructed to hold gaze on the target as accurately as possible. For visual direction judgments, the target was flashed for one frame subjects indicated whether the target was above or below and left or right of their point of fixation. Videos were analyzed to extract the movement of the eye and to register all images to a common reference. Results: Pursuit and fixation precision was similar, with a standard deviation of about 5 arcmin and largely overlapping distributions of retinal loci. Target landing points following small saccades were more variable, and showed significant offsets compared to pursuit and fixation loci. Judgments of visual direction were typically twice as noisy as fixation, and in one amblyopic subject were three to four times as noisy. Discussion: There is no single cone on which a target must fall to be "looked at" but subjects are able to make absolute retinal position judgments with a precision of around 10 arc min. The various eye movement systems are as good or better than these judgments, and do not appear to share the same reference point as perceived visual direction.

Acknowledgement: Supported by the NSF Center for Adaptive Optics.

B4 238 The effect of distractors in prosaccade, antisaccade, and memory-guided saccade tasks

Stefan Van der Stigchel[1] (s.van.der.stigchel@psy.vu.nl), Wieske van Zoest[1,2], Jason J. S. Barton[2]; [1]Vrije Universiteit, Amsterdam, the Netherlands, [2]University of British Colombia, Vancouver, BC, Canada

Saccade trajectories are modulated by the presence of an irrelevant distractor. These modifications have been attributed to competitive interactions of activation patterns in the superior colliculus, a midbrain structure involved in encoding stimuli as potential saccade targets. Variations in the balance between target and distractor activations in different saccadic paradigms may therefore be reflected in differential effects of distractors on the saccadic trajectory.

To explore this, we investigated the effect of distractors in prosaccade, antisaccade, and memory-guided saccade tasks. We hypothesized that target activation would be reduced in antisaccades (where there was never a stimulus at the target location) and in memory-guided saccades (where the stimulus at target location has disappeared). If so, a model of competition between target and distractor activations would predict that distractors would induce greater distortions of saccadic trajectory in antisaccades and memory-guided saccades, than in prosaccades.

In the same set of 8 subjects we measured vertical prosaccades, antisaccades and memory-guided saccades (using a 1500 ms interval) with and without a distractor. The results showed that deviation away from the irrelevant distractor was larger in an antisaccade than in a prosaccade. Still more deviation away was observed in the memory-guided saccade paradigm. These results confirm the hypothesis that a distractor evokes more competition when there is a weaker target representation. They also illustrate the potential of using saccade deviations as a probe of saccade-related activation patterns in the ocular motor system.

B5 239 Within-hemifield mutual inteference and repulsion in the programming of antisaccades

Elizabeth Roy[1,2] (elizabethroy@gmail.com), Ipek Oruc[1,2,3], Jason Barton[1,2,3]; [1]Department of Ophthalmology and Visual Sciences, University of British Columbia, [2]Division of Neurology, University of British Columbia, [3]Department of Psychology, University of British Columbia

Background: A previous study of prior probability effects uncovered a mutual interference effect when the two high-probability antisaccade locations were located in the same hemifield, and thus processed by the same hemisphere.

Objective: We hypothesized that a mutual interference effect would have a spatial distribution for targets at different locations within a single hemifield.

Methods: We assessed prosaccades and antisaccades in 8 normal subjects, contrasting low-probability blocks with 8 possible target locations (0.125 probability for each target) and high-probability blocks with 2 possible target locations (0.50 probability for each target). There were four high-probability blocks that varied the angle of separation between the two targets, from 10°, 30°, 90° to 150°. We assessed latency, directional error and amplitude precision.

Results: Effects on prosaccades were minimal. For antisaccades, increasing prior-probability reduced latency and improved accuracy. However, this benefit was less for targets in close proximity (10° or 30°). The patterns of directional errors and amplitude precision for these close-proximity targets showed that saccadic trajectories were deviated away from the location of the other potential target.

Conclusion: The mutual interference effect is strongest when targets are closer than 90° apart, a directional separation that is similar in magnitude to the directional tuning of receptive fields of neurons in the frontal eye field and superior colliculus. Our results also show that this interference is more specifically a mutual repulsion, causing saccades to deviate away from the other location.

Acknowledgement: supported by CIHR grant MOP-81270

B6 240 A sequential sampling model of saccadic double-steps in direction

Casimir Ludwig[1] (c.ludwig@bristol.ac.uk), Iain Gilchrist[1]; [1]Department of Experimental Psychology, University of Bristol, UK

Sequential sampling models have been used to account for latency distributions of saccades directed to a single target (1). In these models saccade generation is a process of accumulating activity or evidence from a baseline level to a response criterion.

We present an extension of this basic scheme. Saccade direction is coded by an one-dimensional motor map. The units within this map accumulate evidence in favour of a target being in their "response field". A saccade is generated whenever the activity of one unit reaches criterion. The saccade direction is determined by the direction coded by the winning unit.

The model contains a number of critical features: 1) population coding: the onset of a target activates a large number of units in a graded fashion so that the drift rate is highest for the central unit, but drops-off gradually with increasing distance away from the target; 2) passive decay: the accumulation of activity is leaky; 3) two forms of noise: variability in the input into the motor map triggered by the onset of a target, and variability in the units' activity during accumulation.

The model was tested against empirical data from a double-step study (2). It effectively accounts for: 1) variability in saccade latency and direction under single target conditions; 2) the shape of direction transition functions under double-step conditions; 3) global effect saccades when the angular separation between two target steps is small; 4) the basic gap effect in saccade latency and its lack of influence on the saccadic dead time; 5) the variation in saccadic dead time with increasing target separation.

1. Carpenter, R. H. S. & Williams, M. L. L. (1995) Nature 377, 59-62.

2. Ludwig, C. J. H., Mildinhall, J. W. & Gilchrist, I. D. (2007) Journal of Neurophysiology.

B7 241 Prior probability effects and their inter-hemispheric interactions in human prosaccades and antisaccades

Saqib Ali Gowani[5] (saqib_gowani@hotmail.com), Jason Barton[1,2,3], Micheal Levin[1,2], Christopher Fox[2,4]; [1]Department of Neurology, [2]Ophthalmology and Visual Sciences,, [3]Psychology,, [4]Graduate Program in Neuroscience , University of British Columbia, Vancouver Canada, [5]Faculty of Medicine, Aga Khan University, Pakistan

Knowledge about the prior probability of target location may be exploited by the ocular motor system to enhance the efficiency of saccadic programming. However, little is known about whether these effects vary with saccadic programming demands or about their spatial organization.

Our first goal was to determine if the effect of prior probability differed significantly between prosaccades and antisaccades. Our second goal was to determine if prior probability effects differed between trials in which two targets were processed by the same cerebral hemisphere or by different hemispheres.

We performed two experiments. In the first, we contrasted a low-probability condition (0.125) consisting of eight targets, with two high-probability conditions (0.50) consisting of two targets, one in which the targets spanned the horizontal meridian, and one in which the targets spanned the vertical meridian. In a second experiment we replicated this design and added a third high-probability condition, in which the two targets were confined to a single quadrant.

We found that the effects of increased prior probability on prosaccades were minimal, with at most a slight reduction in reaction time. Antisaccades showed a much larger reduction in reaction times and improved directional accuracy, with less reflexive prosaccade errors. Both the directional accuracy and spatial precision of antisaccades were better for targets that spanned the vertical meridian, indicating a between-hemisphere advantage.

We conclude, first, that prior probability effects are larger for the more attentionally demanding antisaccade task. Second, the effects of prior probability on the computation of antisaccade trajectory show an inter-hemispheric advantage, consistent with theories of hemispheric interactions in attentional processing, through either divided resource allocation or selective filtering by the corpus callosum.

B8 242 Corrective saccades drive saccadic adaptation independently of explicit interpretation of retinal error

Junghyun Park[1] (jpark@caltech.edu), Shinsuke Shimojo[1,2]; [1]Biology, California Institute of Technology, [2]JST/ERATO Shimojo Implicit Brain Functions Project

Systematic displacements of saccade targets while the eye is in mid-flight lead to a gradual change in saccade amplitudes. A) What drives this saccadic adaptation: post-saccadic retinal error signals or secondary corrective saccades? B) How susceptible is this process to explicit knowledge regarding the source of the retinal error?

Participants (N=10) were tested in a 3x2 manipulation. A) Three conditions tested the effect of explicit cues signaling that post-saccadic retinal error was due to a target shift rather than saccade inaccuracy. In the conventional saccadic adaptation condition, the target spot simply stepped from 10° to 7°. In the color condition, the target shift was marked by a color change. In the bar condition, a long vertical bar was presented throughout the trial in-between the original and final target positions. B) Participants were either encouraged to make corrective saccades, following the target wherever it is; or prohibited from making corrective saccades, stopping wherever the first saccade landed. Each of the 6 condition combinations was tested on different days to prevent transfer of adaptation.

A) Saccadic adaptation occurred in all encouraged conditions and in about half of prohibited conditions where participants unconsciously and unwillingly made secondary saccades. Six participants successfully (>95% of trials) suppressed secondary saccades in >1 of the prohibited conditions. When secondary saccades were suppressed, saccadic adaptation was abolished despite of the presence of retinal errors. B) Explicit knowledge did not affect saccadic adaptation: secondary saccades to the shifted target location resulted in saccadic adaptation even in color and bar conditions where participants could clearly tell that the target had assumed a new position and thus the movement wouldn't "correct" the error.

These results suggest that the adaptive change in saccade amplitude involves implicit processes arising from the corrective saccade, and is independent of explicit knowledge of the source of visual error.

B9 243 Suppression of steady state smooth pursuit by irrelevant flashes

Dirk Kerzel[1] (dirk.kerzel@pse.unige.ch), Blandine Ulmann[1]; [1]Faculté de Psychologie et des Sciences de l'Education, Université de Genève

We examined the effects of briefly flashed stimuli on steady state pursuit. Subjects pursued a small cross moving at a velocity of 11 deg/s. After about 1 sec of pursuit, two bars subtending 45 deg horizontally were presented above and below the pursuit target. Presentation time was 30 ms. Because of the elongated shape and short presentation duration, very little perceivable motion along the direction of pursuit was produced by the stimulus. After flash presentation, smooth pursuit continued for another second. We observed a decrease of pursuit gain of about 10% starting 200 ms after flash onset. At the same time, the probability of catch-up saccades decreased from 4-5% to 1-2%. Pursuit gain recovered after another 200 ms. Increasing the eccentricity of the bar or decreasing its contrast reduced the effect of the distractor on smooth pursuit gain, but did not affect its latency. Compared to a visual flash, the presentation of a brief click sound produced only a very small decrease of pursuit gain. However, the click inhibited catch-up saccades at the same latency as the visual flash. Making the occurrence of the flash highly predictable or highly unpredictable did not change the pattern of results. Overall, our findings resemble previous studies showing that task-irrelevant flashes suppress the occurrence of saccades during reading and increase the latency of goal directed saccades. However, the latency of the suppression of smooth pursuit is much longer: Saccadic suppression occurs after ~80 ms, while smooth pursuit was affected after ~200 ms. The short latencies of saccadic suppression suggest a subcortical origin, maybe in the superior colliculus. The much longer latencies for the suppression of smooth pursuit suggest that cortical circuits are involved. This seems to be true for smooth pursuit and catch-up saccades.

Acknowledgement: D. Kerzel was supported by the Swiss National Foundation (SNF 10011-107768/1).

Locomotion I: General

Author Presents: 8:30 - 10:15 am

B10 244 Locomotor interception of unpredictable moving targets

Gabriel Diaz[1] (diazg2@rpi.edu), Flip Phillips[2], Brett Fajen[1]; [1]Dept. of Cognitive Science, Rensselaer, [2]Dept. of Psychology, Skidmore College

A variety of creatures ranging from predators in the wild to humans on the playing field repeatedly demonstrate the ability to intercept moving targets. Behavioral studies suggest that humans intercept moving targets by maintaining a constant bearing angle; that is, by keeping the target in a fixed exocentric direction. In the majority of these studies, the targets moved along linear paths at constant speeds. By comparison, targets in the real world often change directions and speeds in ways that range from completely predictable to completely unpredictable. Our experiment was designed to investigate the "in between" case in which targets change speeds in a semi-predictable manner. Subjects sat in front of a large projection screen and watched computer generated displays that simulated linear self-motion over a textured ground plane. Simulated speed was controlled by adjusting a foot pedal, the position of which was mapped onto speed according to a first-order lag. A spherical target approached the subject's path from one of three angles. Between 2.5 and 3.25 s after the trial began, target speed changed by an amount that was taken from a normal distribution of speed changes. The mean of the distribution was positive such that target speed usually increased, but occasionally decreased. Subjects' behavior was compared to that of an ideal pursuer, who moved in such a way as to maximize the likelihood of being able to intercept the target by anticipating the most likely change in target speed. Subjects' behavior was similar to that of the ideal pursuer, indicating that they adopted a strategy that allowed them to perform at near optimal levels. Differences between behavior of subjects and the ideal pursuer were also found under some conditions. Our findings provide insight into the strategies that humans adopt to deal with uncertainty in realistic interception tasks.

Acknowledgement: NSF BCS 0545141
URL: http://www.cogsci.rpi.edu/pandalabs

B11 245 **Evaluating Alternative Metaphors for Augmented Locomotion through Large Scale Immersive Virtual Environments**

Victoria Interrante[1] (interran@cs.umn.edu), Brian Ries[1], Eleanor O'Rourke[2], Leanne Gray[3], Jason Lindquist[1], Lee Anderson[4]; [1]Department of Computer Science, University of Minnesota, [2]Department of Computer Science, Colby College, [3]Department of Computer Science, Kansas State University, [4]Department of Architecture, University of Minnesota

Previous research shows that when participants can use direct walking to control their movement through a small, HMD-based immersive virtual environment (IVE), they report a greater sense of 'presence' in that environment than when they must use a metaphoric or indirect action, such as stepping-in-place or pressing-a-button on a hand-held wand for locomotion control. However, when the IVE is larger than the available physical space, it becomes necessary to re-consider the use of alternative metaphors.

We introduce a novel method for naturalistic, augmented direct locomotion through large-scale IVEs: seven-league-boots, describing its technical implementation and discussing alternative options and parameters. We then present the results of a series of experiments that seek to provide qualitative and quantitative insight into the relative strengths and weaknesses of this method in comparison to three commonly-used alternatives: virtual flying/gliding, via a button-press on a wand; uniformly accelerated real walking, achieved by allowing the user to walk normally but applying a uniform gain to the output of the tracker that re-defines his corresponding position in the virtual world; and normal walking without gain, but with intermittent major adjustments of the location and orientation of the IVE relative to the real-world position of the participant.

Seven-league-boots locomotion is characterized by an exaggeration of –only– the component of a person's movement that is aligned with his direction of intended travel. This requires knowing when purposeful travel is intended, and accurately predicting its direction.

A within-subjects experiment with 8 naïve participants found significantly higher 7-point ratings of overall preference for IVE exploration via boots (μ=6.25, ó=0.71) than with uniform gain (μ=3.38, ó=1.92), flying (μ=4.25, ó=0.89), or interrupted walking (μ=3.88, ó=1.46). A comparison of the accuracy of self-localization with respect to occluded landmarks in IVEs explored via boots vs flying is forthcoming and will also be reported.

Acknowledgement: This research was supported by the National Science Foundation (IIS-0313226), by the University of Minnesota through a Digital Technology Center seed grant and by the Linda and Ted Johnson Digital Design Consortium Endowment and Lab Setup Funds.
URL: http://www.cs.umn.edu/~interran/boots0.pdf

B12 246 **Catching fly balls in VR: A test of the OAC, LOT and trajectory prediction strategies**

Boris Khomut[1] (b.k@brown.edu), William Warren[2]; [1]Dept. of Cognitive & Linguistic Sciences, Brown University, [2]Dept. of Cognitive & Linguistic Sciences, Brown University

Professional baseball players somehow manage to intercept and catch fly balls successfully. Three perceptual strategies have been proposed to explain the outfielder's ability and to predict the fielder's interception path. (1) TP: The trajectory prediction strategy (Saxberg, 1987) proposes that the fielder perceives the ball's initial conditions, computes its trajectory, and runs directly to the predicted landing point. (2) OAC: The optical acceleration cancellation strategy (Chapman, 1968) proposes that the fielder continuously controls their radial motion (toward the ball) by running to null the vertical optical acceleration of the ball. Transverse motion (lateral) is controlled independently by holding the bearing direction of the ball constant. (3) LOT: The linear optical trajectory strategy proposes that the fielder runs so as to keep the ball's rising optical trajectory straight rather than curved; this maintains a constant ratio between the tangents of the ball's elevation and azimuth angles (tana/tanb = c). These strategies are normally highly correlated, but they can be tested in VR by manipulating the ball's trajectory. Brown University players were tested in an immersive virtual environment (12 x 12 m) while wearing a head-mounted-display (60 x 40 deg, 50-70 ms latency) with trackers on the head and glove. The ball's trajectory was manipulated by increasing or decreasing the gravitational constant (g) at the peak of flight. Trials in which gravity was changed were matched with normal trials in which the ball traveled the same distance on a parabolic arc. Participants made rapid and continuous adjustments to compensate for the change in gravity, inconsistent with TP. Moreover, their radial and transverse velocities varied independently, inconsistent with LOT. Behavior was most consistent with the combination of OAC and constant bearing strategies. We describe a dynamical model that implements this control strategy.

B13 247 **Visual odometry by leaky integration**

Markus Lappe[1] (mlappe@psy.uni-muenster.de), Michael Jenkin[2], Laurence Harris[2]; [1]Psychological Institute II, Westf. Wilhelms-University, Muenster, Germany, [2]Center for Vision Research, York University, Toronto, Canada

Visual motion can be a cue to travel distance when the motion signals are integrated. Previous work has given conflicting results on the precision of travel distance estimation from visual motion: Frenz and Lappe reported underestimation, Redlick, Jenkin and Harris overestimation of travel distance. In a collaborative study we resolved the conflict by tracing it to differences in the tasks given to the subjects. Self-motion was visually simulated in a immersive virtual environment. Subjects completed two tasks in separate blocks. They either had to report the distance traveled from the start of the movement as in earlier studies of Frenz and Lappe, or they had to report when they reached a predetermined target position as in earlier studies by Redlick et al. Consistent with both earlier studies, underestimation of travel distance occurred when the task required judgment of distance from the starting position, and overestimation of travel distance occurred when the task required judgment of the remaining distance to the previewed target position. Based on these results we developed a leaky integrator model that explains both effects with a single mechanism. In this model, a state variable, either the distance from start or the distance to target, is updated during the movement by integration over the space covered by the movement. Travel distance mis-estimation occurs because the integration leaks and because the transformation of visual motion to travel distance involves a gain factor. Mis-estimates in both tasks can be explained with the same leak rate and gain in both conditions.

Acknowledgement: supported by DFG LA-952/2 & 3, BMBF BioFuture, EC Drivsco, and NSERC

B14 248 **Effect of UFOV Impairment on Kinematics of Curve Driving**

Monica Severson[1] (mseverso@smith.edu), Ergun Y. Uc, MD[2,3], JonDavid Sparks, BA[2,4], Matthew Rizzo, MD[2,5,6]; [1]Department of Neuroscience, Smith College, Northampton, MA, [2]Department of Neurology, University of Iowa, Iowa City, [3]Neurology Service, Veterans Affairs Medical Center, Iowa City, IA, [4]Department of Biostatistics, University of Iowa, Iowa City, [5]Department of Mechanical and Industrial Engineering, University of Iowa, Iowa City, [6]Public Policy Center, University of Iowa, Iowa City

Objective: To assess profiles of motor vehicle kinematics (control) in drivers with impaired Useful Field of View (UFOV) while approaching and driving on a curve.

Methods: Licensed, active drivers with impaired UFOV (n=5) due Alzheimer's disease (n=4) or stroke (n=5) and elderly controls (n=5) with no neurological disease with normal UFOV (1251±272 msec vs. 354±103, p<0.0001, Wilcoxon Rank Sum) drove an instrumented vehicle on a 45 mph rural 2-lane highway. We assessed vehicle control measures (speed,

Saturday Posters

steering, lateral and longitudinal acceleration, brake and accelerator pedal position) and lane violations on a straight baseline segment and during 10 second approach to a curve and while driving along the curve.

Results: There were no differences in vehicle control measures and lane violations between groups during the baseline segment. Compared to controls, drivers with high UFOV had a larger reduction in their speed while approaching the curve (7.1±2.2 mph vs. 1.6±1.3, p=0.009, Wilcoxon Rank Sum) and drove slower on the curve . Once in the curve, drivers with high UFOV showed a higher speed variability (1.5±0.5 mph vs. 0.9±0.4, p=0.047) and smaller mean steering wheel excursion (12.2±4.0 degrees vs. 17.1±2.5, p=0.028). The impaired UFOV group had a tendency to commit more lane violation errors (0.8±0.5 vs. 0.2±0.5, p=0.072) during approach to the curve, but not on the curve.

Conclusion: Drivers with impaired UFOV slowed down more than controls in preparation for entry into a curve, yet committed more safety errors during this phase. Despite possible compensatory strategies such as driving slower and with smaller mean steering wheel excursion on the curve (driving closer to the shoulder), the drivers with impaired UFOV showed reduced control of their vehicle speed. These findings suggest that curves represent an added challenge for vehicle control and driving safety for drivers with impaired UFOV.

Acknowledgement: Supported by NIH AG17177.

B15 249 Visual control of locomotor steering: An fMRI study

John Wann[1] (J.P.Wann@rhul.ac.uk), David Field[2], Richard Wilkie[3]; [1]Royal Holloway, Univ of London, [2]University of Reading, [3]University of Leeds

Controlling direction of locomotion is fundamental to all mobile animals, and it is particularly critical for humans, whether as pedestrian or in vehicles. At ECVP 2006 Field, Wilkie & Wann presented an fMRI study exploring the neural correlates of human heading judgments and the equivalence to areas identified in macaques, including the ventral intraparietal area (VIP). Furthermore, we illustrated how the presence of a visible path, providing heading error information, activated bilateral regions focused on, but not exclusive to, parietal eye fields (LIP, although other cortical eye fields were not selectively activated by the pathway). Here we focus on how these regions are engaged when participants are actively steering over a textured ground plane to keep within the bounds of a roadway. The anterior portion of our parietal region of interest became more active when steering errors occurred, and the steering task also engaged bilateral areas of the cerebellum, left dominant dorsal premotor cortex, and supplementary eye fields (SEF). While the SEF activation was due to the eye-movements occurring during active steering, a saccade task and fixation conditions were used to exclude eye-movements as the primary factor in the activations observed in other key areas. (Supported by the UK EPSRC)

Acknowledgement: Supported by the UK EPSRC
URL: http://www.rdg.ac.uk/arl

B16 250 Simulated visual impairment affects night-time driving and pedestrian recognition

Joanne Wood[1] (j.wood@qut.edu.au), Alex Chaparro[2], Trent Carberry[1], Byoung Sun Chu[1]; [1]School of Optometry and Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, Australia, [2]Department of Psychology, Wichita State University, Wichita, KS

PURPOSE: To determine how simulated visual impairment impacts on night-time driving performance and pedestrian recognition measured under real road conditions. EXPERIMENTAL DESIGN: Night-time driving performance of 20 young normal participants (M=27.5 ± 6.1 yrs) was assessed on a closed road circuit for three different visual conditions. The visual conditions were mounted in modified goggles and contained simulated cataracts, refractive blur selected to match the visual acuity of the cataract condition and normal vision. All participants had binocular visual acuity greater than 6/12 (20/40) when wearing the goggles and satisfied the visual requirements for driving. Driving measures included road sign recognition, detection and avoidance of low contrast road hazards, lane-keeping and time to complete the course. Participants were also scored on recognition of pedestrians who wore either black clothing or retroreflective markings on either the torso or the limb-joints to create “biomotion.” RESULTS: Simulated visual impairment reduced night-time driving performance ($p<0.05$); posthoc testing indicated that these differences were greatest for the cataract condition, even though the cataract and blur conditions were matched for visual acuity. While visual impairment significantly reduced the ability to recognise the darkly clad pedestrians, the pedestrians wearing “biomotion” were seen 80% of the time. CONCLUSIONS: These data confirm that driving performance under night-time conditions is significantly degraded by the effects of early visual impairment and that pedestrian recognition is greatly enhanced by marking limb-joints to create “biomotion” which was relatively resistant to the effects of visual impairment.

Acknowledgement: Queensland Transport and staff of the Mt Cotton Driver Training Centre

B17 251 A Reinforcement Learning Model of Visually Guided Braking

Chris R. Sims[1] (simsc@rpi.edu), Brett R. Fajen[1]; [1]Department of Cognitive Science, Rensselaer Polytechnic Institute

Models of continuously controlled visually guided action consist of laws of control that describe how informational variables map onto action variables. These models suffer from at least three problems. First, they are far too rigid to capture the flexibility that humans exhibit when adapting to changes in the environment, the dynamics of the controlled system, and costs associated with making different kinds of errors. Second, existing models tend to ignore the inherent limitations of human perceptual and motor systems. Third, there is no compelling account of how laws of control are learned through experience. Reinforcement learning (RL) provides a potentially powerful framework for developing models of VGA that address the weaknesses of existing models. We developed a RL model of visually guided braking that simulates how an agent might learn a behavioral policy that maximizes performance in terms of stopping within a small radius of a target. While RL is widely used for optimal behavior in discrete tasks, a significant obstacle posed by visually guided action is the continuous state and action spaces. Our model represents continuous perceptual input (distance-to-target and velocity) and motor output (brake pressure) using tile coding for function approximation. This feature enables the model to achieve near-optimal task performance while greatly speeding learning, which occurs using the Q-learning update rule. Further, our RL model is designed to explore biologically realistic limitations on performance (e.g., perceptual noise, stimulus discriminability thresholds, and motor variability), as well as variations in reward structure. In contrast to the potentially arbitrary constraints of control law models, reinforcement learning optimally adapts behavior only to the constraints of the model’s physical embodiment and the reward structure of the task. The model will be evaluated by comparing simulated data with data from experiments with human subjects performing a simulated braking task.

Acknowledgement: NSF 0236734

B18 252 Optic flow serves as a teaching signal for visual-locomotor adaptation

William Warren[1] (Bill_Warren@brown.edu), Hugo Bruggeman[1], Wendy Zosh[1]; [1]Department of Cognitive & Linguistic Sciences, Brown University

Humans rely on two strategies to walk to a goal: (1) Optic flow strategy: null the visual angle between the heading specified by optic flow and the visual direction of the goal; (2) Egocentric direction strategy: null the angle between the locomotor axis and the egocentric direction of the goal. Optic flow dominates in environments with sufficient visual surface structure. In the 1960's, Held proposed that optic flow might also drive prism adaptation during walking.

We test this hypothesis by adapting participants to displays in which the optic flow pattern was displaced from the walking direction by 10 deg to the right, and then testing them with normal flow. Participants walked to a target in an immersive virtual environment (the 12 m x 12 m VENLab)

Saturday Posters

while wearing a head-mounted display and head tracker. Two worlds were used in both adaptation and test phases: (a) a lone target line (minimal optic flow), or (b) textured surfaces and posts (rich optic flow). This created a 2x2 design with four groups of participants.

In the Line world, results show gradual adaptation, with gradually reduced heading error and straighter paths over 36 trials. In the Textured world there was immediate behavioral adaptation in the first few trials. When both adapted and tested in the Line world, participants showed a small negative after-effect, such that heading errors and paths deviated in the opposite direction. But when adapted in the Textured world and tested in the Line world, there was a large negative after-affect. In contrast, when tested in the Textured world, both after-effects were immediately abolished.

The results indicate that optic flow serves as the teaching signal that adapts the visual-motor mapping between egocentric direction and walking direction. Optic flow thus dominates both the guidance of walking and visual-locomotor adaptation in visually structured environments.

B19 253 **The influence of locomotion on the axis-aligned motion bias in large situated display environments.**

Igor Dolgov[1, 2] (idolgov@cox.net), Christopher Todd[2], David Birchfield[2,3], Michael McBeath[1], Harvey Thornburg[2,4]; [1]Department of Psychology, College of Liberal Arts and Sciences, Arizona State University, [2]Arts, Media and Engineering Program, Herberger College of Fine Arts and Ira A. Fulton School of Engineering, Arizona State University, [3]School of Music, Herberger College of Fine Arts, Arizona State University, [4]Department of Electrical Engineering, Ira A. Fulton School of Engineering, Arizona State University

Work by Morikawa (1999) and Dolgov, et al. (2005) confirmed that stationary observers reliably misjudge projected destination of axis-misaligned figures in the direction the axis is tilted, a phenomenon we named "Axis-Aligned Motion" (AAM) bias. The current study evaluates whether or not the AAM bias is diminished if observers can respond with a navigational action versus stationary pointing. Participants observed moving symmetric and asymmetric figures in a large, overhead-projection, situated-display environment. The task was to judge projected destination of figures that move along the floor and then disappear midway across a colored 3 meter diameter circle. Eight participants completed 24 trials in each of the 3 experimental conditions: 1) stationary observers estimating projected destination of shapes using a laser pointer; 2) mobile observers that begin walking to the projected destination after the shape finishes moving; and 3) mobile observers that begin walking as soon as the shape begins to move. Replicating previous research, stationary observers reliably misjudge projected destination of axis-misaligned moving figures in the direction the axis tilts. Across all conditions, final destinations of axis-aligned symmetric shapes were judged significantly more accurately than asymmetric and axis-misaligned symmetric shapes ($p<0.05$). The impact of locomotive action on the AAM bias was supported by the absolute magnitude of error being significantly greater ($p<0.05$) in the stationary versus mobile conditions, which did not significantly differ from one another. The findings confirm the existence of the AAM bias in a large situated-display environment and demonstrate that its influence on motion perception can be mitigated by allowing observers to locomote to the estimated destination. They support that AAM is a natural regularity for which observers have developed a bias, and that this bias is diminished for navigational action tasks such interception, consistent with previous research demonstrating differences in perceptual phenomena for stationary versus active tasks.

B20 254 **Recalibration of the relationship between visual and action space: Evidence for generalization across actions**

Colin Ellard[1] (cellard@watarts.uwaterloo.ca), Lori Wagar[1], Meghan Eller[1]; [1]Department of Psychology, University of Waterloo

In a blind walking task, participants can be induced to under or overestimate the distances to visual targets by training them with mismatching viewed and walked distances (Ellard & Thompson, VSS 2002). This may indicate that participants have recalibrated the relationship between visual space and action space, or it might mean that they have learned a series of associations between the appearance of a target and the effort required to walk to it. In order to distinguish between these possibilities, we conducted new studies in which we trained participants using mismatched visual and walked target locations, and then tested them by asking them to either throw a ball at a visual target or to complete a spatial updating task. In both cases, the training consisted of 21 blindwalking trials at distances ranging from 8 to 16 m. On each trial, the participant was asked to view the target and then, while blindfolded, they were led to a location that they were told corresponded to the visual target location. In conflict conditions, the walked location was either 20% closer (-20 condition) or 20% further away (+20 condition) than the visual target location. Following training, some participants were required to throw a ball at a visual target. Other participants were presented with a spatial updating task in which they were asked to briefly view an offset visual target, walk forward without vision until told to stop, and then turn to face the target Results from both the ball throwing and the updating task showed that the conflict training exerted an effect on responses in the predicted directions, but the -20 condition exerted a much stronger effect than the +20 condition. These findings provide preliminiary evidence that our training procedure recalibrated the relationship between visual space and action space.

Visuomotor Control: Hand Movements

Author Presents: 8:30 - 10:15 am

B21 255 **Visually guided pointing and the Müller-Lyer illusion: why are the data so contradictory?**

Nicola Bruno[1] (nick@psico.units.it), Paolo Bernardis[2]; [1]Dipartimento di Psicologia & BRAIN Center for Neuroscience, Università di Trieste, [2]Scuola Superiore di Studi Umanistici, Università di Bologna

Some models of visual function propose that vision-for-action and vision-for-perception use different spatial representations, so that the visual guidance of action can be accurate even when there are systematic biases in conscious visual perception. Support for this counterintuitive prediction has come from behavioral studies suggesting that visually guided actions are largely immune from visual illusions. However, contrary to this prediction other studies have documented substantial illusory effects in motor tasks. Such large contradictions in the literature pose a challenge, and suggest that we might obtain useful insights about the visual guidance of pointing if we could understand the factors behind these differences of results. We have reanalyzed 33 independent studies of pointing on the Müller-Lyer and related illusions. Our reanalysis shows that estimates of the illusion effect average slightly above zero but vary widely across studies (from around zero to comparable to perceptual effects). In addition, our reanalysis shows that a substantial proportion of this variability can be explained by four factors: the initial position of the pointing finger, the quality of visual feedback during the pointing action, the number of trials per condition of the experiment, and the interaction of feedback and trials. These findings suggest that pointing is immune from the illusion under certain conditions, but it can be strongly affected by it under others. We propose, in particular, that immunity of pointing from visual illusions is not a matter of response mode but depends on a subtle interplay of a variety of factors, a crucial role beeing played by feedback-driven motor learning.

Acknowledgement: Supported by MIUR - PRIN 2005057573_004

B22 256 **Execution generated illusory motor bias: two systems, one representation**

Gord Binsted[1] (gord.binsted@usask.ca), Crystal Ehresman[2], Matthew Heath[3], Deb Saucier[2]; [1]University of Saskatchewan, [2]University of Lethbridge, [3]University of Western Ontario

Previous research has suggested that the neural substrates of visual perception (i.e. ventral stream; inferior temporal projections) are separate from those for the visually control of actions (i.e. dorsal stream; parietal projections). Further, (Glover 2004) has posited a supplementary separation of the dorsal pathway between the planning and control of action: planning (inferior parietal) being under the influence of perception while online control (superior parietal) works on metrically precise visual information. This study analyzed eye and hand movements directed toward both configurations of the Müller-Lyer in an entirely closed-loop procedure. Participants were asked to point to the right vertex of a visual stimulus in two conditions: the control condition where the figure (in-ML, neutral, out-ML) remains unchanged throughout the movement and the experimental condition where the figure (neutral) changes to an illusory configuration (in-ML, out-ML) after movement onset. Based on the planning and control hypothesis two effects were predicted: (1) action-bias should reduce throughout execution due to online control in control trials (2) action-bias should be absent in experimental trials, and (3) saccadic-bias should only be present during control trials. Counter to the planning and control position, but consistent with previous work from our group (see Heath et al 2004, 2006), action-bias was not only present (and not mediated by online control) in both experimental and control conditions but become more pronounced throughout execution (experimental). Further, while primary saccades were influence by illusory configurations (control conditions; see Binsted & Elliott 1999), illusory bias developed within the secondary "corrective" saccades during experimental trials. These results support the position that a unitary spatial representation underlies both action (planning or control) and perception and, further, that this representation is common to both the manual and oculomotor systems.

B23 257 Grasping after a delay: More ventral than dorsal?

Volker H. Franz[1] (volker.franz@psychol.uni-giessen.de), Constanze Hesse[1], Susanne Kollath[1]; [1]University of Giessen

It is often assumed that grasping is only controlled by the dorsal cortical stream if visual information about the target object is easily available. After a short delay between stimulus presentation and grasping the dorsal information should be decayed and the action should be guided by the ventral stream. Accordingly, grasping should not be affected by certain visual illusions under full-vision conditions, but it should be affected after a delay (because only the ventral stream is assumed to be deceived by these illusions). We tested this for the Müller-Lyer illusion. In experiment 1 (N=16), we investigated grasp illusion and perceptual illusion for full-vision and 5sec delay conditions. The perceptual illusion was independent of delay (p=.23), while grasping showed a strong increase of the illusion effects (p<.001). This replicates the increase of the motor illusion found in the literature. In experiment 2 (N=8), we tested whether the delay causes this increase by comparing open loop grasping (shutter goggles close when movement starts) with the 5sec delay condition. Illusion effects on grasping were constant (p=.90), suggesting that delay is not the critical factor. In experiment 3 (N=20), we systematically decreased the amount of visual feedback available during the grasping movement using the conditions: full vision, vision suppressed when fingers had traveled 2/3 or 1/3 of the way to the target object, open loop (goggles close when movement starts), and open loop after go-signal (goggles close with auditory go-signal). Illusion effects decreased the more visual feedback was provided (p=.001). This suggests that the critical factor is visual feedback and not different memory systems in dorsal and ventral streams.

Acknowledgement: This work was supported by grant FR 2100/1-2 from the Deutsche Forschungsgemeinschaft (DFG).

B24 258 Evidence for the Use of a Binocular Tau-dot Strategy in Visually Guided Reaching

Joe Anderson[1] (joseande@indiana.edu), Geoffrey Bingham[1]; [1]Department of Psychological and Brain Sciences, Indiana University

In this work, we propose a novel control strategy for the visual guidance of targeted reaching based on the use of binocular disparity information. The disparity information that we propose is different from that previously proposed (Gray & Regan, 2004). We claim that individuals with binocular vision can use a disparity-nulling strategy combined with information about the rate of change of disparity to control velocity changes of a reach and bring the hand to the target. Although disparity-nulling strategies for the control of visually-guided reaching have been proposed before (Bingham et al, 2001); none of these proposals included a control mechanism for the timing of the movement. The accurate control of movement timing via control over velocity is paramount for successful human action. In this model, velocity can be directly controlled using a purely optical, binocular tau-dot strategy. Using this strategy, an individual need only hold the value of disparity defined tau-dot at ~-.5 in order to achieve soft contact of the hand at the target. We isolated the use of binocular disparity in a manually controlled distance matching task to test this hypothesis. Eight participants were asked to match in the dark the distance of two point-lights in depth by reaching and moving one light along a track to the distance of a second, target light. The trajectories of these reaching movements were recorded using a Mini-bird motion measurement system. Disparity tau-dot values were computed using three methods. Tau-dot values were computed by analyzing the viewing geometry and kinematics, by taking the derivative of tau, and using the slope of a line fit to tau values. All three methods produced equivalent measures of tau-dot. Results show that participants use a constant tau-dot strategy beginning just before the decelerative portion of the reach and ending just before target contact.

B25 259 A Binocular Tau-dot Model for Guiding Reaches

Geoffrey Bingham[1] (gbingham@indiana.edu), Joe Anderson[1]; [1]Department of Psychological and Brain Sciences, Indiana University

Vision is used to program the initial, feedforward component of a reach as well as to control accuracy during the feedback component of a reach. Previous research has shown that binocular information is important for both components. Vergence can be used to program the feedforward component of a reach by providing distance information. It's been proposed that disparity matching could be used in the feedback component, however, this would not specify how to control the hand's approach velocity. One well known control strategy for visually controlling approach is the classic monocular tau-dot strategy: move so as to preserve tau-dot at -.5. This yields constant decleration to stop at a target. Monocular tau cannot be used to guide the hand to a target. Instead, we propose a disparity tau-dot strategy. Disparity tau is defined as the ratio of the relative disparity between hand and target to the temporal rate of change of that disparity. What types of trajectories would be produced by moving so as to hold this disparity tau-dot constant? We generated simulated reaching profiles based on our disparity tau-dot model. Both position and velocity profiles were output by integrating the model over time given a constant tau-dot value, initial hand and target distances from the eye, and initial hand velocity. Using representative values produced characteristic reach trajectories. The simulated reaches exhibited acceleration to a peak velocity followed by deceleration to soft contact at the target. Constant temporal change of disparity tau does not correspond to constant change of time-to-contact of the hand relative to a target! This constant tau-dot model is different from monocular tau-dot because it generates both acceleration and deceleration. This result is important because the trajectories look exactly like those of natural reaches meaning that it may well indeed be used to guide such reaches.

B26 260 Planning movements well in advance

Constanze Hesse[1] (constanze.hesse@psychol.uni-giessen.de), Denise D.J. de Grave[2], Volker H. Franz[1], Eli Brenner[2], Jeroen B.J. Smeets[2]; [1]Experimental Psychology, Justus Liebig University Giessen, [2]Faculty of Human Movement Sciences, Vrije Universiteit Amsterdam

It has been suggested that the precise metrics of grasping movements directed to visible objects are computed in real-time and are therefore unaffected by previous experience or any earlier programming (Cant, et al., 2005, Neuropsychologia, 43(2), 216-226). We have tested whether the properties of a visually presented distractor object can influence the kinematics of a subsequent grasping movement performed under full vision. Ten participants grasped a target object after viewing a small or large elliptical distractor object in a certain orientation (0° or 30°). The target object appeared at the same location and could be either the same object in the same orientation as the distractor, or a circular object, which is neutral in orientation. When grasping the circular target object, grip orientation was affected in the direction of the previously presented distractor object. That is, at the time of maximum grip aperture grip orientation was 23.3° ± 2.2° after having seen the distractor in 0° orientation and 28.9° ± 1.6° after having seen the distractor in 30° orientation. Moreover, as in classical visuomotor priming, grasping movements were initiated 30ms ± 4ms faster when distractor and target were identical. Our study provides evidence that the planning of fully visually guided movements is influenced by prior perceptual experience. This planning is reflected in a change of movement parameters, in particular grip orientation, by the properties of the previously perceived object. This finding challenges the notion that grasping movements are controlled on the basis of real-time information alone.

Acknowledgement: This research is supported by DFG-Grant FR 2100/1-2

Saturday Posters

B27 261 **Vision predominates sensorimotor transformations for online grasping control**

Matthew Heath[1] (mheath2@uwo.ca), Luc Tremblay[2], Gord Binsted[3]; [1]The Universitiy of Western Ontario, [2]University of Toronto, [3]University of Saskatchewan

Visual feedback has been shown to play a pivotal role shaping metrical and efficient spatiotemporal grasping parameters (Jeannerod, 1985). In the present investigation, we sought to determine the degree visual feedback predominates the exemplar specification of grasp kinematics (i.e., peak grip aperture, time to peak grip aperture) by applying an intrinsic afferent perturbation to the grasping limb. Specifically, participants completed closed-loop (i.e., with continuous visual feedback) and open-loop (i.e., visual feedback withdrawn at movement initiation) grasps to midline objects in the depth plane under an environment wherein 33% of the trials entailed an unexpected and small amplitude (1 mm) high-frequency (70 Hz) vibration to the antagonist muscle (i.e., the biceps) of the grasping limb. The purpose of the tendon vibration was to induce erroneous sensory feedback concerning the reaching characteristics (e.g., absolute position and velocity) of the grasping limb. For closed- and open-loop trials performed without tendon vibration, maximal grip aperture scaled with veridical object size and occurred at approximately 70% of movement time. Interestingly, closed-loop trials performed with tendon vibration elicited kinematic parameters parallel to non-vibrated counterparts whereas open-loop trials showed a decrease in grip aperture scaling and delayed onset of maximal grip aperture. Moreover, time-course examination of grasp kinematics showed that closed-loop grasps were refractory to tendon vibration throughout the movement trajectory; however, open-loop grasp parameters were sensitive to an early (i.e., at peak acceleration) and continuous influence of tendon vibration. Those results confirm the central role of vision in the specification and online control of action and provide putative evidence of an inhibitory central nervous system mechanism, or mechanisms, allowing vision to supercede other afferent resources for the online control of reach and grasp movements.

Acknowledgement: Supported by NSERC.

B28 262 **Gauging Affordances for Reaching through Apertures**

Shaziela Ishak[1] (shaziela@nyu.edu), Karen Adolph[1]; [1]Psychology, New York University

Affordances—possibilities for action—are constrained by the fit between the physical properties of the actor and the environment. For example, fitting the body through a narrow opening is constrained by the dimensions and orientation of both the aperture and actors' body. Vision allows actors to compare their body dimensions to the size of the aperture, and enables them to plan prospectively how best to orient the appropriate body parts relative to the shape of the opening. Adaptive motor decisions depend on the ability to detect affordances accurately.

In three experiments, we examined the correspondence between motor decisions and actual affordances for reaching through apertures. Participants fit their hands through a range of diamond-shaped apertures (0 cm - 40 cm) to retrieve small targets. Using an adaptive psychophysical procedure, we estimated affordance thresholds for each participant (smallest aperture they could fit their hand through 50% of the time). We examined participants' motor decisions normalized to each participant's affordance threshold.

Experiment 1 showed that participants accurately scaled motor decisions for fitting their dominant hand through apertures to their hand size, and that decisions and thresholds were reliable over two blocked protocols. Experiment 2 examined the effects of habitual practice; participants made equally accurate motor decisions when reaching with their more practiced dominant hand and less practiced non-dominant hand. Experiment 3 showed that participants recalibrated their motor decisions to take changing body dimensions into account; motor decisions normalized to affordance thresholds while wearing a hand-enlarging glove were similar to motor decisions normalized to affordance thresholds without the glove.

In all 3 experiments affordance thresholds were highly correlated with participants' hand width. Additionally, participants produced a range of information gathering behaviors ranging from solely visual exploration to manual exploration of the apertures.

B29 263 **Do binocular depth cues have a special role in grasping?**

Simon Watt[1] (s.watt@bangor.ac.uk), Bruce Keefe[1], Paul Hibbard[2]; [1]School of Psychology, University of Wales Bangor, [2]School of Psychology, University of St. Andrews

When grasping with one eye covered the finger and thumb are opened significantly wider than for binocularly-guided grasps, as if to build in a margin of error. This has been interpreted as evidence for a functional specialism for binocular vision in the control of grasping (Servos et al., 1992; Watt & Bradshaw, 2000). Such studies have, however, confounded the available depth cues and the precision with which object properties are estimated. Removing binocular cues from a normal scene degrades depth information, and so impaired performance is to be expected even if grasping does not depend specifically on binocular cues. We first measured JNDs in object size for computer-generated objects viewed binocularly and monocularly. In the binocular condition the object was a sparse random-dot stereogram depicting a rectangular block. In the monocular condition the same shape was defined by texture gradients on its surfaces. Objects were presented along a horizontal surface, below eye level. By varying object distance (cf. Hillis et al, 2004) we determined stimulus conditions in which the precision of estimates of object size was matched across binocular and monocular conditions. We then measured movement kinematics for grasps to these "matched" stimuli. Appropriate haptic feedback was provided. Vision of the hand and stimulus was occluded at movement onset. For most observers, grasp apertures did not differ significantly when reaching for matched binocular and monocular stimuli. Their grasps were smaller under monocular viewing when monocular size estimates were more precise. For some observers the pattern of JNDs predicted trends in the grasp apertures, but grasps remained slightly larger in the monocular condition. These results suggest that grasping is not controlled by a specifically binocular system, but the weighting given to binocular cues may be higher than is predicted by statistically optimal cue integration (Knill, 2005).

B30 264 **Independent gaze-centered representations of reach targets viewed with left vs. right eye**

Aarlenne Khan[1] (aarlenne@ski.org), Gunnar Blohm[1], Lei Ren[1], J Douglas Crawford[1]; [1]Centre for Vision Research, York University, Toronto, Ontario, Canada

Numerous studies on visuomotor control (reaching and pointing) have implicitly assumed that there is a single eye-centered representation of target location for planning movements. However, visual information about target location enters our brains through two eyes which are horizontally separated and therefore provide disparate location information. In this study, we explored whether information about target location from the two eyes is actively transformed into a common eye-centered representation for reach space or whether the eye which encodes target location matters. We dissociated the location of targets presented to the two eyes by having seven subjects pointing to a distant central target while fixating on various (near) horizontally displaced, peripherally viewed targets,, a) with the right eye only or b) left eye only. We measured the final pointing positions of the fingertip in space. When pointing to peripheral viewed targets, subjects tend to overshoot the position of the target depending on its position relative to gaze. During viewing with each eye, this gaze-dependent pattern of overshoot errors depended on target location relative to each eye independently. These results suggest that the information about target location from the two eyes is not actively transformed into a single common target representation.

Acknowledgement: Support provided by NSERC, Canada

B31 265 **Visual control of hand position and orientation during one-handed catching**

Brett Fajen[1] (fajenb@rpi.edu), Christopher Cramer[1]; [1]Department of Cognitive Science, Rensselaer Polytechnic Institute

To catch a ball, one must move one's hand to the right place at the right time, with the palm oriented roughly orthogonal to the ball's direction of motion. Predictive models of catching are based on information about when the ball will pass within reach, and where it will be and in what direction it will be traveling when it reaches that point. Recent studies suggest that both passing distance and direction of motion-in-depth are overestimated, leading some to conclude that hand movements are not guided by predictive information. However, viewing conditions were restricted and eye, head, and body movements were constrained in these studies, and the perceptual judgment tasks used to measure perceived passing distance and direction of motion-in-depth were unlike natural catching tasks. In this study, we used a natural catching task to measure perceived passing distance and direction of motion-in-depth. Subjects wore a stereoscopic head-mounted display. Head and hand position and orientation were tracked by a motion tracking system. Virtual balls were projected into the air along a parabolic path and passed within reach of the subject. Passing distance and approach angle were manipulated independently. Subjects were instructed to reach out and catch the virtual balls with their right hand, orienting the hand so that the palm was orthogonal to the ball's direction of motion. Analyses focused on the effects of passing distance and approach angle on hand position and orientation. The implications of these findings for predictive models of catching will be discussed.

Acknowledgement: NSF 0545141

B32 266 **Reaching to a Point or Reaching over a Distance - What is the Difference?**

Lore Thaler[1] (thaler.11@osu.edu), James Todd[1]; [1]Department of Psychology, The Ohio State University

Observers perform approximately veridical when asked to walk to or reach for a target under "open-loop" conditions. However, perceptual judgments of relative depth extent are systematically distorted.

One possible explanation for this dissociation is that motor response and perceptual judgment are based on fundamentally different processes. Another possible explanation is that performance has been compared across tasks that require subjects to use different types of visual information. Whereas judgments of relative depth extent require the representation of distances, reaching for a target can be performed based on a point-to-point mapping of effector-to-target location that does not require the representation of distances. Consequently, we would expect equivalent performances on motor and perceptual tasks when they rely on the same visual information. The experiments presented here were designed to test this prediction.

On each trial, subjects viewed a target line segment (TLS) in depth that varied in length across trials. In the "motor" task, subjects performed "open-loop" reaches, where they matched the length of their reach to the length of the TLS. In some cases, hand and TLS starting locations coincided, and subjects could reach to the TLS endpoint. In other cases, TLS and hand starting locations differed, and subjects had to rely on perceived TLS length alone. In the "perceptual" task, the TLS was briefly presented and subjects adjusted an auxiliary line segment to match the perceived length of the TLS.

Our results show, that performance in perceptual and motor tasks is equivalent. Subjects are more accurate and reliable when they can rely on information on TLS endpoints, than when they must rely on TLS length information alone and they show systematic errors in the latter case. We suggest that perceptual and motor processes are tightly connected and that systematic errors are caused by distortions in perceived depth extent.

URL: http://www2.psy.ohio-state.edu/visionlab/lore/grasp_vr.html

B33 267 **Performance in rapid, sequential visually-guided pointing movements**

Shih-Wei Wu[1] (sww214@nyu.edu), Maria F DalMartello[2], Laurence T Maloney[1,3]; [1]Department of Psychology, New York University, [2]Department of General Psychology, University of Padova, [3]Center for Neural Science, New York University

Purpose: We investigated how directional change, distance, and reward affected the speed and accuracy of rapid pointing movements to multiple targets.

Method: On each trial subjects saw two targets presented on a horizontal LCD touch screen. They attempted to hit both targets in a specified order within 400 ms after they initiated movement. Successful hits resulted in monetary rewards. Subjects were first trained to perform the task (640 trials) without reward. In the experimental session, subjects were rewarded for hits. Four subjects participated, three naïve.

We varied direction: the two movements required a change of 0, 90, 180, or 270 degrees in direction; distance: The two movement distances were equal (7.5cm) or the second was increased by a factor of 1.375; and reward structure: In one reward condition, both targets had the same value. In the other reward condition, the second target was worth 5 times more than the first target. Subjects performed 16 blocks (4 directions x 2 distances x 2 rewards) of 50 trials each for a total of 800 experimental trials per subject.

Results: When distance and reward were equal, all subjects spent considerably more time transiting to the first target (mean 148±15ms) than to the second (mean 106±9ms) and the likelihood of hitting the first was correspondingly higher (87±1%) than for the second (63±2%). When the distance to the second target was greater subjects spent only 13±2ms more on the second movement. When reward was unequal, subjects spent more time in transiting from first to second target but with only a slight increase in probability (7.6%) of hitting the second. We found no significant influence of hitting one target on the probability of hitting the other. This lack of interaction and the overall tendency to favor the first target were unexpected and will be discussed.

Acknowledgement: NIH EY08266

B34 268 **Learning in image-guided reaching changes the representation-to-action mapping**

Bing Wu[1,2] (bingwu@andrew.cmu.edu), Roberta Klatzky[1,3], Damion Shelton[2], George Stetten[2,3,4]; [1]Department of Psychology, Carnegie Mellon University, [2]Robotics Institute, Carnegie Mellon University, [3]Human-Computer Interaction Institute, Carnegie Mellon University, [4]Department of BioEngineering, University of Pittsburgh

In training trials, subjects reached with a needle to a hidden target in near space using ultrasound guidance. Systematic errors were initially introduced by displacing the ultrasound sensor in depth, relative to the reaching point. Subjects learned to accommodate to the displacement with practice. The improvement, in theory, could be accomplished by (i) adjustment of target-location representation, (ii) learning specific motor responses, or (iii) establishment of a new representation-to-motor mapping. Experiment 1 assessed the first hypothesis. Using a visual matching paradigm, subjects' judgments of target location were measured before and after the training. Although reaching accuracy improved with training, there was no corresponding change in visual matching. Moreover, training did not generalize fully to a new reaching point, as would be expected if learning corresponded entirely to refinement of target location. The results thus gave little support to the hypothesis. In Experiment 2, using a task of aligning a hand-held stylus with a visible line, subjects' motor responses were measured before and after the training. Again needle guidance improved with training, but there was no corresponding change in hand alignment, which contradicts the motor-learning hypothesis. Experiment 3 assessed whether subjects learned a general mapping from representation to action. After training as before, the ultrasound sensor was moved up to the same plane as the reaching entry point, causing a shift in the target position on the image. Generalized re-mapping predicts that the previous motor compensation should be imposed on the new location representation, producing a corresponding error. As predicted, the initial error in subjects' insertion response was very similar to the learned correction during the training. The remapping that resulted from cognitive correction is similar to perceptual effects of prism goggles, where feedback from reaching to one spatial location generalizes to others with corresponding distortion magnitude.

Acknowledgement: Supported by grants from NIH (#R01-EB000860) and NSF (0308096)

B35 269 **Constraint induced learning in a visually guided motor task**

Uta Wolfe[1] (uwolfe@hws.edu), James Gray[1], Laurence Maloney[2,3]; [1]Department of Psychology, Hobart and William Smith Colleges, Geneva, NY, [2]Department of Psychology, New York University, [3]Center for Neural Science, New York University

Visuo-motor planning is influenced by previous experience with the visual world, the reward structure of the environment, and the state of one's motor system. A physical constraint on one's joints, be it through injury or an external restraint, can be thought of as changing both the cost structure of movement and the state of one's motor apparatus. Here we investigated how joint constraints at the wrist, fingers and elbow affect movement times and kinematics in a visually guided grasping and reaching task.

Experiment 1: Participants (n=6) were asked to place a series of small discs into slots as fast as possible. Blocks of unconstrained trials were alternated with blocks during which the participant wore a brace around the fingers, wrist or elbow. Each participant performed blocks with each constraint. Movement times were recorded and compared between the constrained and unconstrained trials and between the unconstrained trials prior to and after each constraint.

Experiment 2: Participants (n=9) performed the task above while their movement times and 3D position and orientation of their hand, wrist, elbow, and shoulder were recorded with a Polhemus Liberty. As in Experiment 1, unconstrained and constrained blocks were alternated, but each participant was exposed to only one constraint (wrist (n=5) or elbow (n=4)).

Results: In both experiments, while all constraints slowed movements significantly, repeatedly moving with the wrist constraint (but not with the elbow or finger constraint) led to significantly faster movements after the constraint was removed. Since this improvement in movement time was an aftereffect specific to the wrist constraint, it was not simply the result of repeated practice and must have been due to a new compensatory strategy learned as a result of experience with the constraint. Compensations that were identified from the joint position and orientation data will be discussed.

Acknowledgement: NS047178-01A1

B36 270 **Human pointing movements in a probabilistic environment**

Anna Seydell[1] (anna.seydell@psychol.uni-giessen.de), Brian McCann[2], Julia Trommershäuser[1], David Knill[2]; [1]University of Giessen, Germany, [2]University of Rochester, NY

Recent studies indicate that humans plan pointing movements to maximize gain by taking into account deterministic spatial distributions of costs and rewards in a display (e.g. Trommershäuser, et al., 2003, JOSA A, 20, 1419). We asked whether subjects can similarly learn to optimize their pointing movements when rewards and penalties are binary (success or failure), but stochastic; that is, when hitting different points on a target lead probabilistically to success or failure on a trial according to spatial probability distributions unknown to a subject.

Subjects pointed to a rectangular target zone overlayed with two rectangular "goalies." The goalies moved stochastically to a new position at the time a subject's finger touched the table. This new position was drawn randomly from a uniform distribution centered at the goalies' original positions. In different conditions, we used different starting positions of the goalies, and jump distributions of different widths, indicated by the color of the goalies. Hits inside the target region, unblocked by a goalie, earned 100 points, while hits outside the target region or blocked by a goalie incurred a 100 point loss. Optimal aim points were determined by three factors – the initial positions of the goalies, the distributions of their jumps, and the subject's own motor variability.

Subjects' initial pointing strategies were suboptimal; however, over several sessions , subjects adjusted their aim points to account for changes in expected gain incurred by changes in initial goalie position and goalie jump distribution, even when this involved qualitative changes in strategy (e.g. aiming at the boarder of the target zone rather than at the large space in between the two goalies). Subjects' performance expressed in terms of expected gain was close to optimal. We conclude that humans are able to use stochastic feedback to quickly learn optimal movement strategies in stochastic environments.

Acknowledgement: this research was supported by grants DFG TR528 1-3 to J.T., and NIH R01-EY13319 to D.K.

B37 271 **The covariance structure of speeded reaching movements**

Todd E Hudson[1,2] (hudson@cns.nyu.edu), Uta Wolfe[3], Laurence T Maloney[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University, [3]Department of Psychology, Hobart & William Smith Colleges

Purpose: Movement planning takes into account both movement uncertainty and rewards/losses associated with the possible outcomes of the movement. Previous research has focused on uncertainty in movement endpoint. Here, we manipulate reward/loss and examine the covariance structure of uncertainty along the movement trajectory. To do so we required subjects to pass to the left of an invisible virtual obstacle in reaching to targets to earn monetary rewards.

Methods: Targets were located at one of three positions on the screen (either on the subject's midline, or to the right of the midline) spaced 3.8 cm apart. A line on the screen marked the edge of an invisible vertical half-plane, parallel to the screen, and situated 66% of the way between the start point and the screen. Its edge was always .7 cm to the right of the target. Each of 6 naïve subjects completed trials across three different penalty conditions and for three locations of the target/obstacle. Subjects practiced touching targets, and were allowed to freely explore the location of the virtual half-plane with feedback before the main experiment. Trajectories were monitored with an Optotrak 3020 and feedback was immediate. Subjects were instructed to earn the greatest reward possible.

Results: Subjects avoided the obstacle more as the penalty Increased and as the edge was displaced to the right. We computed the covariance between the fingertip position in passing through the obstacle plane and in hitting the target plane. Surprisingly, the correlation of horizontal displacements in the two planes changed sign with position of the obstacle. For the leftmost position of the obstacle it was positive and then became smaller and finally negative for the middle and right target locations, respectively. We discuss these results and covariance along the entire trajectory In terms of current models of visual feedback control of movement.

Acknowledgement: NIH EY08266, NIH NS047178-01A1

Attention: Neural Mechanisms

Author Presents: 8:30 - 10:15 am

B38 272 Attentional modulation of the BOLD-fMRI contrast response functions in early visual areas

Xiangrui Li[1] (xiangrul@usc.edu), Zhong-Lin Lu[1], Bosco S. Tjan[1], Barbara A. Dosher[2], Wilson Chu[1]; [1]Department of Psychology and Dana and David Dornsife Cognitive Neuroscience Imaging Center, University of Southern California, Los Angeles, [2]Department of Cognitive Sciences, University of California, Irvine, CA

The contrast response function (CRF) characterizes fundamental input-output properties of visual neurons. In functional MRI, CRF can be obtained for each individual's retintopically defined early visual areas (Boynton et al, 1999). Here, we measured CRFs of BOLD activity in V1, V2, V3, V3A, and V4v of the human visual cortex to identify the mechanisms of covert attention. Using a rapid event-related design, we measured BOLD responses to a brief (100 ms) sinusoidal grating windowed by a 5-7° annulus. Each fMRI run consisted of four grating contrast conditions in a counter-balanced pseudo-random sequence: 0, 1x, 3x, and 10x of each subject's orientation identification threshold. In separate runs, subjects reported either the orientation of the grating (45±5°) or the identity of a letter ("T" or "L") presented simultaneously in the center of the display. CRFs in the five visual areas responding to the grating annulus were obtained in both the central letter ("unattended") and the peripheral grating ("attended") conditions. The Naka-Rushton equation, R = Rmax (Gc + cspn)2 /[c502 + (Gc + cspn)2], where cspn and G represent spontaneous activities and contrast gain of attention, was fitted to the pair of CRFs in each visual area. The impact of attention depended critically on stimulus contrast: Attention had a greater effect for low stimulus contrasts; but diminished and becomes absent in high stimulus contrast conditions. In all five cortical areas, attention increased spontaneous activity by a factor of about 4.0 and amplified stimulus contrast by a factor of 2.0 to 3.4. By simultaneously increasing the contrast gain and spontaneous activity of the visual system, attention enhances the ability of the perceptual system to detect weak signals at the expense of sacrificing its dynamic range. Studying attentional modulation of the full CRFs provides a framework to systematically evaluate the impact of attention on the fMRI BOLD response in early visual areas.

Acknowledgement: Supported by NSF 04207994 and NEI EY016391

B39 273 Perceptual load-induced selection as a result of neural competition in early visual cortex

Ana Torralbo[1,2] (ana.torralbo.capilla@gmail.com), Diane Beck[2], Arthur Kramer[2]; [1]Universidad Autónoma de Madrid, Spain, [2]Beckman Institute, UIUC

Perceptual load has been proposed as a determining factor in the degree to which unattended information is processed. Although manipulations that increase visual processing demands have modulated the processing of unattended items, as predicted by perceptual load theory, a clear definition of perceptual load is still needed. Here we propose that sensory competition at the level of the visual cortex may determine perceptual load. The biased competition model of selective attention proposes that stimuli presented simultaneously in the visual field are not processed independently, but instead interact in a mutually suppressive way that suggests a competition for neural representation. Furthermore, this competition can be biased by either bottom-up (e.g. saliency properties of the stimulus) or top-down (e.g. actively searching for the target according to the current behavioural goals) mechanisms. We propose that these suppressive interactions and the resulting top-down biasing mechanisms needed to resolve the competition, may determine the perceptual load of the task, and thus degree to which the unattended information is filtered. We argue that previous manipulations of perceptual load, which include increasing the number and/or the heterogeneity of a set of stimuli, also increase sensory competition. Furthermore, we test a new manipulation of perceptual load derived from predictions of biased competition theory. Specifically we asked whether a variable known to increase sensory competition--the distance between stimuli--will modulate the flanker effect. We varied the distance between items in the search array, while keeping set size and heterogeneity constant and equating the target-flanker separation in both conditions. We found smaller flanker effects for the high density displays than the low density displays, consistent with the idea that the competition and resulting bias necessary to overcome the competition may determine the degree to which unattended information is processed.

B40 274 The influence of a visual task on fMRI activation patterns in the visual cortex

Joongnam Yang[1] (yangjo@upstate.edu), Dan Ts'o[1]; [1]Department of Neurosurgery, SUNY Upstate Medical University

PURPOSE: We tested the hypothesis that more neural resources in visual cortex are used in visual processing when subjects are involved in a task, compared to their retinally-driven responses. Using fMRI, we investigated whether there is any difference in activation in the visual areas between passive viewing and a discrimination task.

METHODS: The entire visual field was divided into five bars (horizontal or vertical), and two bars equally distant from the fixation point were presented in each trial. The bars consisted of small chromatic/achromatic squares, (black/white, L-M, and (L+M)-S, following the DKL space), that flickered at 5 Hz and lasted for 2.5 seconds. The bar locations were randomly selected from predetermined five locations with respect to the fixation. Subjects' task was either to fixate ('blank' and 'no-go' blocks), or to fixate and press a button ('go' blocks) to indicate which contrast of the flickering squares is greater between the two bars. There were five trials in each block and the three blocks were randomly presented five times in each session.

RESULTS: In the fixation task, as the bars moved from the fixation to the periphery, activations spread from foveal representation to the periphery in the visual cortex in a manner consistent with known retinotopy. For both vertical and horizontal bars, most of the visual areas were activated. In the contrast discrimination task, similar (sometimes enhanced) retinotopically-appropriate responses were observed. However, small but significant additional activations were observed in the areas surrounding the retinotopically-appropriate areas in V1, V2, V3A, and V4/V8. Strong additional activations were also shown in V4 for chromatic (L-M and S) bars than for luminance bars.

CONCLUSIONS: Discrimination task not only enhances retinotopically-appropriate response, consistent with enhanced response in single-cell research, but also involves additional neural resources in V1, V2, V3A, and V4.

B41 275 Spatial Distribution of Attention Effects in Human Visual Cortex

Jason C. Park[1] (korsakoff@gmail.com), Xian Zhang[1,2], John Ferrera[2,3], Donald C. Hood[1], Joy Hirsch[1,2]; [1]Dept. of Psychology, Columbia University, [2]Functional MRI Research Center, Columbia Univeristy, [3]Clinical Neuropsychology [PhD program], CUNY Graduate Center

Purpose: To better understand the mechanisms of visual attention, the spatial distribution of two effects of attention (contrast gain and baseline change) were studied with fMRI.

Method: Eight subjects experienced two different conditions: simply fixating the center without a task (passive-viewing/P condition) or performing a two-back memory task on the color of the fixation (two-back/T condition). A full-field flashing checkerboard was presented as the background for both conditions. During both conditions, the color of the fixation changed from black to either red or green for 500 ms, every 2000ms. In the rest period, the fixation changed to blue. The flashing checkerboard's contrast was set as 0, 6.25, 12.5, 25, 50 or 100%. Both the contrast gain and the baseline change effects were estimated for each voxel by fitting a contrast response function (CRF): R=B+(Rmax*Cá)/(ó á+ Cá), where R is the amplitude of the response, B is the baseline, Rmax is the asymptotic amplitude of the response, C is the contrast, á is the exponential term for the steepness and, ó is the semi-saturation contrast. The equation was fitted to the results for each voxel and the values of B and ó for the two conditions (Bt-Bp and ót-óp) compared. Bt-Bp <0 indicates a suppression in baseline BOLD signal and ót-óp>0 a decrease in contrast gain.

Results: The spatial distributions of the contrast gain and the baseline change effects differ from each other. The T condition, compared to the P condition, shows a decrease of contrast gain (ót-óp>0) for all eccentricities; the effect is weaker in V1 than in extra-striate cortex. The baseline change effect, however, varied with eccentricity: Bt-Bp > 0 in the center and Bt-Bp < 0 in the periphery.

Conclusion: The different spatial distribution of the two effect of attention suggests that they take place through different mechanisms.

Acknowledgement: NIH/NEI Grant EY 02115 and The Dana Foundation

B42 276 Feature-based attention increases gain and sharpens tuning of motion selective channels

Sam Ling[1] (ling@nyu.edu), Taosheng Liu[1,2], Marisa Carrasco[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University

Background: Two mechanisms have been proposed to explain how attention affects signal processing: gain (signal enhancement) and tuning (external noise exclusion). Gain and tuning can be distinguished by using the equivalent noise paradigm, which measures threshold at different levels of external noise. Whereas the gain model only predicts attentional benefits with low external noise, the tuning model predicts attentional benefits with high external noise. Using this paradigm, we have shown that spatial attention only increases the gain of motion selective channels (VSS 2006). In the present study we assessed the influence of feature-based attention on the gain and tuning of motion selective channels by cueing observers to a global motion direction under different external noise levels.

Methods: In each trial, observers were shown a moving dot cinematogram at fixation (100 ms). The local motion directions of individual dots were drawn from circular gaussian distributions centered on a direction, either clockwise or counterclockwise from the cue direction. In the Attended condition a small cue at fixation pointed to one of four directions 600 ms prior to the stimuli presentation, instructing observers to attend to that upcoming direction. In the Neutral condition, the same cue appeared simultaneously with the stimulus. Observers performed a 2AFC direction discrimination task, reporting whether the global motion was clockwise or counterclockwise relative to the cue direction. External noise was manipulated by varying the coherence of the dot fields, which was defined as the variance in dot trajectories. We obtained direction thresholds for different levels of external noise.

Results: For all observers, attention reduced thresholds across all motion coherence levels, i.e., for both low and high external noise levels. These findings are consistent with a model where attention both increases the gain (benefit at low noise) and narrows the tuning (benefit at high noise) of direction selective channels.

Acknowledgement: NRSA to S.L. (F31 NS051111-03) & NIH to M.C. (R01 EY016200-01A2)

B43 277 Perceptual decisionmaking in human visual cortex

John Serences[1] (john.serences@uci.edu), Geoffrey Boynton[2]; [1]Department of Cognitive Sciences, University of California, Irvine, [2]Department of Psychology, University of Washington

When deciding between two noisy sensory states (e.g. is motion to the left or right), single-unit recording studies show that neural activity in early visual areas tracks the quality of the sensory information, whereas activity in parietal and frontal cortices more closely tracks the categorical decision process. Here we used fMRI to track the computation of a simple perceptual decision in human observers given a variable amount of sensory evidence. Observers viewed a display containing two moving-dot apertures, one in each of the upper quadrants. On each 12s trial, a variable percentage (0%, 50%, or 100%) of the dots in each aperture moved coherently at either 45° or 135°. Occasionally the speed the dots in one aperture slowed, which instructed observers to press one of two buttons indicating the currently perceived direction of motion. A multivariate pattern classification analysis of the fMRI signal was used to estimate the degree of neuronal selectivity in a given visual area for each perceptual state. The pattern of activation in nearly all visual areas discriminated the direction of motion in high-coherence displays. However, the pattern of activation in some mid and high level areas also discriminated the perceived direction of motion even in the absence of sensory evidence (0% coherent motion), suggesting that neural activity within these regions more closely tracks the perceptual state of the observer.

Acknowledgement: Supported by F32EY01726 (JS) and EY12925 (GMB)

B44 278 Behavioral measures of cross-modal attention are consistent with fMRI responses in V1 and not MT+.

Vivian Ciaramitaro[1,2] (vivian@salk.edu), Geoffrey Boynton[1]; [1]The Salk Institute for Biological Studies, [2]University of California, San Diego, Deparment of Psychology

Purpose: In a previous fMRI study, we showed that the response to an unattended visual stimulus depended on the modality subjects were attending to, and that this dependence varied across visual areas. In V1/V2, the response to an unattended stimulus was weakest when another visual stimulus was attended. However, in MT+, the response to an unattended stimulus was weakest when an auditory stimulus was attended. This leads to the question, which areas, higher or lower, best represent the perceptual effects of cross-modal attention? In the present study, we used a visual motion aftereffect (MAE) to measure the response to an unattended visual stimulus as a function of the attended modality. Will our psychophysical measures of attention agree with our fMRI measurements in V1 or MT+?

Methods: Two drifting gratings, to the left and right of fixation, and auditory stimuli (binaural or dichotic) were presented simultaneously. Subjects were cued to attend to one stimulus and perform either a speed discrimination task on a visual stimulus or a frequency discrimination task on an auditory stimulus. The contrast of the visual gratings varied from trial to trial. At the end of each trial, the strength of the MAE was measured using a nulling procedure in which subjects judged the direction of motion of a fixed contrast grating presented unpredictably at one of the two possible grating locations.

Results: The strength of our MAE at an unattended visual stimulus was weaker when attending to another visual stimulus compared to attending to an auditory stimulus. This is consistent with our fMRI measurements in V1/V2. Furthermore, the MAE strength increased gradually as a function

of stimulus contrast, which is again consistent with contrast-response functions in V1, not MT+. We therefore conclude that our MAE results reflect responses in earlier stages of visual processing.

Acknowledgement: Acknowledgements: NIH-NEI 12925

B45 279 Activity in monkey V4 reflects target identification and saccade direction in free viewing visual search

Angela Gee[1, 2] (alg2021@columbia.edu), Anna Ipata[1, 2], Michael Goldberg[1, 2]; [1]Department of Neurobiology and Behavior, Columbia University, [2]New York State Psychiatric Institute

We studied the activity of V4 neurons in a free viewing visual search task, in which monkeys reported the orientation of a target among distractors and were free to move their eyes. Previously, we reported that activity in the macaque lateral intraparietal area (LIP) in the search task predicted the saccade goal and latency, and also discriminated between targets and distractors even when the monkey made a saccade away from the receptive field. There is a known anatomical connection between V4, an extrastriate area involved in object processing, and LIP. In this experiment, we examined the role of V4 in identification of the target and representation of the saccade direction and compared it to the role of LIP in an identical search task. We trained monkeys on a free viewing visual search task in which they reported the orientation of a target among distractors with a non-targeting hand movement. After the stimuli appeared, the monkeys were free to move their eyes, and they made a first saccade to the target about half the time. We also trained monkeys on a saccade task in which they made a saccade to a single object which could be a target or a distractor from the search task. In the saccade task there was no difference in the early responses evoked by the search target or the search distractor. Here, the monkey attended to the objects by making a saccade, but did not have to discriminate them. When the monkey had to discriminate the objects in the search task, the target evoked a greater response, independent of the direction of the saccade. Like LIP, V4 also displayed a separate signal reflecting the direction of the impending saccade but unlike LIP, this saccadic signal did not correlate with saccadic latency.

B46 280 Gamma band levels index voluntary shifts of attention to faces

Ayelet Landau[1,2] (ayeletlandau@berkeley.edu), Michael Esterman[1,2], Lynn Robertson[1,2], William Prinzmetal[1]; [1]University of California, Berkeley, [2]Veterans Adminnistration Northern California Health Care System, Martinez

Behavioural studies suggest that voluntary and involuntary attention may operate using different mechanisms. The present study examined this issue in EEG activity induced by voluntary and involuntary attention. Participants performed a face-discrimination task under conditions of voluntary or involuntary attention. A peripheral cue preceded the face in both tasks, but for involuntary attention it was non-predictive, while for voluntary attention the face appeared more often in the cued location (70%). Both sessions included target-absent trials allowing evaluation of cue-related activity in isolation. Behaviorally, both voluntary and involuntary conditions produced better performance on valid than invalid trials (RT). Spectral analysis of the EEG revealed increases in gamma-band response, but the pattern was different for voluntary and involuntary conditions. For target absent-trials there was greater cue-related activity in the voluntary than the involuntary condition that peaked about 150 ms after cue onset. This finding is consistent with greater use of the cue during voluntary attention. Similar gamma band increases were recorded for the face targets in both attention conditions. On valid trials, this activity was significantly less in the voluntary compared to the involuntary condition, presumably because subjects shifted their attention to the cued location in the voluntary attention condition. On invalid trials the relative magnitude of the face-related activity reversed and there was greater power in the voluntary session. That is expected because in the predictive session, subjects have shifted their attention to the cued location which in these trials is erroneous and an additional shift of attention is then required. Thus, gamma band activity reveals a difference in cue-related activity for voluntary and involuntary attention and an interaction with trial type in target-related activity between these two types of attention.

B47 281 Attenuating illusory binding with TMS of the right parietal cortex

Michael Esterman[1] (esterman@gmail.com), Timothy Verstynen[2], Lynn Robertson[3,4]; [1]Department of Psychological and Brain Sciences, Johns Hopkins University, [2]Department of Physiology, University of California, San Francisco, [3]Veterans Administration Medical Center, Martinez, CA, [4]Department of Psychology, University of California, Berkeley

A number of studies from neuroimaging and neuropsychology have implicated various regions of parietal cortex as playing a critical role in the binding of conjunctions of color and form. In order to further investigate the network involved in color-form integration, the current study used rTMS to disrupt parietal activity while normal perceivers performed a task that produces frequent binding errors known as 'illusory conjunctions'. We tested several specific parietal regions that have been associated with feature binding and defined them anatomically for each participant. The voxel location was marked on each high resolution MRI image, and scalp location was determined using a stereotaxic localization system. Participants made fewer contralateral binding errors after suprathreshold 1 Hz rTMS of the right intraparietal sulcus (IPS), while perception of the features themselves (colors and shape) was unaffected. Improved binding after right IPS stimulation was also indicated by a significant increase in the probability of binding as estimated by a multinomial probability model. No perceptual effects were found following left IPS stimulation, or stimulation of the right angular gyrus at the junction of the transverse occipital sulcus (IPS/TOS). Several possible mechanisms as to how right IPS stimulation decreased illusory conjunctions are proposed.

B48 282 Dissociating the cognitive mechanisms of sustained attention and response inhibition: An fMRI study using a conjunctive go/no-go task

Lilach Shalev[1] (l.shalev.1@bham.ac.uk), Carmel Mevorach[2], Harriet Allen[2], Glyn Humphreys[2]; [1]School of Education, the Hebrew University of Jerusalem, Israel, [2]School of Psychology, the University of Birmingham, UK

In many aspects of everyday life we have to sustain out attention across time to detect low probability targets, whilst concurrently we must refrain from responding to irrelevant stimuli that nevertheless have a high frequency of occurrence. Previous studies have conflated these two aspects of performance, making it difficult to distinguish the underlying neural substrates. Using an experimental procedure to separate out sustained attention and response inhibition, we fractionated the neural circuits supporting the underlying cognitive mechanisms. Event-related fMRI data were acquired during a go/no-go task where target-and distractor-frequencies were manipulated. Neural processes involved in sustaining attention were revealed by a conjoint analysis of areas activated independently for 'go' and no-go' events when targets were frequent relative to when they were infrequent. This revealed reliable activations in a network of cortical and sub-cortical areas primarily in the right hemisphere. Neural processes underlying the cognitive process involved in response inhibition were shown by subtracting the activation associated with 'no-go' events when targets were infrequent relative to when they were frequent. This isolated activation in the right inferior parietal lobe. The proposed distinction between sustained attention and response inhibition was supported by analyses of the time course of the haemodynamic response. We propose that sustaining attention over time is accomplished by a distributed cortical and sub-cortical network which is activated throughout the task in hand, while cognitive mechanisms involved in response inhibition are associated with the right inferior parietal lobe. The work suggests that response inhibition can be decomposed, separating cognitive from motor mechanisms.

B49 283 **The Left Inferior Parietal Lobe Modulates the Selection of Low Salient Stimuli**

Carmel Mevorach[1] (c.mevorach@bham.ac.uk), Lilach Shalev[2], Harriet Allen[1], Glyn Humphreys[1]; [1]Behavioural Brain Sciences Centre, School of Psychology, University of Birmingham, UK, [2]Department for Education & Psychology, Open University Israel, Tel Aviv, Israel

The posterior parietal cortex is implicated in attentional selection. In the present study we used fMRI to examine the role of posterior parietal cortex in selection based on the saliency of target and distractor information. Hierarchical stimuli were presented to participants and the task (respond to local or global) was crossed with the saliency of the target level (local salient, global salient). We found unique activation in the left posterior parietal cortex and the left lateral occipital complex for conditions where the less salient level had to be selected irrespective if this was the local or the global stimulus. In addition, ROI analysis revealed a positive correlation between the differences in BOLD signal change in left posterior parietal cortex for responses to low, relative to high, saliency targets and RT cost for low salient targets in reaction times. The highest percent signal change was in the left inferior parietal region for those conditions in which the less salient target level had to be selected. In contrast, there was no evidence for lateralised activity for selection based on the level of processing. The data suggest a specific role for the left inferior parietal lobule in salience-based selection.

B50 284 **Temporal Dynamics of an Attentional Switch**

Sarah Shomstein[1] (shomstein@cmu.edu), Dwight Kravitz[2], Marlene Behrmann[1]; [1]Carnegie Mellon University, [2]National Institute of Health

Recent neuroimaging studies have suggested an important role for a network of fronto-parietal regions in attentional switching. Several regions within the frontal cortex (e.g., MFG , FEF, etc) as well as regions within the posterior parietal cortex (e.g., SPL and precuneus) exhibit selective activation time locked to shifts of attention. Little is known about the temporal dynamics of this circuit. We examined cortical activity of human observers during shifts of attention between vision and audition using event related potentials (ERP). Participants viewed an RSVP stream of letters (4 letters/sec) appearing in the center of a computer screen (surrounded by distractor RSVP streams); simultaneously, they listened to letters spoken binaurally through headphones. Before each run, a verbal instruction directed attention to either the auditory or the visual stream. Occasional digit targets appeared within the attended (auditory or visual) stream and participants pressed a button to indicate target detection. If the digit was a '2,' participants were to maintain attention on the currently attended modality; if it was a '4,' they were to switch attention to the other sensory modality and to begin to monitor that stream. ERP components in visual sensory areas exhibited enhanced early and late components following a shift from audition to vision, as compared to a shift from vision to audition, reflecting attentional modulation for the attended sensory modality. Of interest was the temporal dynamic of shift-related components observed over frontal and parietal electrodes following the instruction to shift attention between modalities in either direction. Activity over frontal electrodes exhibited enhancements that were earlier than those observed over the parietal electrodes. These results introduce a temporal dimension to the existing fMRI findings, suggesting that frontal areas are engaged earlier than the parietal attentional shifting areas and may even serve as the top-down signal to activate parietal cortex.

B51 285 **Abstract withdrawn**

B52 286 **The role of spatial and selective attention in the perception of bistable images.**

Michael Pitts[1] (mpitts@lamar.colostate.edu), Jan Nerger[1], Clea Stalmaster[1]; [1]Psychology, Natural Sciences, Colorado State University

Recent studies (Pitts, Nerger, & Davis, 2007; Kornmeier & Bach, 2004; 2005) report early event-related potentials (ERP) associated with perceptual reversals of bistable images -- enhanced P1 and N1 amplitudes and a broad reversal-related negativity (180-400msec post-stimulus). Pitts et al argue these results support a model of bistable perception (see Slotnick & Yantis, 2005) in which changes in early spatial and selective attention, indicated by P1 & N1 enhancements and the selection negativity (see Anllo-Vento, Luck, & Hillyard, 1998), modulate perceptual reversals.

In the present study, a Necker-type stimulus was presented for 800msec with a 400msec ISI to allow time-locking of ERPs to stimulus onset. Observers pressed one of two response buttons after each trial to indicate left or right perceptual orientation of the stimulus. Unlike previous studies, this method permits us to correlate ERPs to what the observer perceived on each trial rather than simply whether a reversal had occurred or not. Recordings were partitioned into four categories based on reported percepts in each trial and the preceding trial: Left stable, right stable, left-to-right reversal, right-to-left reversal. By making comparisons among these four waveforms we can directly assess multiple competing models of bistable perception.

Preliminary analyses reveal a frontal positivity (~140-380msec) and occipital/temporal/parietal negativities (~170-400msec) at sites contralateral to the perceived foreground of the stimulus for reversal vs. stability trials, e.g. by comparing left-to-right reversal trials with right stability trials and vise versa. A comparison of the two different reversal waveforms (L to R vs. R to L) revealed a contralateral negativity (~220-400msec) at parietal and temporal sites, whereas a comparison between the two types of stability waveforms (L vs. R) revealed no differences at the equivalent sites. Taken together, these results support a model of bistable perception whereby reversals are initiated by shifts in spatial and/or selective attention.

B53 287 **ERP 'blink' instructions revisited: Effects on attention-related processes**

Julie Bolduc-Teasdale[1,2] (julie.bolduc.teasdale@u .ca), Michelle Beaupré[1,2], Nicolas Robitaille[1,2], Michelle McKerral[1,2]; [1]Centre de Recherche en Neuropsychologie et Cognition, [2]Department of Psychology, Université de Montréal, Québec, Canada

An important challenge for researchers working with electrophysiological measures is the reduction of ocular artifacts and more specifically, the blinking phenomenon. Despite the fact that most experiments include a "do not blink" instruction in their protocol, very few studies have investigated its impact on cerebral activity, and more precisely on attention-related processes. Although previous studies have shown that, when given, the instruction leads to a reduction in amplitude of the P3b during a two-stimulus oddball paradigm, methodological weaknesses could be responsible for the observed results. Therefore the current study aimed to reevaluate the effect of the "do not blink" instruction on the P3b while counterbalancing conditions between two groups of subjects for whom two experimental conditions (1- "do not blink" instruction; 2- no blink instruction) were presented in different order. The paradigm used was a modified three-stimulus oddball task which enabled us to not only look at the P3b, but also at the P3a wave, which has been interpreted as an orientation of the attention response. The use of this P3a-evoking paradigm consequently adds to the novelty of the current study. While no effect was detected regarding the P3b, a significant decrease in P3a amplitude was observed in the first group during the second experimental bloc. This group received the 'no 'blink instruction' condition prior to the "do not blink" instruction condition. However an opposite effect was observed for the second group for whom the P3a amplitude also decreased during the second bloc, this time the 'no blink instruction' condition. Thus, contrary to previous studies implying that the instruction altered or reduced the attentional resources available to perform the task at hand, the results obtained in the present study rather suggest the presence of a task-related habituation effect.

Acknowledgement: Funding for our research was provided by FRSQ and NSERC.

B54 288 **Adaptation and habituation of visual responses in the superficial and intermediate layers of the superior colliculus (SC)**

Susan Boehnke[1,2] (susan@biomed.queensu.ca), David Berg[3], Pierre Baldi[6], Laurent Itti[3,4,5], Doug Munoz[1,2]; [1]Centre for Neuroscience Studies, Queen's University, [2]Department of Physiology, Queen's University, [3]Neuroscience Graduate Program, University of Southern California, [4]Department of Computer Science, University of Southern California, [5]Department of Psychology, University of Southern California, [6]Department of Computer Science, University of California Irvine

One neural correlate of visual attention is a decrease in the neural response to a target after prior presentation of an orienting 'cue' (e.g. inhibition of return). This decreased responding could be the result of repeated stimulation of a neuron's receptive field resulting in either 'adaptation' – a lower level mechanism related to neural fatigue, or 'habituation' – where an organism stops responding to an irrelevant stimulus but recovers the response after a change in stimulus properties. We dissociated adaptation from habituation in superficial (SCs) and intermediate (SCi) layer neurons of the SC, a hub of oculomotor and attentional processing. SCs receives visual input from the retina directly or via V1, while the SCi receives convergent input from visual and motor areas. Monkeys were rewarded for fixating a central point while a series of 7 successive stimuli were briefly flashed (100 ms duration; 100-400 ms interval) in the receptive field of the neuron. On 70% of trials all flashed stimuli were identical, while on others, the 4th was either brighter, dimmer or absent (10% each). If reduced neural response is due to habituation, some recovery of the response (dishabituation) should occur to any oddball stimulus. However, if the reduced response is due to adaptation, the response should be further reduced after the brighter, but recover after the dimmer or absent stimulus. The largest decrease in response (often > than 50%) was to the second stimulus, and subsequent stimuli resulted in only small further reductions. The shorter the inter-flash interval, the greater these reductions. The pattern was globally similar in SCs and SCi, but there was a greater reduction to the 3-7th stimuli in SCi. Responses to oddball stimuli in SCs neurons were suggestive of adaptation, while responses in SCi neurons showed features of both adaptation and habituation.

Acknowledgement: National Science Foundation, Canadian Institute for Health Research

B55 289 **A neural network model of simultaneous visual discrimination: Incentive modulation of visual stimulus salience.**

Mark Dranias[1] (mdranias@cns.bu.edu), Daniel Bullock[1], Stephen Grossberg[1]; [1]Department of Cognitive and Neural Systems and Center of Excellence for Learning in Education, Science, and Technology, Boston University

A neural network model of a simultaneous visual discrimination task is presented. The model explains how incentive motivational learning enhances the salience of visual stimuli, biasing the activity of visually-sensitive neurons in anterior inferotemporal cortex and visually and motivationally-sensitive neurons in orbitofrontal cortex. The performance of the visual discrimination task relies on interactions between several brain regions. These brain regions can be divided into four functional classes: (1) Perceptual- registering visual or gustatory inputs (inferotemporal and rhinal); (2) Drive- calculating the value of anticipated outcomes using hunger and satiety inputs (amygdala and hypothalamus); (3) Incentive- resolving the value of competing stimuli (orbitofrontal); and (4) Adaptive Timing- detecting the omission or delivery of rewards (basal ganglia and SNc/VTA). Simulations of the interactions between these brain regions demonstrate that a feedback signal from orbitofrontal to inferotemporal cortex underlies the attentional modulations of inferotemporal neurons that has been observed in previous studies of the visual discrimination task. Model mechanisms are tested further with simulations of a variant of the visual discrimination task with reinforcer devaluation wherein hunger and satiety inputs influence cue preference. In this task two cues are simultaneously presented as before, but each cue is associated with a different food reward. Changes in the drive inputs to the model are seen to influence cue preference, visual cue salience, and saccadic reaction time. The same model mechanisms and parameters are shown to be capable of replicating behavioral responses and the electrophysiological activations of neurons reported in a number of studies employing a Pavlovian conditioning task.

Acknowledgement: Partially supported by an NSF Science of Learning grant to CELEST

Scene Perception I

Author Presents: 10:30 am - 12:15 pm

B56 290 **Boundary Extension in the Transsaccadic Representation of Layout**

Christopher Dickinson[1] (cdickins@udel.edu), Helene Intraub[1]; [1]Department of Psychology, University of Delaware

Could memory for unseen layout beyond the edges of a view (boundary extension; BE) facilitate the integration of successive views? For this to be the case, BE would 1) need to occur following a retention interval as brief as a saccade, and 2) survive a gaze shift. On each trial, 3 photographs of unrelated scenes were presented for 325 ms each in an RSVP sequence. They were followed by a masked retention interval (42, 100, or 250 ms; between-groups variable) and repetition of a scene from serial position 1, 2, or 3. The repeated picture remained on the screen while the observer rated the view as the same, more close-up, or more wide-angle than the target (5-point scale). In Experiment 1 (N=108), targets were either close-up or wide-angle views, and test pictures were either the same view or the alternate view. The rating pattern diagnostic of BE occurred across all conditions. Most important, close-ups yielded BE at all masked intervals and at all serial positions. After a retention interval as brief as 42 ms, observers tended to rate the same close-up as being more close-up than before, indicating that memory for the target included extended boundaries. In Experiment 2 (N=31), we recorded observers' eye movements (EyeLink II). All targets and test pictures were identical close-ups. Following a 42 ms mask, test pictures appeared on either the same side of the screen as the RSVP sequence or the opposite side, necessitating a gaze shift. BE occurred in both cases for all target serial positions (mean retention interval on trials with a gaze shift = 346 ms). Spatial extrapolation of layout occurred rapidly for all scenes in dynamic presentations, even across gaze shifts. BE is likely available in transsaccadic memory to facilitate view integration during normal visual scanning.

Acknowledgement: This research was supported by NIMH Grant MH54688.

B57 291 **Conceptual Masking: Is it really all about the concept or does layout matter?**

Kristin O. Michod[1] (kmichod@gmail.com), Helene Intraub[1]; [1]The University of Delaware

The onset of a new, meaningful visual event is thought to induce conceptual masking (Potter, 1976). Does layout contribute to the "meaning" of a scene? Given the same objects, would changes in layout induce conceptual masking? In Experiment 1, each of 16 photographs (the targets) was presented for 125 ms, interspersed with a to-be-ignored photograph for 250 ms (the "conceptual mask") and a visual noise mask for 500 ms. Each conceptual mask contained the same background with a new set of 3 objects, however, in one condition (N = 32) the objects were always presented in the same layout, whereas in the other, they appeared in a different layout each time (N =32). Following presentation, a 2AFC test was administered, in which each target photograph was paired with a similar distractor (same concept, different details). Although the conceptual mask contained the same new objects in both conditions, recognition memory decreased significantly with a changing layout (80% vs. 70%; $t(62) = 3.10$, $p < .01$). In Experiment 2, more complex conceptual masks were presented. There were 4 conceptual mask conditions (N = 40 in each): a) different objects/same layout, b) different objects/different layout c) same objects/different layout and d) same objects/same layout (i.e., a repeating picture). Concep-

Saturday Posters

tual masking is limited or non-existent when the same mask repeats (Intraub, 1984). In comparison to the repeating picture condition (78% recognized), orthogonal planned comparisons showed that memory decreased significantly when the conceptual mask changed each time: different objects/same layout (72%), different objects/different layout (70%), or same objects/different layout (74%). Thus, even when gist was maintained (same objects; same background), layout changes interfered with memory for the attended pictures. Both experiments demonstrate that conceptual masking involves more than the onset of a new global concept; a new layout also disrupts processing of briefly presented scenes.

Acknowledgement: NIMH Grant MH54688

B58 292 **Memory for Viewpoint Changes in Naturalistic Scenes**

Monica S. Castelhano[1] (monica@psych.umass.edu), Alexander Pollatsek[1], Keith Rayner[1]; [1]University of Massachusetts Amherst

How do we represent viewpoint changes of a scene? We tested three hypotheses about how people would perform in a test of recognition memory for a speci?c viewpoint of a scene: 1) the views in memory are stored independently and compared to the test image independently (Independence hypothesis); 2) the views are stored in memory in a viewpoint independent 3-D representation, which is compared to the test image (3D hypothesis); 3) the views in memory are stored independently, but comparison to the test image is a function of the sum of the strengths of the degree of match of the memory views to the test image (Combined hypothesis). To test these hypotheses, two study images were shown from either the same or different viewpoints of a scene. Immediately following, participants indicated whether a test image was identical to a study image. When shown a different viewpoint of the scene, the viewpoint could be taken between the two study images (Interpolation condition) or outside the two study images (Extrapolation condition). In Experiment 1, there were many more errors for interpolated than extrapolated views. In Experiment 2, the two study images were from two different scenes, and were tested with the equivalent different viewpoint conditions. Results con?rmed that this effect was not due to a stimulus anomaly or to a lag effect on memory accuracy. We developed memory models of the hypotheses described above and found that the memory performance was consistent with the Combined hypothesis. Therefore, we proposed that the visual system does not construct a common memory representation, however both images are simultaneously involved in the retrieval process.

Acknowledgement: This work was supported by Grant HD26765 from the National Institute of Health and by a grant from Microsoft Corporation.

B59 293 **Object and scene recognition in tiny images**

Antonio Torralba[1] (torralba@csail.mit.edu), Rob Fergus[1], William T. Freeman[1]; [1]Computer Science and Artificial Intelligence Laboratory, MIT

The human visual system is remarkably tolerant to degradations in image resolution: in a scene recognition task, the performance of subjects is similar whether 32x32 color images or multi-mega pixel images are used. Even object recognition and segmentation is performed robustly by the visual system despite the object being unrecognizable in isolation. We present a set of studies to evaluate the minimal image resolution required to perform a number of recognition tasks (scene recognition, object detection and segmentation) and we show that images need 32x32 color pixels. Performances degrade fast below this resolution. The small size of each image carries two important benefits: (i) it permits computer vision tools to be easily applied and (ii) huge image databases may be easily collected. We present a database of 70,000,000 32x32 color images gathered from the Internet using image search engines. Each image is loosely labeled with one of the 70,399 non-abstract nouns in English, as listed in the Wordnet lexical database. Hence the image database represents a dense sampling of all semantic categories. Computer vision traditionally consider a few unrelated classes which are treated independently to one another. In contrast, we use our database in conjunction with a semantic hierarchy, obtained from Wordnet, to impose tree-structured dependencies between the 70,399 classes.

B60 294 **Integrating Central and Peripheral Information During Object Categorization**

Kimberly MacKenzie[1] (kjmack@brandeis.edu), Yaihara Fortis-Santiago[1], Jozsef Fiser[2]; [1]Department of Neuroscience, Brandeis University, Waltham MA 02454, [2]Volen Center for Complex Systems and Department of Psychology, Brandeis University

Images presented at fixation provide more information to the visual system than images presented parafoveally. However, it is not clear whether it is more beneficial to receive the larger amount of information first in sequential categorical comparisons. Theories based on activation of mental sets, pure information content, or interference make different predictions on the likely outcomes of such tasks. In our study, subjects made same-different category judgments on a large set of briefly appearing pairs of gray-scale images of everyday objects, which were presented on a gray background. Each image extended 5 degrees of visual angle, could appear in either the center (C) or corners (S) of the screen for 12.5, 25, or 50 msec, and was followed by a random mask presented for 25 msec. Pairings of position, timing, and category were fully randomized and balanced across trials, and the ISI between the two images within a trial was kept at 12.5msec. Subjects were instructed to fixate at the center of the screen, and their eye movements were monitored. There was a significant advantage in conditions where the central image appeared first and the peripheral image second (C-S) compared to the opposite order (S-C) ($t(16)=0.02$, $p < 0.05$). However, the relation between stimulus presentation time and categorization performance in the C-S condition was non-monotonic: longer duration was not always paired with better performance. These results rule out pure information-based explanations and suggest that object information received earlier constrains how efficiently information received subsequently is processed in categorization tasks.

B61 295 **Functional Representations of Layout Are Disrupted by Irrelevant Objects**

Thomas Sanocki[1] (sanocki@usf.edu), Noah Sulman[1]; [1]University of South Florida

Recent work to be reviewed indicates that a brief presentation of a prime scene (as little as 200 ms) activates a functional representation of its layout. The representation is functional because it facilitates (speeds) subsequent processing of depth relations within the scene. Evidence indicates that the representations are somewhat abstract and are activated in parallel across the visual field, with relatively little capacity limitation. The representations appear to be intermediate-level, and separate from later stages of processing in which spatial relations are resolved.

The present experiments show that the positive effects of scene primes can be nullified by irrelevant objects. The general method was to present a scene prime for 200 to 800 ms, followed by a target with two laterally separated spatial probes marking locations. The prime scene was either the same scene as the target (sans markers), or the same scene with two irrelevant objects added. The objects were a task-irrelevant color, and were the same orientation as or inverted relative to the larger upright or inverted prime. In control conditions, there was the same amount of preparation time but a fixation stimulus replaced the scene prime. Reaction time to indicate which spatial marker (left or right) is closer to camera point was the main measure (accuracy was uniformly high).

Consistent with previous results, the spatial responses were faster with scene primes relative to control, with scene primes becoming fully functional after only 200 ms of presentation. When irrelevant objects were added to the prime, the facilitory effect was reduced. When the irrelevant objects were opposite in orientation to the larger scene, the effect was reduced further, to levels of performance equal to when only general scene-background information is presented. The negative effects of misoriented objects imply they interfered with the activation of an appropriate reference frame.

URL: http://chuma.cas.usf.edu/~sanocki/research.html

B62 296 **Color information impairs change detection**

Maarten J. van der Smagt[1] (M.J.vanderSmagt@fss.uu.nl), Tanja C. W. Nijboer[1]; [1]Experimental Psychology, Helmholtz Institute & Utrecht University, Utrecht, The Netherlands

Categorization and naming of a scene is faster for scene images presented in color than for otherwise identical images presented in greyscale. This especially holds for natural scenes, for which appropriate color information is deemed 'diagnostic'. It has been proposed that color specifically facilitates the detection of the gist of such a scene. Therefore, we hypothesized that color information might impair change detection when only details (though obvious in retrospect) of an image are changed.

Participants viewed a set of scene-image pairs in a change-detection flicker paradigm. The images were presented in alternating fashion (200 ms presentation duration) interleaved by a 200 ms blank interval. The participants' task was to press a button as soon as they discovered which part of the scene had changed. Subsequently, they were asked to verbally describe the change. Each image pair was presented in both greyscale and in color, but participants never viewed the same scene twice.

The distribution of reaction times across participants and images was shifted between color and greyscale versions of the image pairs. Changes in greyscale image pairs were generally perceived faster than the same changes in color image pairs for both natural and manmade scenes. In addition, changes in manmade scenes appeared to be detected faster than those in natural scenes. However, this latter finding may bear solely upon the difference in complexity of images of both scene types.

The results suggest that indeed color information is especially important for the encoding of the gist of a scene. When color information is absent, a more detailed representation of the scene may be constructed, hence the superior change detection observed.

Acknowledgement: Supported by the Netherlands Organization for Scientific Research (NWO)

B63 297 **Differential perceived speeds explain the apparent compression in slit viewing**

Haluk Ogmen[1,2] (ogmen@uh.edu), Murat Aydin[1], Michael Herzog[3]; [1]Dept. of Electrical & Comp. Eng., University of Houston, [2]Center for Neuro-Engineering & Cognitive Science, University of Houston, [3]Brain Mind Institute, EPFL

Purpose. When a figure moves behind a stationary narrow slit, observers often report seeing the figure as an integrated whole but compressed along the axis of motion (anorthoscopic perception). Under-estimation of the speed of the moving object was offered as an explanation for this apparent compression. Here, we present results inconsistent with this hypothesis and offer an alternative explanation: The apparent compression is caused by the fact that the trailing parts of the figure are perceived to move faster than the leading parts.

Methods. The perceived speed and width of an ellipse (7.1 deg wide, 5 deg tall) moving (3.6, 7.1 or 10.7 deg/s) behind a slit (21 arcmin wide) were measured. In separate sessions, the perceived speeds of the leading and trailing halves of the ellipse were also measured. Moreover, we quantified the visibilities of the leading and trailing parts of a 5x5 square grid array moving behind the slit.

Results. 1) For all speed values tested, the ellipse was perceived as compressed and the magnitude of the compression increased with speed. 2) However, this compression cannot be explained by the under-estimation of the speed, since the ellipse was always perceived to move faster, not slower, than its physical speed. 3) The trailing part of the ellipse was always perceived to move faster than its leading part. 4) The results of the visibility experiment show that the slower perceived speed for the leading part might be due to its reduced visibility.

Conclusion. The apparent compression of a figure in slit viewing results from differential perceived speeds of its parts. More specifically, the trailing parts of the figure are perceived to move faster than its leading parts. The differential visibility of the different parts might play a role in determining the perceived speeds.

B64 298 **Aspects of painting perception**

Slobodan Markovic[1] (smakovi@f.bg.ac.yu), Ana Radonjic[2]; [1]Laboratory of Experimental Psychology, University of Belgrade, Serbia, [2]Department of Psychology, Rutgers University - Newark

In this study the three aspects of paintings perception were investigated: (1) judgments of physical properties (e.g. how colorful a painting appears), (2) judgments of subjective or implicit features (e.g. how warm a painting appears) and (3) judgments of representational content (e.g. how mimetic a painting appears). The classic semantic differential methodology was used in order to specify the underlying factorial structure of judgments within these categories. In the preliminary studies, a representative set of paintings with sets of elementary dimensions (bipolar scales) from three categories were selected. Four factors of physical properties judgments were extracted: Form (precise, neat, salient form, etc.), Color (color contrast, lightness contrast, vivid colors, etc.), Space (voluminosity, spatial depth, oval contours, etc), and Complexity (multicolored, ornate, detailed, etc). Four factors of implicit features judgments were extracted: Regularity (arranged, precise, regular, etc.), Relaxation (calming, warm serene, etc), Hedonic Tone (beautiful, pleasant, healthy, etc), and Arousal (impressive, strong, interesting, etc). Four factors of judgements of "what message the artist wanted to transmit" were obtained: bipolar factor with Illusion of reality on positive pole (e.g. exact optical representation of external world) and Construction of reality on negative pole (e.g. artist experimented with colors and shapes), Subjectivism (expression of emotions, fantasies and the like), Social ideology (historical events, transmission of religious messages) and Decoration (production of beautiful and pleasant objects). The main outcome of these factor analyses is the construction of instruments for measurement of three aspects of paintings perceptual experience. Results of further correlation analyses revealed two large clusters of factors corresponding with two general artistic styles. Cluster 1 was defined as a combination of Realism and Painterly style (factors Form, Space, Regularity and Illusion of Reality) and Cluster 2 was defined as a combination of Expressionism and Painterly style (factors Color, Arousal, Constructivism and Subjectivism).

B65 299 **A Test of the Consistency of Scene Preferences across Cultures**

Xiaomin Yue[1] (xyue@usc.edu), Mark Lescroart[2], Edward Vessel[3], Irving Biederman[1,2]; [1]Department of Psychology, University of Southern California, [2]Neuroscience Program, University of Southern California, [3]Center for Neural Science, New York University

People from a variety of developed world cultures express relatively similar preferences for scenes, preferring images that depict: a) large expanses ("vista"), b) where something is likely to happen ("mystery"), c) where there is a vantage point where they can see a lot and not be seen themselves ("refuge"), and d) natural rather than human-made entities ("nature"). Theorists (e.g., Kaplan & Kaplan, 1989) have argued that these preferences are an outgrowth of the evolution of perceptual/cognitive mechanisms that led to selection of locations in which game or threats could be safely detected in an environment that afforded water and useful plants. Biederman & Vessel (2006) showed that the four factors, taken together, could account for 62% of the variance in the ratings of scene preferences by USC undergraduates. An independent factor was novelty, with preferences declining with repetition for all the scenes. Would these preferences be expressed in individuals from a culture with little contact with western artifacts or scenes? The Himba are a semi-nomadic people in a remote region of Namibia with minimal contact with developed-world scenes or artifacts. To assess their preferences for viewing scenes (that could be correlated with Western preferences), the Himba (and Western comparison subjects) were shown a pair of scenes, side by side for a rela-

Saturday Posters

tively brief period of time. The subject would then indicate which of the two pictures s/he would like to see again and that picture was then shown at 2X its original size in the center of the screen. There was moderate consistency of preferences across subjects within the Himba and Western groups but no agreement across groups. Preliminary analyses indicate that the Himba preferred depictions of novel scenes, whether natural or human made.

Acknowledgement: NSF BCS 04-266415, 05-31177, 06-17699.

B66 300 **The Elevation of Visually Perceived Eye Level (VPEL) Is An Oscillatory Function of Visual Pitch**

Wenxun Li[1] (wl18@columbia.edu), Leonard Matin[1]; [1]Department of Psychology, Columbia University, New York

In our laboratory, a pitched-from-vertical visual field, either fully-structured and well-illuminated or consisting of only two pitched-from-vertical lines in darkness, exerts a large influence on the elevation of a target's setting to appear at visually perceived eye level (VPEL). The influence is nearlinearly related to the orientation of the visual field over the +-30° pitch range; VPEL lies above or below true eye level with the field pitched topforward (+) or topbackward (-), respectively. In naturalistic environments, however, VPEL has been reported to assimilate to the ground surface between +-7° downhill and uphill (O'Shea & Ross). Since uphill corresponds to topbackward pitch, this appears opposite to the laboratory work. Here we extend the inducer's pitch range to +-120° in 10° steps around a horizontal axis at true eye level in the frontoparallel plane 63 cm from the subject's eye. The inducer consists of two parallel 104 cm x 0.7 cm lines (phosphorescent tape) at a radial distance 37 cm from the pitch axis. The elevation of the VPEL target (circular, red, 10' dia) was presented in an erect plane 100 cm from the monocularly viewing subject, the same plane containing the inducing lines when erect (0°) and at +-25° horizontal eccentricity. We discover that the nearlinear function previously measured over the narrower pitch range is a portion of an oscillatory function over 360° with a fundamental wavelength approximately of 90° in the pitch dimension (4 cycles/360° of pitch). Over the nearlinear range (+-30°) VPEL increases from -11° (11° below true eye level) at -30° pitch to +6° at +30° pitch; a smaller second VPEL peak (+4°) occurs at -60° pitch and a second minimum (-4°) at +60° pitch. The extended function is reasonably represented as a superposition of two sinusoids. Both sets of previous results are consistent with the oscillatory function.

Acknowledgement: Support: NSF grant BCS-06-16654 and NIH grant EY10534.

B67 301 **Solider direction and soldier location: Image fusion and compression in two scene perception tasks**

Timothy Dixon[1] (Timothy.Dixon@bris.ac.uk), Eduardo Canga[2], Stavri Nikolov[2], Tom Troscianko[1], Jan Noyes[1], Dave Bull[2], Nishan Canagarajah[2]; [1]Department of Experimental Psychology, University of Bristol, UK, [2]Centre for Communications Research, University of Bristol, UK

The recent interest in image fusion – combining images of differing modalities such as visible light and infrared radiation – has created a growing body of research that indicates when fusion methods might be of more or less benefit, with the use of multiple assessment methods advised (e.g. Essock et al., 2004). The current work presents two such experiments, comparing different fusion methods (contrast pyramid [CP]; shift-invariant discrete wavelet transform [SIDWT]; and dual-tree complex wavelet transform [DT-CWT]) and JPEG2000 compression (no compression; low compression, .32bpp; high compression, .08bpp), as well as target location. In Experiment 1, participants indicated whether a soldier was facing left or right in six locations across a scene. In Experiment 2, they indicated whether a soldier was to the left or right of a clearing of trees in 12 locations across a scene. The results for Experiment 1 indicated no difference in fusion methods, but significant effects of compression and target location, with these two interacting. Reaction times (RTs) were slower with increased compression, and increased eccentricity of target, although RTs dropped for furthest targets, revealing an edge effect. Experiment 2 revealed main effects of fusion, compression and location, and an interaction between compression and fusion. RTs were faster for the SIDWT and DT-CWT than for CP, and slower between clean and high compression, with CP becoming much slower than the other fusion methods with increased compression. In addition, RTs slowed as target location approached the centre of the clearing, indicating an increase in uncertainty in participant response. Results indicate use of differing fusion schemes can benefit global target location but not more local target identification. However, compression has greater effect on identification rather than location. Future directions are presented, using an eye-tracking paradigm to further explore how fusion methods might be differentiated.

Acknowledgement: This work has been funded by the UK MoD Data and Information Fusion Defence Technology Centre. The original 'UN Camp' infrared and visible images were kindly supplied by Alexander Toet of the TNO Human Factors Research Institute. These images are available online at www.imagefusion.org.

URL: http://www.ablen.com/hosting/imagefusion/images/toet2/toet2.html

2D Shape and Form

Author Presents: 10:30 am - 12:15 pm

B68 302 **Seeing shape in noise: tuning characteristics of global shape mechanisms**

Gunter Loffler[1] (gloe@gcal.ac.uk), David M. Bennett[1], Gael E. Gordon[1]; [1]Department of Vision Sciences, Glasgow Caledonian University, Scotland

How local orientation information is pooled to yield global shape is a fundamental question in vision research. The aim of this study was to probe the characteristics of global shape mechanisms.

Stimulus arrays were oriented Gabors which sampled the circumferences of multiple concentric shapes in a polar grid. Individual Gabors were oriented tangentially to the global shape (signal) or randomly (noise); coherence was the independent variable. For signal elements positioned randomly in the array, about 15 signal elements (10%) were sufficient to detect concentric circular shapes. Sampling from ellipses, smoothed triangles, squares or pentagons yielded equally high sensitivities; performance declined for more complex shapes. Confining the signal to a single annulus reduced the number of elements needed to reach threshold to as few as 4 (2.5%). Overall performance for an array can be explained by probabilistic summation across multiple concentric shape detectors. We utilised the different rules found for signal summation within, compared to across, detectors to investigate the tuning of shape mechanisms. When elements were offset radially within 5% of the shape's radius, thresholds increased only slightly but doubled for 20% offsets. When element orientations were jittered within 12° of being tangent to the shape, thresholds remained constant but doubled for 25° jitter.

Our results provide evidence for highly sensitive detectors, tuned to circles but also other shapes, which sum information globally but only within specific annuli. These global mechanisms are broadly tuned with respect to the position and orientation of the local detectors from which they pool information. The relatively broad tuning for position makes an interesting prediction: if elements were taken from a pentagon and placed on a circular ring, they should be perceived as a pentagon rather than a jagged circle. Inspection shows this to be the case and provides a compelling new shape illusion.

Acknowledgement: This research is supported in part by EPSRC Grant No. GR/S59239/01.

B69 303 **New local and global shape illusions due to grouping**

Baingio Pinna[1] (baingio@uniss.it); [1]University of Sassari, Dept. of Sciences of Languages, Italy

The problem of perceptual organization concerns the perception of a world populated by phenomenal objects but not by differences of luminances and edges. The main question Wertheimer (1921) suggested is: how do the elements in the visual field 'go together' to form an integrated, holistic percept? He answered the question by discovering some 'grouping principles'. The problem of grouping is strongly related but not superimposable to the problem of shape perception. The main questions we want to answer are: Can grouping influence shape perception? What is the relationship between grouping and shape perception? To answer these questions the role of several gestalt grouping principles (similarity, proximity, good continuation) were studied through psychophysical experiments in conditions where whole simple geometrical shapes (e.g. square, triangle) are composed by similar or different element components. The grouping of these components was varied in different directions and orientations by varying the gestalt principles to test if and how it affects the shape of both whole object and element components. The results revealed several new shape illusions demonstrating that grouping principles strongly influence the shapes of both the whole object and the element components. The resulting shape illusions occur under new conditions and are opposite to what expected from other well-known illusions: Oppel-Kundt, Helmholtz's square, Attneave's and Palmer's triangles, Giovannelli illusion. The results demonstrated that grouping is not only related to how individual elements create larger wholes separated from others, but to the more general problem of shape perception. The new phenomena link grouping to shape perception more deeply by suggesting that the latter can be likely reduced to the former. This likely happens because grouping principles induce new symmetric organizations in the entire set of element components that define the whole shape that in its turn determines the shape of each component element.

Acknowledgement: Fondazione Banco di Sardegna, Alexander von Humboldt Foundation, PRIN ex 40% Cofin. es. 2005 (prot. 2005112805_002) and Fondo d'Ateneo (ex 60%).

B70 304 **Prolonged exposure to global structure induces 'remote' tilt-aftereffects**

Neil Roach[1] (nwr@psychology.nottingham.ac.uk), Ben Webb[1], Paul McGraw[1]; [1]Visual Neuroscience Group, School of Psychology, The University of Nottingham

Selective adaptation is a powerful psychophysical technique that has provided important insights into the organisation and properties of information processing in the visual system. One classic visual adaptation phenomenon is the tilt-aftereffect (TAE), whereby prolonged exposure to an oriented stimulus alters the perceived orientation of subsequently viewed stimuli. The properties of the TAE point towards a locus early in cortical visual processing, and extant models of the effect propose a central role for changes in excitatory and/or inhibitory interactions between, orientation-selective neurons in primary visual cortex. Here, using adapting stimuli containing complex global structure, we report sizeable TAEs that exhibit markedly different characteristics to those traditionally reported. Whereas the presence of a TAE following adaptation to a Cartesian grating requires spatial overlap between adaptor and test stimuli, aftereffects induced by adaptation to a polar (circular, radial) grating extend to remote, unadapted spatial regions. We further demonstrate that the direction and magnitude of these spatially remote TAEs are consistent with the local orientation implied by the global structure, rather than simple propagation of effects from nearby adapted regions. Manipulation of the relative spatial frequency of adapting and test stimuli results in a tight spatial frequency tuning profile for the traditional TAE. In contrast, remote TAEs resulting from global form adaptation show little or no spatial frequency tuning. These findings demonstrate that mechanisms which pool orientation information across space in order to extract global structure exert a marked influence on local orientation coding.

B71 305 **The role of 2D and 3D symmetry information in face processing in the human brain**

Christopher Tyler[1] (cwt@ski.org), Cathy Kao[2], CC Chen[2]; [1]Smith-Kettlewell Eye Research Institute, San Francisco, CA, [2]Department of Psychology, National Taiwan University, Taipei 106, Taiwan

Purpose. Symmetry is an important cue in face perception because faces have a high degree of bilateral and other symmetries. We ask to what extent the cortical areas responding to faces are responding on the basis of the symmetry cue alone, and conversely whether any cortical face areas show symmetry invariance?

Methods. We considered two types of symmetry: a) image symmetry, where one part of the image is the mirrored transform of the other part about an axis and b) object symmetry, where the correspondences are interpretable as parts of a symmetric 3D object. We used functional magnetic resonance imaging (fMRI) to compare cortical responses in human observers to front-view faces relative to a variety of symmetry manipulations of the same images.

Results. Both ventral and dorsal cortical areas were more activated by the face images than to Fourier-matched scrambled images: the classic fusiform (FFA) and occipital (OFA) face areas, the middle occipital gyri (MOG), and dorsal areas in the superior temporal and intra-occipital sulci. Contrasting faces and symmetrized scrambled versions showed a similar pattern of activation except in the right OFA, suggesting its involvement in facial symmetry processing. The response to front-view vs. 3/4-view faces (having the same 3D object symmetry but disrupted 2D image symmetry) showed strong responses in the MOG and IOS but little differential activation in the FFA or OFA, suggesting that face processing in the latter is holistic and viewpoint invariant. Contrasting upright vs. inverted faces showed robust differential activation at all sites.

Conclusions. Both dorsal and ventral face-responsive regions were robust to 2D symmetry manipulations, but only the FFA and OFA showed invariance under 3D manipulation, implying that they incorporate a 3D face representation. The strong face-inversion effects are attributable to the use of whole faces including neck and hair features.

Acknowledgement: Supported by NIH EY 13025
URL: www.ski.org/cwt

B72 306 **Perceiving Planar Symmetric Objects in 3D Scenes**

Tadamasa Sawada[1] (tsawada@psych.purdue.edu), Zygmunt Pizlo[1]; [1]Department of Psychology, Purdue University

Purpose: Because most man-made objects and animals are symmetric, detecting symmetric objects is important for humans. Indeed, human observers have little difficulty in determining whether a given object is symmetric or not, regardless of the viewing direction. Prior research concentrated on the case where the retinal image itself was symmetric. However the retinal image of a symmetric object is symmetric only for a small set of viewing directions. We tested perception of planar (2D) symmetric objects when the objects were slanted in depth and the retinal image itself was not symmetric. Experiments: In the first experiment, we tested symmetry detection with dotted patterns and polygons. Symmetry can be detected reliably in the case of polygons, but not dotted patterns. In the second experiment, we tested the role of image features representing the symmetry of a 2D figure (orientation of the projected symmetry axis and symmetry lines) vs. that representing the 3D viewing direction (orientation of the axis of rotation). Symmetry detection is more reliable when the projected symmetry axis or lines are known to the subject, but not when the axis of rotation is known. Finally, we tested symmetry detection with orthographic and perspective images. Symmetry detection with orthographic images is slightly better than that with perspective images. Based on these results, we will propose a computational model of symmetry detection. This model operates on shapes of contours, rather than on corresponding vertices. Generalization of these results to the case of images of volumetric (3D) symmetric objects will be discussed.

B73 307 **Symmetry and relational structure in the perception of rectangular frames**

Stefano Guidi[1,2] (sguidi@berkeley.edu), Stephen E. Palmer[2]; [1]University of Siena, [2]Department of Psychology, University of California, Berkeley

The current project maps the internal structure of a rectangular frame through goodness ratings of one or more probe targets placed at different positions and orientations in its interior (Palmer, 1991). In Experiment 1, participants rated the goodness-of-fit for a single, small, circular dot placed at each of 7 x 11 positions within a rectangle. The highest ratings occurred when it was at the center, decreasing as a function of distance from it. In addition to this “center bias” toward global balance, elevated goodness ratings were found for positions along the vertical and horizontal symmetry axes of the frame and also along the local symmetry axes that bisect the corners. Experiment 2 showed that the corner effects were, in fact, due to local symmetries along the corner bisectors rather than to global diagonals. Experiments 3 and 4 used a single more structured probe target - a small isosceles triangle – to map the orientational structure of the rectangle in more detail. The results confirmed both the importance of the center and the symmetry structure of the whole configuration, but also showed a directional “facing bias” to have the triangle point into (rather than out of) the rectangle. Further experiments investigated the influence of a second dot in the same rectangle. The pattern of ratings as a function of position changed globally and dramatically, but symmetries and relational structure were still the most important factors, accounting for almost 70% of the variance. These results may be relevant to the empirical study of aesthetic preference, such as the “center bias” and the “facing bias” reported by Palmer and Gardner (VSS-06, VSS-07).

Acknowledgement: Jonathan S. Gardner

B74 308 Masking exposes multiple global form mechanisms at intermediate levels of visual processing

Ben S. Webb[1] (bsw@psychology.nottingham.ac.uk), Neil W. Roach[1], Jon W. Peirce[1]; [1]Visual Neuroscience Group, School of Psychology, University of Nottingham

Human perceptual studies have demonstrated the existence of mechanisms at intermediate levels of visual processing that are specialised for the detection of radial and circular form. However, these configurations are only two members of a family of forms defined by their pitch angle, where radial and circular form have pitch angles of 0 and 90 degrees, respectively. It is not clear whether the visual system encodes the entire family of spiral forms with two cardinal mechanisms or multiple mechanisms each tuned to a different pitch angle. To determine which encoding strategy the visual system favours, we examined the effects of configural backward masking on human observers’ ability to detect global structure in Gabor arrays with different pitch angles. Each array (generated anew prior to each trial) consisted of 100 Gabors (carrier sf 6 c/deg, envelope sd 0.166 deg) randomly positioned within a circular annular window (inner diameter 1 deg, outer diameter 10 deg). Four observers judged which of two stimulus intervals contained global structure. One interval (the ‘foil’) contained Gabor elements with random orientations; the other (the ‘test’) contained Gabor elements with a variable proportion of orientations coherent with a pitch angle chosen from the range 0-90 degrees. Both test and foil were followed by a masking image composed of Gabors with a given pitch angle. When mask and test had the same pitch angle we found a 2-3 three-fold elevation in thresholds for detecting global structure that could not be explained by local orientation masking. The magnitude and bandwidth of this effect was similar for all pitch angles tested, suggesting that two cardinal mechanisms are insufficient to encode the entire family of spiral forms. We conclude that there are multiple mechanisms at intermediate levels of visual processing tuned for spiral form.

Acknowledgement: Supported by the Leverhulme Trust and BBSRC

B75 309 Hysteresis between shape-defined categories

Frances Wilkinson[1] (franw@yorku.ca), Seema Shahjahan[1], Hugh Wilson[1]; [1]Centre for Vision Research, York University

Hysteresis is the tendency of a dynamical system to display bias toward a given state or category based on recent history. Here we evaluate hysteresis between shape-defined categories using a multidimensional shape space framework we have previously used to examine categorical perception of fruit (Wilkinson et al, ECVP 2004). The bounding contours of many rounded objects can be described as sums of radial frequency (RF) components of specified amplitude and relative phase and represented as points within multidimensional RF space. Fruit shapes occupy regions of this space, in some cases adjacent (e.g. pear and avocado) and in others, separated by uncommitted regions (e.g. pear and apple).

To examine hysteresis both between fruit categories and at the boundaries between fruit regions and non-committed regions of this shape space, 20 participants were tested in 2 conditions on each of 6 fruit continua. In both conditions, participants were first shown exemplars of the two endpoints (e.g. apple and pear), followed by the presentation of the continuum beginning at one end (e.g. apple), with each step along the continuum presented for 500 ms separated by a 250 ms grey screen. In the STOP conditions, participants indicated the point at which the shape “stopped being an apple”; in the CHANGE condition, they indicated when the stimulus had clearly “changed into a pear”. Each of the 6 continua was presented 5 times in each direction in each condition.

Significant hysteresis was found between similarly shaped fruit (pear/avocado) and also at the boundaries between fruit categories and uncommitted regions of this space (apple/uncommitted/pear), indicating the involvement of cooperative/competitive mechanisms in establishing and maintaining categorical regions within this space. Our findings will be considered in the context of the recent distinction between dynamical and judgmental hysteresis made by Hock et al (Spatial Vision, 2005).

Acknowledgement: Supported by NSERC #OP0007551 to FEW and NSERC #OP227224 to HRW

B76 310 Frequency-based categorization of complex visual objects

Johannes Haushofer[1] (haushof@fas.harvard.edu), Chris I. Baker[2,3], Nancy Kanwisher[2]; [1]Department of Neurobiology, Harvard Medical School, Boston, MA 02115, [2]Department of Brain & Cognitive Sciences & McGovern Institute for Brain Research, MIT [3]Laboratory of Brain and Cognition, NIMH, NIH

How do we come to group visual objects into discrete categories? Prior evidence suggests a role for stimulus frequency (Rosenthal et al., 2001). We tested whether stimulus frequency could drive category formation for high-level visual objects, and what the underlying mechanisms are. We generated a two-dimensional continuum of complex visual stimuli which resembled eight-armed starfishes. Stimuli were presented following a bimodal frequency distribution: two regions of the stimulus space were shown with high frequency ("peaks"), while intermediate stimuli were shown less often. Subjects categorized the stimuli into "male" and "female". Importantly, no feedback was given; this enabled us to assess which criteria were used in categorization. We found that subjects closely followed the frequency distribution: one frequency peak was categorized as "male" and the other as "female", and the category boundary ran along the frequency minimum between the peaks. Since the category boundary was oriented obliquely to the physical dimensions, this suggests that frequency can influence categorization independently of physical stimulus dimensions. Categorization was most stable, and reaction times were shortest, at the extremes of the frequency spectrum, consistent with the formation of a frequency-based category axis. Remarkably, frequency-based categorization emerged within less than 50 trials, suggesting high sensitivity to frequency information. In a second experiment, we asked whether passive exposure to the frequency distribution is sufficient to influence categorization. Subjects passively viewed the same frequency distribution and subsequently guessed the category membership of each stimulus. Again judgments closely followed the frequency distribution. These results suggest that i. stimulus frequency can strongly influence the categorization of complex visual objects, ii. this influence is independent of physical dimensions and may be based on the establishment of a frequency-based category axis, iii. learning of frequency information is extremely fast, iv. passive exposure is sufficient for frequency to influence categorization.

B77 311 **When change blindness fails: Factors determining change detection for circular patterns**

Christian Kempgens[1] (cke7@gcal.ac.uk), Gunter Loffler[1], Harry S. Orbach[1]; [1]Department of Vision Sciences, Glasgow Caledonian University

Purpose:

When pattern elements have random orientation, human ability to detect changes in orientation of a single element deteriorates dramatically with the total number of elements (change blindness set-size effect). However, when elements have orientations that are tangent to a circle, there is little, if any, set-size effect (Kempgens, Loffler & Orbach, VSS 2006). What are the factors producing this surprising ability to detect change in multi-element configurations?

Methods:

Stimuli were composed of multiple D6 (6 cpd) elements, which were positioned as if on circular contours. We studied the effects of set-size (3-40 elements), inter-element spacing (0.7° - 4.7°), closure (a circle vs. a circular arc), circle radius (1.2°-6.2°), element orientation (tangential, radial, or jittered by ±2° to ±45° with respect to tangential), element position (radial jitter of up to ±50% of the 2.7° base radius), and the number of objects (three 120° arcs cut from a circle and everted) formed by the pattern elements. Subjects indicated in which of the sequentially presented stimuli one element had changed its orientation.

Results:

Orientation change detection (threshold approximately 10°) was largely independent of set-size, inter-element spacing, closure, radius and small orientation (up to 6°) and radial position (up to 10%) jitter. However, jittering position or orientation above these levels drastically impaired performance, as did increasing the number of objects formed by the pattern elements.

Conclusions:

Our results are in agreement with global mechanisms, which are relatively broadly tuned for orientation and position, sampling shape information within circular annuli. The relation between thresholds for single-circle patterns and patterns consisting of three objects (a triplet of non-concentric arcs) is consistent with probability summation between these units.

B78 312 **Dimensional consistency effects with illusory dimensions**

Jennifer Bittner[1] (jlb503@psu.edu), Michael Wenger[1], Brianna Sullivan[1], Rebecca Von Der Heide[1]; [1]Psychology, The Pennsylvania State University

Studies of facial perception have shown that observers' performance identifying facial parts (e.g., nose from face A) is better when that part is present in the context of the correct source face rather than a different source face. Studies of the perception of hierarchical forms have shown that observers' performance identifying local elements is better when those elements are combined to form a global pattern that is consistent rather than inconsistent (e.g., small Hs combined to form a large S). We describe here a first experiment designed to test the general hypothesis that effects in facial perception and effects in object perception reflect the same characteristics of visual perception. There are two specific hypotheses that are addressed in this work: (a) Perceptual organization relies as much or more on similarity at the level of second-order characteristics than at the level of first-order physical characteristics, and (b) perceptual organization reflects both perceptual and decisional factors. The present experiment uses stimuli in which the global forms emerge as illusory contours, with these contours being either consistent or inconsistent with the local forms. Observers are presented with these stimuli and make identification responses to both the global and local forms. The design allows for both the detection of dimensional consistency effects, and inferences regarding perceptual independence, and perceptual and decisional separability. Results indicate that (a) it is possible to obtain dimensional consistency effects with illusory contours, and (b) both perceptual and decisional components are implicated in these effects.

B79 313 **Compression in slit viewing occurs not in space but at object level**

Murat Aydin[1] (maydin@mail.uh.edu), Michael Herzog[3], Haluk Ogmen[1,2]; [1]Dept. of Electrical & Comp. Eng., University of Houston, [2]Center for Neuro-Engineering & Cognitive Science, University of Houston, [3]Brain Mind Institute, EPFL

Purpose. When a figure moves behind a stationary narrow slit, observers often report seeing the figure as an integrated whole although only the part of the figure confined to the narrow area of the slit is visible at any single instant (anorthoscopic perception). We used this paradigm to investigate the principles of "non-retinotopic" form perception in human vision. In slit viewing, the figure is also perceived as compressed along the axis of motion. However, it is still unclear whether the space in the vicinity of the slit or the figure itself undergoes compression. In a psychophysical experiment, we tested these two hypotheses. In addition, we investigated the role of perceptual grouping in slit viewing.

Methods. The perceived width of a bar (width: 17 arcmin; height: 4 arcmin), flashed for 31 ms in the center of the slit area (21 arcmin wide), was measured both in isolation and in the presence of a moving circle (8.5 deg/s) behind the slit. The perceived width of the same bar was also measured while it was moving (8.5 deg/s) behind the slit, again both in isolation and in the presence of a circle moving in either the same or opposite direction.

Results. 1) In all conditions, the moving circle was perceived as compressed. 2) The perceived width of the flashed bar was similar regardless of whether the perceptually compressed moving circle was presented. 3) The perceived width of the moving bar was smaller when it was presented concurrently with the perceptually compressed circle moving in the same but not in the opposite direction.

Conclusion. Our results indicate that in non-retinotopic form perception, compression of form results from figural rather than spatial compression and that compression properties can transfer between objects if they are perceptually grouped (e.g. based on the Gestalt principle of "common fate").

Special Populations: Development

Author Presents: 10:30 am - 12:15 pm

B80 314 **Developmental changes in the capacity to process faces**

Rebecca Von Der Heide[1] (rjv151@psu.edu), Michael Wenger[1], Rick Gilmore[1], Matthew Walsh[1], Brianna Sullivan[1], Jennifer Bittner[1]; [1]Psychology, The Pennsylvania State University

The ability to correctly recognize a face is a skill that develops with age. Children are slower and less accurate at recognizing faces and do not appear to reach adult levels until some point between adolescence and adulthood. There is evidence to suggest that this gradual improvement in the ability to recognize faces with age is a quantitative rather than qualitative change and could be indicative of an in increase in processing capacity (Itier & Taylor,2004). Unfortunately, definitions of processing capacity in the literature are relatively imprecise, and the statistical measures used to test hypotheses regarding changes in capacity are rarely linked to theoretical definitions. The present study defines processing capacity as the way the perceptual system performs across changes in workload, at the level of the hazard function of the response time distribution (Townsend & Ashby,1978; Townsend & Nozawa,1995; Townsend & Wenger,2004; Wenger & Townsend,2000).Use of this measure in studies of facial perception in adults has shown that the major distinctions between the processing of configural and non-configural stimuli occur at the level of processing capacity (Ingvalson & Wenger, 2005; Wenger & Townsend, 2006). The present study uses the same framework to study developmental differences in the capacity to process changes in featural and configural information in upright and inverted faces. Experiment 1 is the first study to employ the aforementioned measures of processing capacity in a sample of children. Results indicate that these measures can be used successfully with children ages 6 years or older.

B81 315 The Development of Abstract Numerical Processing in Parietal Cortex

Jessica Cantlon[1,2] (jfc2@duke.edu), Melissa Libertus[1,2], Elizabeth Brannon[1,2], Kevin Pelphrey[1,3]; [1]Psychology & Neuroscience, Duke University, [2]Center for Cognitive Neuroscience, [3]Brain Imaging and Analysis Center

Functional imaging and lesion studies of adult humans have established a neuro-cognitive link between numerical processing and regions of parietal cortex. Adults with lesions to areas of parietal cortex that encompass the intraparietal sulcus (IPS) exhibit impaired performance on symbolic numerical tasks but not on tasks that test knowledge of other semantic domains (e.g., Dehaene & Cohen, 1991). In addition, functional magnetic resonance imaging (fMRI) studies have revealed number-specific activity in the adult IPS relative to control tasks for non-symbolic numerical values (e.g., Ansari et al., 2006; Cantlon et al., 2006; Piazza et al., 2004). Thus regions of posterior parietal cortex in the adult brain respond to numerical values abstractly, independent of notation.

We tested 7-y-old children and adults as they chose the larger of two numerical values from two visual arrays of dots (non-symbolic condition) or two Arabic numerals (symbolic condition) during an fMRI scan. The numerical comparisons were identical in both conditions and were either easy (0.5 ratio between values) or difficult (0.8 ratio). We examined BOLD activity during the symbolic and non-symbolic conditions as a function of the ratio between the numerical values of the comparisons. Adults exhibited a bilateral ratio effect in posterior parietal cortex whereas children only exhibited this numerical ratio effect in the right hemisphere. The different patterns of brain activity evoked by children and adults may be related to the development of an automatic, symbolic system of numerical representation that has not yet reached maturity by 7 years of age.

B82 316 Six-year-old children do not integrate visual-haptic information optimally

Monica Gori[1,2] (monica.gori@unige.it), Maria Michela Del Viva[3,4], Giulio Sandini[1,2], David Burr[3,4]; [1]IIT Italian Institute of Technology, [2]DIST University of Genoa, [3]Dipartimento di psicologia Universita' di Firenze, [4]CNR Istituto di Neuroscienze Pisa

Recent studies suggest that information from our five senses is integrated in a statistically optimal (Bayesian) fashion, weighting each sensory input with an estimate of its reliability (inverse variance of sensory noise). In this study we investigate whether 6-year-old children also integrate visual and haptic information optimally. We asked 3 adults and 11 6-year-olds to judge the width of real plastic blocks (about 5 cm wide) using vision, touch or both. In the bimodal condition the block passed through an opaque barrier that concealed the hands from view, allowing a conflict to be introduced between the visual and haptic modalities while creating the illusion of a continuous block. Subjects reported whether the test blocks of variable widths appeared to be narrower of wider than the probe, producing bias-free psychometric curves from which perceived subjective equality (PSE) and threshold (root-variance) were calculated. The children were significantly worse than adults in both the visual and haptic judgments (1,5 times for vision, 2 times for touch), suggesting that these perceptual capacities were still developing, particularly for touch. Adult observers combined visual and haptic information optimally: the PSEs in bimodal conflict conditions were well predicted by the variance-weighted average of visual and haptic information; and audio-visual thresholds were lower than either unimodal threshold, very close to the Bayesian prediction. Children, on the other hand, combined information sub-optimally, giving far too much weight to touch. This was true both for the PSEs (that tended to follow haptic rather than visual information), and bimodal thresholds that were 1,5 times higher than the vision-only task. In both cases the actual weight for about equal to that of vision, while it should have been 2,2 times lower. These results show that perceptual systems of 6-year-olds are immature, particularly in integrating cues from different modalities.

B83 317 Infants' Visual Habituation Patterns Show Large Within-Session Variability

Rick Gilmore[1] (rogilmore@psu.edu), Laura Murray-Kolb[1], Jung Min Lee[2]; [1]Dept of Psychology, Penn State University, [2]Martinos Center for Biomedical Imaging, Massachusetts General Hospital

Looking time habituation dominates studies of visual perception and cognition in infants and yet remains poorly understood. Inspired in part by psychophysical approaches, we analyzed individual patterns of habituation using regression techniques (Thomas & Gilmore, 2004). The goal was to determine whether individual infants show consistent patterns of habituation within a single session. One group (n=57) viewed patterns of optic flow depicting motion of the viewpoint 45 deg to the left or right of center. A second group (n=73) viewed movie clips of two different infant faces. Each infant viewed 7 trials of one display (familiar), followed by 7 trials of a different (novel) display. Linear and nonlinear functions were fit to looking time data for each infant and goodness of fit assessed by the Bayesian Information Criterion (BIC). On average, younger (3-4 month-old) infants looked longer than older (5-6 mo-old) ones, $F(1,126)=8.99$, $p=.003$, faces elicited longer looking, $F(1,126)=8.52$, $p=.004$, and the familiar display drew longer looks than the novel one, $F(1,126)=9.17$, $p=.003$. Nevertheless, infant looking time patterns differed across the two phases. Fewer than 1/5 infants habituated to both the familiar and novel displays according to the standard 50% decrement from baseline criterion. Moreover, for 57/130 infants, a flat line through the mean provided the best fit to the observed looking time data in both phases of the experiment. When looking times declined, a 3-parameter exponential function provided the best fit. The results suggest that few infants show systematic look time patterns to both familiar and novel displays within the same experimental session. While average looking times across infants may show statistically detectable trends, individual data do so inconsistently. The results call into question the generality of claims made about infants' perceptual or cognitive abilities based on group, not individual-level habituation data.

Acknowledgement: Supported by NICHD (HD041476 伉)
URL: http://www.personal.psu.edu/rog1/pubs/thomas.gilmore.2004.pdf

B84 318 Good-poor reader accuracy differences in four-dot masking

Richard Kruk[1] (krukr@ms.umanitoba.ca); [1]University of Manitoba

Good and poor readers differ on a variety of visual processes related to visual attention and rate of visual processing. Poor readers show increased visual attentional dwell time, evidence of left visual field "minineglect," differences on measures related to visual magnocellular processes (higher dot motion coherence threshold, constrast sensitivity for low spatial and high temporal frequency stimuli), and lower accuracy on measures of visual masking. The current study examined reader group differences in performance on one form of backward masking that is related to visual attention – four dot masking. 132 children in Grade 1, half at risk of reading disability, and half typically developing readers matched on age and gender, were administered a four-dot masking task in which target location (left and right visual fields), eccentricity (central, peripheral), and mask duration (48, 96, and 192 ms) were varied. Poor readers consistently scored lower than poor readers. Poorer performance was found at the 192 ms duration condition, showing that the expected four-dot masking effect was obtained, and stronger masking was found for peripheral targets compared with central targets. Although no location effect was found in the overall sample, a subgroup of poor readers, scoring one or more SD below the average on a standardized reading measure, showed anomalous performance for targets in the left visual field, but not for targets in the right visual field. Results are discussed in relation to visual attentional development in good and poor readers.

Acknowledgement: Supported by the Social Sciences and Humanties Resarch Council of Canada

B85 319 **Representational Momentum in Preterm and Full-term Children**

Nicole Taylor[1] (ummendar@cc.umanitoba.ca), Lorna Jakobson[1]; [1]Department of Psychology, University of Manitoba

When an object that is moving along a particular path vanishes, observers' memory for the object's final position is biased in the direction of continuing motion (Freyd & Finke, 1984). This effect is seen even with static stimuli in which motion is simply implied (Freyd, 1983). This memory bias, referred to as the representational momentum (RM) effect, is seen in both children and adults (Futterweit & Beilin, 1994; Hubbard, Matzenbacher, & Davis 1999). Several recent studies (e.g., Senior et al., 2002) suggest that images depicting implied motion activate brain regions involved in actual motion processing. Given this, we might expect to see that children with motion-processing deficits would show an atypical RM effect. Previous research in our laboratory has shown that children born prematurely at very low birth weight (VLBW < 1500 g) are at risk for impairments in both low-level and high-level motion processing (MacKay et al., 2005; Jakobson et al., 2006). In the present study, we compared the RM effect in 5-9 year old, VLBW children to that seen in an age-matched sample of full-term controls. Full-term children showed a robust RM effect, and the strength of this effect was negatively correlated with their global motion coherence thresholds (r = -.55); in other words, control children who were more proficient at global motion perception showed a larger memory bias. VLBW children did not show an RM effect, and tended to have higher motion coherence thresholds than controls, overall. There was, moreover, no relationship between performance on the RM task and motion coherence thresholds (r = -.06) in this group. These results are consistent with research suggesting overlap in the neural substrates supporting the processing of implied and actual motion, and extend our earlier work demonstrating that VLBW children are at risk for problems associated with poor motion processing.

Acknowledgement: This research was supported by an NSERC grant to LJ

B86 320 **Infants' ability to enumerate multiple spatially-overlapping sets in parallel**

Jennifer Zosh[1] (jzosh@jhu.edu), Lisa Feigenson[1], Justin Halberda[1]; [1]Psychological and Brain Sciences, The Johns Hopkins University

The ability to nonverbally enumerate large numbers of items in parallel (e.g., an array of 40 dots) is seemingly contradictory to the limit of 3-4 individual objects that can be stored in parallel in tasks of attention and working memory. However, recent work addressed this paradox by showing that adults can enumerate up to 3 sets of objects (e.g., 10 red, 8 green, and 17 yellow dots) in parallel (Halberda, Sires & Feigenson, 2006). To date, the developmental origin of this ability to enumerate multiple sets remains unclear. By 6 months, infants can enumerate at least 1 set of items (Xu & Spelke, 2000). And by 10 months, they can track up to 3 individual objects in parallel (Feigenson & Carey 2003, 2005). The current studies ask whether the limit on the number of individual objects infants can represent also constrains the number of sets they can represent. Infants were habituated to arrays consisting of 2, 3, or 4 sets of spatially intermixed colored dots (4 - 20 dots per set). They then saw alternating test arrays. In the Discriminable test array, one of the colored sets (randomly determined) changed its numerosity. In the Non-Discriminable test array, all of the sets changed their numerosity by an amount known to be undetectable by infants of the relevant age. Thus, the change in total number of dots was equated across test trial types, yet only in the Discriminable arrays did the number of dots in one of the subsets change substantially. Results show that infants detected a change with arrays containing 2 sets, but not with 3 or 4 sets. Thus, infants, like adults, can track multiple numerosities in parallel. Furthermore, the upper-limit on the number of sets they can enumerate appears to be bounded by constraints on working memory.

B87 321 **Spatial lateral interactions during childhood**

David Boutin[1,2] (d.boutin@umontreal.ca), Dave Ellemberg[1,2]; [1]Department of Kinesiology, Université de Montréal, [2]Centre de Recherche en Neuropsychologie et Cognition (CERNEC)

We studied the development of spatial lateral interactions. Participants were adults (mean age = 23 years-old) and children aged 8, 10, 12, 14 and 16 years (n = 18 per age). We measured the apparent contrast of a foveally viewed Gabor as a function of the spacing of horizontally adjacent Gabors. Each Gabor had a contrast of 40%, a vertical carrier spatial frequency of 3 cycles per degree (? = σ = 20 arc min), and a spread of 0.58 degrees. Inter-element spacing ranged from 1.5 to 6 cycles from the centre of the target to the centre of either of its adjacent flankers. The data make three points. First, at the smallest inter-element spacing, there is a reduction in the apparent contrast of the central Gabor for each age group tested. Second, at the smallest inter-element spacing, apparent contrast was significantly less reduced for the 8, 10, 12 and 14-year-olds compared to the two older groups. There was no significant difference between the 16-year-olds and the adults. Finally, compared to the adults, the measured reduction in apparent contrast extends over shorter distances for all other groups tested. Together, these results suggest that spatial lateral interactions mature very slowly and that they still have not reached adult-like characteristics by 16 years of age. This is consistent with recent findings that GABA expression in the human visual cortex does not become adult-like until late teens or even early adulthood [Boley et al., (2005). Society for Neuroscience].

Acknowledgement: Supported by an NSERC grant to D.E.

B88 322 **The impact of maturation and aging on mechanisms of attentional selection**

Ran Carmi[1] (carmi@usc.edu), Po-He Tseng[2], Ian Cameron[3], Laurent Itti[1,2], Doug Munoz[3]; [1]Neuroscience Program, University of Southern California, [2]Computer Science Department, University of Southern California, [3]Centre for Neuroscience Studies and Department of Physiology, Queen's University

How do mechanisms of attentional selection change as people mature and age? To investigate this question, we tracked the eyes of 3 groups of human observers (children: 10-13, adults: 20-28, and elderly: 69-73) as they watched MTV-style video clips (30 s each) constructed from unrelated shots of natural scenes (2-4 s each). It was previously shown that jump cuts - abrupt transitions between shots - lead to stereotypical changes in the balance between bottom-up and top-down influences on attentional selection (http://journalofvision.org/6/9/4). Specifically, the impact of bottom-up influences peaks shortly after jump cuts, followed by monotonic decreases for up to 2.5 s. Here we investigated the effects of maturation and aging on the balance between bottom-up and top-down influences. We analyzed the input video clips with a bottom-up computer model of attentional selection, and probed the impact of bottom-up influences by quantifying the accuracy of the model in predicting saccade targets (>40,000 in total). We found that the overall impact of bottom-up influences increased monotonically as a function of age (>10% magnitude difference between adjacent age groups, p<<0.01). Temporal changes in the impact of bottom-up influences were highly conserved between the children and the adults, but differed substantially in the elderly. A straightforward yet counter-intuitive interpretation of the results is that people become more bottom-up driven as they mature and age. Alternatively, jump cuts may affect attentional mechanisms differently in different ages, leading to more random selections by children and slower utilization of top-down information by the elderly.

Saturday Posters

Poster Session C

Saturday, May 12, 2:00 - 6:30 pm, Municipal Auditorium

V1 and Thalamus: Anatomy and Organization

Author Presents: 4:00 – 5:45 pm

C1 323 **Precise topographic encoding of visual stimuli in the human pulvinar**

Jason Fischer[1,2] (jason.t.fischer@gmail.com), David Whitney[1,2]; [1]Center for Mind and Brain, University of California, Davis, [2]Department of Psychology, UC Davis

The human pulvinar has been subject to increasing study as evidence accumulates that it plays an active role in visual perception, specifically in spatially directed attention. Single-unit studies have reported retinotopic organization in some sub-regions of the monkey pulvinar (Bender, 1981). However, such topography has not been found in human subjects. Establishing whether topographic encoding exists is a fundamental step in advancing our understanding of the pulvinar's role in visual processing. Here we use fMRI to test for position-sensitive encoding in the human pulvinar. Subjects passively viewed flickering Gabor stimuli that were located at one of five eccentricities from a central fixation point. Spatial patterns of BOLD responses corresponding to each of the Gabor positions were cross-correlated, producing a Fisher z score for each pair. As the spatial separation between Gabors increased, the correlation between patterns of activity across voxels within the right pulvinar decreased significantly, indicating precise position-sensitive encoding. Right hemisphere pulvinar discriminated Gabors separated by less than 2 degrees visual angle (at ~10 deg. eccentricity). The voxels within the pulvinar showing the strongest position sensitivity exhibited more precise discrimination than did 99.99% of the voxels in the rest of the brain outside of visual cortex (V1, V2, V3, V4, and VP). The data also reveal a surprising lateralization: across all seven subjects, right hemisphere pulvinar showed strong topographic encoding while left hemisphere pulvinar showed little or no position sensitivity. Other studies have provided some evidence for lateralization of function in the pulvinar, e.g. Karnath et al. (2002), in which a group of stroke patients suffering from spatial neglect had damage to the right pulvinar but not the left. It is possible that the lateralization in topographic encoding that we see here is related to the functional lateralization reported by Karnath and elsewhere.

C2 324 **The connectivity of the human pulvinar: A diffusion tensor imaging tractography study**

Sandra E. Leh[1] (sandra@bic.mni.mcgill.ca), M. Mallar Chakravarty[2], Alain Ptito[1]; [1]Cognitive Neuroscience Unit, Montreal Neurological Institute/McGill, Canada, [2]McConnell Brain Imaging Center, Montreal Neurological Institute & Hospital, McGill University, Montreal, Canada

Introduction: Previous studies in nonhuman primates and cats have shown that the pulvinar receives input from various cortical and subcortical areas involved in vision. Although the contribution of the pulvinar to human vision remains to be established, anatomical tracer and electrophysiological animal studies on cortico-pulvinar circuits suggest an important role of this structure to visual spatial attention, visual integration (e.g. 1) and higher-order visual processing (2, 3). Because methodological constraints limit human investigations of the pulvinar's function, its role can at present only be deduced from animal studies (e.g. 4, 5). Methods: In the present study, we used an innovative imaging technique namely, Diffusion Tensor Imaging (DTI) tractography, to determine cortical and subcortical connections of the human pulvinar. We were able to reconstruct pulvinar fiber tracts and compare variability across subjects in vivo. Results: Here we demonstrate that the human pulvinar is interconnected with subcortical structures (superior colliculus, thalamus and caudate nucleus) as well as with cortical structures (primary visual areas (area 17), secondary visual areas (area 18, 19), visual inferotemporal areas (area 20), posterior parietal association areas (area 7), frontal eye fields and prefrontal areas). These results are consistent with the connectivity reported in animal anatomical studies (e.g. 1, 6, 7, 8, 9). References: (1) Casanova, Freeman & Nordmann, 1989; (2) Casanova et al., 2001; (3) Villeneuve et al., 2005 (2) Shipp, 2004; (5) Grieve, Acuna & Cudeiro, 2000; (6) Hutsler & Chalupa, 1991; (7) Chalupa, Anchel & Lindsley, 1972; (8) Yeterian & Pandya, 1985; (9) Shipp, 2001.

Acknowledgement: This study was supported by a REPRIC training award to SEL on DTI analysis techniques (University of Oxford, United Kingdom), a doctoral scholarship from FRSQ to SEL, and an NSERC research grant to AP (RGPIN 37354-02).
URL: www.bic.mni.mcgill.ca/~sandra

C3 325 **Representation of the ipsilateral visual field in early retinotopic cortex**

Petya D Radoeva[1] (petya@mail.med.upenn.edu), Geoffrey K Aguirre[2]; [1]Neuroscience, University of Pennsylvania, [2]Neurology, University of Pennsylvania

Early visual areas contain neurons responsive to stimuli in the contralateral visual field. At higher levels of the visual hierarchy, neurons with receptive fields that cross the midline are identified. The recovery from cortical injury in other sensory and effector modalities is associated with development or unmasking of responsiveness to the ipsilateral (contralesional) side. In preparation for studies of recovery of visual function following visual pathway lesions, we quantified the normative responsiveness of retinotopically organized visual areas to the ipsilateral visual field. Six subjects participated in fMRI scanning sessions during which polar angle and eccentricity mapping stimuli were presented in isolation to each visual hemifield. All reflective surfaces within the scanner bore and head coil were covered with black cloth or matte tape to eliminate the scatter of light to the other visual hemifield. In preliminary data analyses from two subjects, visual areas were identified on the flattened cortical sheet of each hemisphere by polar angle stimuli presented to the contralateral visual field. In all four hemispheres, voxels with modulation of response by the ipsilateral visual field were identified within areas V1, V2, V3 and hV4. We then examined the correlation between the ipsi- and contralateral peak eccentricity response in these voxels. Amongst early visual areas, area hV4 showed a strong correlation, with R^2 values of approximately 0.5 and greater, and slopes approaching unity. Significant, but far weaker, correlations were observed in V1 and V2/V3. Ongoing analyses will examine the relative contribution of near vs. far periphery responses and the degree to which responsiveness to polar angle is shared across the visual fields.

C4 326 The human occipital lobe: variability and probability maps of the sulci.

Giuseppe Iaria[1,2,3] (giaria@eyecarecentre.org), Steve Robbins[2], Michael Petrides[2]; [1]Human Vision and Eye Movement Laboratory, Univeristy of British Columbia, Vancouver, Canada, [2]Montreal Neurological Institute, McGill University, Montreal, Canada, [3]Department of Psychology, University of Rome "La Sapienza", Rome, Italy

Functional neuroimaging have permitted the mapping of several visual areas of the human brain and have already provided provisional identification of most of the visual areas that were first described in nonhuman primates. However, the lack of an adequate description of the sulcal patterns of the human occipital lobe makes it difficult to establish clear relations between sulcal landmarks and identified visual areas with modern functional neuroimaging. Here, we examined the morphological variation of the sulci of the human occipital region in both the left and the right hemispheres of 40 normal individuals on magnetic resonance images. We identified the occipital sulci and marked their corresponding gray matter voxels on the magnetic resonance images, which had been transformed into the Montreal Neurological Institute standard proportional stereotaxic space in order to construct probability maps. In the medial occipital region, the calcarine sulcus was found to be the longest and most constant sulcus. In the inferior part of the medial occipital lobe, we identified the lingual sulcus and the posterior collateral sulcus, and, in the superior part, the inferior and superior sagittal sulci of the cuneus. On the lateral surface of the occipital lobe, we identified the lateral occipital, the lunate, the transverse and the inferior occipital sulci. The parieto-occipital fissure and the temporo-occipital incisure were also identified on the lateral and medial surfaces of the hemispheres. Finally, we examined the patterns of the occipital sulci and gyri in 20 post-mortem human hemispheres fixed in formalin. We constructed probability maps of the occipital sulci, which provide a quantitative description of the variability of these sulci and may be used to identify the location of voxels in other magnetic resonance images transformed into the same streotaxic space. These maps are a useful tool in the study of functional activations related to visual processing.

C5 327 What makes topographic map boundaries parsimonious?

Kathleen Hansen[1] (hansenka@mail.nih.gov); [1]NIMH, NIH

In some retinotopic occipital regions (for example, V1 and V2), there is one unambiguous way to parcel BOLD topographic data into discrete, coherent regions. The most parsimonious boundaries for these topographic regions are immediately obvious, and virtually all investigators accept these boundaries as likely boundaries of cortical areas. The opposite extreme applies in large portions of frontal, temporal and parietal cortex; these regions may be divisible into cortical areas by other metrics, but they are blank on currently available thresholded topographic maps. But what about regions between these extremes? In much of occipital and parts of frontal, temporal and parietal cortex there is evidence for topographic organization, but unambiguous locations for cortical area boundaries do not leap out of the data. When this occurs, can we parcel the difficult topographic data into likely cortical area locations? On which a priori expectations can we rely? How confident can we be in our conclusions?

We review the variety of conceptual approaches that different neuroimaging laboratories have applied to these basic questions. Because the topographic organization in some parts of the human brain may be complex, we also review some complex topographic organizations previously documented in nonhuman species.

Finally, we provide several novel tests that we have found helpful when considering various topographic parcellations as putative cortical areas. There are undoubtedly many cortical areas that have some topography but do not pass all of these tests; however, each test that a topographic parcellation does pass lends additional weight to the notion that it is equivalent to a cortical area. To illustrate each test, we show how it is passed in our human topographic parcellation V4. This parcellation accounts more parsimoniously for the available data than either of the two competing sets of parcellations, V4v/V4d-topo/V8 and hV4/LO1.

C6 328 Abstract withdrawn

C7 329 The effects of a cholinergic deficit on visual learning in rats

Alexandre Ben Amor[1] (alexbenamor@hotmail.com), Elvire Vaucher[1]; [1]School of Optometry, Université de Montréal

The cholinergic system participates in the continual reorganization of the cortical sensory map. During patterned visual stimulation, acetylcholine is released in the primary visual cortex (V1) and a deficit of this neurotransmitter diminishes neuronal activity of this area. Here, we evaluated if an acetylcholine deficit affects perceptual learning capacity of rats performing a visual discrimination task.

Rats were trained in a visual water maze to determine visual acuity (Prusky et al., 2000). Subjects were then divided into two groups whereby one group received intra-ventricular injections of 192 IgG-saporin in order to lesion the cholinergic fibers and a sham lesion group. After 21 days post-surgery, rats were tested for recall of the visual acuity task and learned an orientation task modified to the water maze. In the orientation task, animals learned to discriminate between a 90° stimulus (reference pattern) and one that varied between 45° and 90°. An 80% success rate was used to define successful learning of the task. Immunostaining of cholinergic fibres in V1 and basal forebrain showed a complete loss of cholinergic innervation of V1. The visual acuity of the lesioned and the sham-operated rats did not differ from pre-surgery levels. The ability of the lesioned group to learn the orientation task was significantly lower than the sham-operated group ($p=0.015$). More trials were necessary for the lesioned group to be able to discriminate between a 75° vs 90° pattern compared to control animals (73 ± 8 and 42 ± 6, respectively). These results suggest that a deficit in acetylcholine may cause a deficit in visual learning.

Acknowledgement: Dr. Mark Burk, Canadian Institute of Health Research, School of Optometry - Université de Montréal.

C8 330 The mechanism underlying large-scale reorganization in human macular degeneration patients

Yoichiro Masuda[1,2] (massuuu@gmail.com), Satoshi Nakadomari[1], Serge O. Dumoulin[2], Sing-Hang Cheung[2], Ayumu Furuta[3], Kenji Kitahara[1], Brian A. Wandell[2]; [1]Ophthalmology, The Jikei University School of Medicine, Tokyo, Japan, [2]Psychology, Stanford University, Stanford, CA, [3]Maeda ophthalmic clinic, Fukushima, Japan

Purpose. There is currently a controversy about the conditions required for reorganization in human adults. Some studies describe large-scale human reorganization in human macular degeneration (MD) patients whereas others do not (Baker et al., 2005; Sunness et al., 2004). We explored the requirement for large-scale reorganization in human MD.

Methods. We report fMRI measurements from one JMD patient, who was diagnosed with binocular JMD thirteen years prior to the experiments. She has about a 40x50 degree diameter central absolute scotoma; she fixates using preferred retinal loci (PRL) in the left lower visual field. We also measured fMRI responses in three healthy control subjects using the same experimental setup and eccentric fixation. We used a wide array of visual stimuli that included faces, scrambled faces, moving gratings and checkerboards. Subjects either passively viewed the stimuli or performed a "one-back" task consisting of detecting consecutive repetitions of identical stimuli.

Results. In the JMD patient widespread responses were observed that extended beyond the representation of the PRL into the cortical representation of central vision (occipital pole). This widespread activation was only present in the JMD patient and not in the control subjects. Importantly, these activations were (a) present only when the JMD patient performed the one-back task and (b) independent of the stimuli. We did not observe any cortical activations beyond those expected from the PRL when using passive stimulus viewing.

Discussion. The widespread V1 activations in the JMD subject have been described as evidence for large-scale reorganization within V1. However, since the activation depends on the task but not the stimuli, we suggest that the reported large-scale human reorganization is mediated by feedback from cortical circuits. The strength of these circuit connections may be increased following retinal damage.

Acknowledgement: We thank Satoru Miyauchi, Masaya Misaki, Hiroshi Horiguchi, Shigeyuki Kan, Kunihiro Asakawa, for their help and comments.

C9 331 Changes in Inhibitory Mechanisms in Human Visual Cortex Throughout the Lifespan

Joshua G. A. Pinto[1,4] (jpinto@centenary.edu), Kyle R. Hornby[1], David G. Jones[2,3], Kathryn M. Murphy[1,3]; [1]Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, ON, [2]Electrical & Computer Engineering, McMaster University, Hamilton, ON, [3]McMaster Institute for Neuroscience Discovery & Study, Hamilton, ON, [4]Biochemistry, Centenary College of Louisiana, Shreveport, LA

Inhibitory processes play a key role in shaping visual perception and many studies have suggested that changes in visual perception throughout the lifespan are linked with changes in neural inhibitory mechanisms. GABA is the major inhibitory neurotransmitter in visual cortex and GABAergic mechanisms are involved in developmental plasticity influencing the maturation of receptive field properties, the spatial and temporal integration of signals, and the timing of neural circuits. The synchronized firing of target neurons is a key function of the GABAergic inhibitory system and the presynaptic cannabinoid receptor -- CB1 -- can inhibit GABA release, depressing fast synaptic signaling and disrupting temporally coordinated firing among neurons. We have studied CB1 expression in human visual cortex throughout the lifespan using Western blot analysis of postmortem tissue samples. We determined the developmental profile of CB1 expression and compared it with the maturation of the GABAA[alpha]2 receptor subunit which is found at the same inhibitory synapses. CB1 expression is initially very high in infant visual cortex (< 1 year of age), falls to low levels between 1-4 years of age, rises steadily to reach the highest levels during the teenage years, then falls again into adulthood showing a small roll off with aging. GABAA[alpha]2 receptor subunit expression is also very high in infants (< 1 year) and then falls to about half that level where it remains. We compared the CB1:GABAA[alpha]2 ratio and found that initially there is more GABAA[alpha]2, then between 4-20 years of age there is a switch to substantially more CB1, followed by balanced expression in young adults and slightly less CB1 in older adults. Taken together, these changes in CB1 and GABAA[alpha]2 expression in human visual cortex suggest that there may be substantial developmental variations in fast synaptic signaling that affect synchronized firing among populations of neurons as well as visual perceptions that depend on temporally coordinated neural activity.

C10 332 Pattern-Pulse Multifocal MEG Mapping of Human Visual Cortex using the General Linear Model

Andrew James[1] (andrew.james@anu.edu.au), Xin-Lin Goh[1], Simo Vanni[2,3]; [1]ARC Centre of Excllence in Vision Science and Research School of Biological Sciences, Australian National University, Canberra, Australia, [2]Research Unit, Low Temperature Laboratory, Helsinki University of Technology, Espoo, Finland, [3]Advanced Magnetic Imaging Centre, Helsinki University of Technology, Espoo, Finland

Objective: Multifocal analysis allows characterization of responses to stimulation of multiple visual field regions by using concurrent stimulation with independent modulation sequences, and decomposition of the resulting compound responses into components due to each region. The introduction of multifocal pattern-pulse stimuli, and the efficient estimation of response components by the general linear model rather than cross-correlation, has increased the flexibility and power of multifocal analysis in the domain of visual evoked potentials [1]. This study presents a multifocal pattern-pulse analysis for the magneto-encephalographic mapping of activity in human visual cortex.

Methods: An 84 region multifocal stimulus comprising 7 rings of 12 sectors extending to 24° eccentricity was defined, with pattern-pulse presentation of checkerboard stimuli at a mean rate of 2 per second to each region, driven by linearly independent sequences. Visual evoked fields were recorded with a Neuromag Vectorview whole-head device which houses 306 SQUID sensors in a helmet array. Ten subjects were recorded, for two repeats of a design presenting 484 pattern-pulses to each of the 84 regions, over 240 seconds, divided into 4 one-minute segments. Fitting of each response signal with the general linear model estimated the elementary response waveforms due to each of the 84 stimulus regions for each of the 306 recording channels.

Results & Discussion: Good signal to noise ratio was obtained from this design for all subjects, with magnetometer responses to single regions achieving peak values of over 200 fT on occipital channels, and gradiometers achieving peak values over 50 fT/cm on occipital channels. Replicability between repeats, measured as peak value divided by standard deviation between repeats indicated amplitude signal to noise ratios that often exceeded 10 on occipital channels, for both magnetometers and gradiometers.

[1] James, AC (2003) IOVS

C11 333 Designer Stimuli Enables VEP Based Separation of Early Visual Areas

Timothy Erlenmeyer[1] (timerlenmeyer@berkeley.edu), Justin Ales[1], Thom Carney[1], Stanley Klein[1]; [1]University of California, Berkeley

There is great interest in developing methods for identifying the VEPs of separate visual areas. This goal has been difficult to achieve because early visual areas are so closely spaced.

Our approach to this problem uses MRI and fMRI to constrain the solution. Previously, we recorded VEP's to each of 192 stimulus patches in a dartboard display.

The VEP dipole sources were initially constrained to the cortical locations specified by the fMRI. Then a nonlinear search allowed the dipoles to move by up to 3mm to improve the fit of the forward model FMeeg) to the VEP data, which achieved excellent agreement between the time functions for the right and left hemispheres for V1 and moderately good agreement for V2. This step was needed because of inaccuracies in both the fMRI and in the dipole forward model. As a result we have two types of forward models predictions: FMfmri based purely on MRI/fMRI information and FMeeg based on the best fit to a high resolution (192 patches) dataset.

To improve signal to noise ratios we replaced the 192 patch stimuli with large designer patches chosen to lie on relatively flat regions of V1 and V2 that individually activate close to 10 times the cortical area. We carried out large patch simulations using the data from our 192 patch experiments. As expected, the FMeeg improved V1/V2 time function isolation. In addition, the designer patch results were compared with those obtained using comparably large uniformly distributed patches (non fMRI constrained) that avoided the horizontal and vertical meridians. The intelligently designed stimulus patches performed substantially better than arbitrary placed patches at separating V1 and V2 responses.

The use of designer stimuli increases SNR, thereby reducing recording time, yet promises to fulfill the goal of separating the responses of multiple visual areas.

Brightness, Lightness and Luminance

Author Presents: 2:00 - 3:45 pm

C12 334 Parametric measurements of lightness in the context of real illuminated objects

Sarah R. Allred[1] (sallred@psych.upenn.edu), David H. Brainard[1]; [1]Department of Psychology, University of Pennsylvania

Purpose: The visual system achieves partial lightness constancy across illumination gradients and variations in object pose. What scene variables mediate this constancy? Here we report parametric measurements of how the slant and reflectance of a background surface affect the lightness of test spots seen against that surface. Methods: Observers looked into an experimental chamber. Two spatially separated cards provided the immediate backgrounds for a test and matching spot. The slant of the background cards could be varied using computer-controlled rotating stages. Changes in the reflectances of background cards were simulated with a hidden projector. Observers compared the apparent lightness of simulated spots projected onto the background cards. We held the slant and simulated reflectance of one background card fixed and varied the slant and simulated reflectance of the other. We obtained matching curves which related the luminance of a spot on the fixed background card to the luminance of a lightness-matched spot on the variable background card. Results: When there were minimal cues to illumination geometry, matching curves depended only the background card's luminance and were independent of the type of manipulation (reflectance or slant) used to achieve a particular luminance. In addition, the matching curves resembled those obtained previously for simple stimulus configurations where test spots where presented against spatially uniform backgrounds. Conclusion: We have developed a paradigm that allows parametric measurement of object lightness in real scene contexts. Within this paradigm we are able to reduce conditions sufficiently that we can replicate key features of classic results. For richer contexts, we expect new patterns to emerge in the parametric data. The data should address the generalizability of extant models developed with reference to much simpler viewing conditions, and allow development of quantitative models of lightness applicable to natural viewing.

Supported by NIH/NEI RO1 EY10016 and P30 EY001583

C13 335 Amodal completion affects lightness perception

Huseyin Boyaci[1] (boyac003@umn.edu), Fang Fang[1], Scott O. Murray[2], Daniel Kersten[1]; [1]Department of Psychology, University of Minnesota, [2]Department of Psychology, University of Washington

It is well-known that perceptual grouping influences the perception of surface lightness; however the extent of the interaction between grouping and lightness is not known. Amodal completion - when two spatially separated surfaces appear to be grouped together behind an occluder - is one of the mechanisms which can facilitate perceptual grouping. We study perceptual grouping and its effect on lightness perception through amodal completion.

Imagine quantizing the luminances in the rectangular form of the classic "Craik-O'Brien-Cornsweet" stimulus to three levels, resulting in four uniformly gray rectangular regions. Like the "Craik-O'Brien-Cornsweet" stimulus, the leftmost and rightmost regions (flanks) have the same luminance. The quantization eliminates the luminance gradients in the bands on either side of the central border, but introduces two additional vertical borders. If these two borders are occluded by two bars, then the surface appears amodally completed and one perceives the leftmost and rightmost rectangular regions to differ in lightness, similar to the "Craik-O'Brien-Cornsweet" effect: the flank, which is spatially closer to the higher luminance band, is perceived to have a higher lightness relative to the other flank.

We studied the magnitude of the effect as a function of the contrast of the central border in the stimulus described above. Three observers viewed the 3-D stimuli binocularly through a stereoscope and performed a pixel matching task. We found that the lightness effect initially gets stronger as the contrast of the central border increases reaching a maximum, then weakens and nearly disappears as the contrast approaches 100 percent. Preliminary fMRI data show that activity in early visual cortical areas reflects the illusory percept. Candidate computational models that can potentially predict the perceptual effect are examined.

Acknowledgement: This work was supported by NIH grant EY015261. The 3T scanner at the University of Minnesota, Center for Magnetic Resonance Research is supported by BTRR P41 008079 and by the MIND Institute. Partial support has been provided by the Center for Cognitive Sciences, University of Minnesota

C14 336 The Hermann grid is an equiluminant weave

Kai Hamburger[1] (Kai.Hamburger@psychol.uni-giessen.de), Arthur G. Shapiro[2]; [1]Department of Experimental Psychology, Justus Liebig University Giessen, [2]Deaprtment of Psychology and Program in Neuroscience, Bucknell University

We define 'weaves' to be a class of stimuli that contain intertwined vertical and horizontal bars. There are two subgroups of weaves: luminance-defined weaves consist of patterns in which the vertical and horizontal bars have different luminance levels; equiluminant weaves consist of patterns in which the bars have the same luminance levels. The classic Hermann grid display (i.e., a white grid superimposed on a black background, or vice versa) is a special case of an equiluminant weave. As with the Herman grid, both luminance-defined and equiluminant weaves produce smudges when the background is brighter or darker than the bars. We demonstrate that 1) luminance-defined weaves produce smudges at every other intersection and equiluminant weaves produce smudges at every intersection; 2) for luminance-defined weaves, the smudges are present in the high-spatial frequency components of the pattern but not in low spatial frequency components; 3) unlike the smudges for equiluminant weaves, the smudges for luminance-defined weaves are not disrupted by jaggy bars, wavy bars, thick bars, or orientation changes; and 4) unlike the smudges for equiluminant weaves, the smudges for luminance-defined weaves occur foveally and can be created with contrast variation (contrast-contrast weaves). One possible framework for considering these effects is that, as suggested in the theory of Schiller and Carvey (2005), the smudges arise out of the co-activation of ON and OFF simple cells with colour-selective simple cells—except that the colour selective cells represent both hue and achromatic sensations. We also suggest another possibility in which the smudges arise from a bi-product of lightness interpolation mechanisms that builds a 1st-order representation from 2nd-order information.

Acknowledgement: This research was supported by the German Science Foundation (Graduate Program 'NeuroAct' 885/1). We thank Karl R. Gegenfurtner for valuable comments on this topic.
URL: http://www.allpsych.uni-giessen.de/kai/ http://www.shapirolab.net/

C15 337 A filtering model of brightness perception using Frequency-specific Locally-normalized Oriented Difference-of-Gaussians (FLODOG)

Alan E. Robinson[1] (robinson@cogsci.ucsd.edu), Paul S. Hammon[2], Virginia R. de Sa[1]; [1]Department of Cognitive Science, UC San Diego, [2]Department of Electrical and Computer Engineering, UC San Diego

The perceived brightness of a surface depends on the brightness of neighboring surfaces. Here, we describe a new low-level computational model of this effect. We extend the ODOG model (Blakeslee & McCourt, 1999), which combines two simple mechanisms. First, the input is filtered by multiscale oriented difference of Gaussian filters. Second, global response normalization equalizes the amount of energy at each orientation across the entire visual field.

In this work we extended the ODOG model with a more neurally plausible normalization step. The normalization step in the ODOG model is necessary to account for a family of illusions known as White's effect, which are often characterized by a highly non-uniform distribution of energy at different orientations. ODOG fails on variations of White's effect that have equal energy across orientations when integrated over the entire image, suggesting a more localized normalization scheme is necessary. A local mechanism also has the advantage of being more plausible for implementation in early visual areas, such as V1, because it only requires short-distance connections between neurons.

In our new model, Frequency-specific Locally-normalized ODOG (FLODOG), energy normalization is computed locally, both in terms of spatial location and spatial frequency. We filter the image into 6 different orientations and 7 scales. Each filter response is normalized by a weighted sum that includes itself and also filter responses for nearby spatial frequencies of the same orientation. This normalization occurs within a local window, the size of which scales with the spatial extent of the filter being normalized.

The FLODOG model successfully accounts for most of the illusions for which ODOG makes correct predictions. In addition, it correctly predicts many variants of White's illusion that ODOG cannot.

URL: http://csclab.ucsd.edu/~alan/pub/

C16 338 Multiplicative Model for Spatial Interaction in the Human Visual Cortex

Xian Zhang[1,2] (xzhang63@gmail.com), Jason C. Park[1], Jennifer Salant[1], Sonya Thomas[1], Joy Hirsch[1,2], Donald C. Hood[1]; [1]Departments of Psychology, Columbia University, [2]Department of Radiology, Center for Neurobiology and Behavior, Functional MRI Research Center, Columbia University

Multiplicative Model for Spatial Interaction in the Human Visual Cortex

Xian Zhang1,2, Jason C. Park1, Jennifer Salant1, Sonya Thomas1, Joy Hirsch1,2 Donald C. Hood1,

1Departments of Psychology, Columbia University

2Department of Radiology, Center for Neurobiology and Behavior, Functional MRI Research Center, Columbia University

Purpose: To understand the neural mechanism underlying spatial interaction, the multifocal visual evoked potential (mfVEP)[1,2] for both the target and neighbor stimuli were recorded simultaneously. A normalization model [3] and a new multiplicative model were fitted to the data.

Methods: The display was a one ring, 24-sector checkerboard display, subtending 44.5°. Each sector consisted of 2 (in angle) by 6 (in eccentricity) checks. The check size was scaled according to cortical magnification. The 1st,...,23rd sectors and the 2nd,...,24th sectors made up two sets of sectors, mutually being the target and the neighbor to each other. Both the target and neighbor varied in 6 levels of contrasts: 0,4,8,6,32,64%.

Results: For most conditions, the relationship between the amplitude of target response and the contrast of the neighbor, as well as the relationship between the amplitude of target response and the contrast of the target, were described with a simple, normalization model. However, when the neighbor stimulus had a much higher contrast than the target stimulus, the amplitude of the target response was larger than that predicted by the normalization model. A multiplicative model was developed to describe these data.

Conclusion: To account for these spatial interaction results requires: 1) a multiplicative mechanism, 2) mutual interaction between neighboring regions, and 3) a mechanism that saturates when the ratio in contrasts between target and neighbor is large. A multiplicative model with these characteristics described the results well.

References: [1] Sutter, E. E. and D. Tran (1992); [2] Hood, D. C., Q. Ghadiali, et al. (2006); [3] Heeger, D. J. (1993)

Acknowledgement: NIH/NEI EY02115, The Dana foundation

C17 339 The transition luminance between the surface-color and the illuminant-color modes may reveal the illuminant represented in the visual system

Takayuki Fukuya[1] (fukuya@u.ip.titech.ac.jp), Keiji Uchikawa[1]; [1]Department of Information Processing, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology

Color appearances may be classified into two modes, the surface-color mode and the illuminant-color mode. The mode of color appearance is determined by the luminance of the stimulus. It has been reported that the transition luminance between the surface-color and the illuminant-color modes depends on the chromaticity of the stimulus. When an illuminant is fixed real surfaces having the same chromaticity should have a luminance limit (the luminance of the optimal color) because spectral components of a surface reflectance range from 0 to 1. If the luminance of a color surface exceeds this luminance limit it should no more appear in the surface-color mode but in the illuminant-color mode. We hypothesize that the visual system somehow knows the luminance limit of a color surface and uses it to determine the transition luminance between the two modes. To confirm this hypothesis we compared the transition luminance and the luminance limit of various color surfaces under various color illuminants (D65, 3000K, 25000K, (x', y') = (0.545, 0.341), (0.269, 0.562), (0.164, 0.076)). The transition luminance was measured in experiments in which the observer could adjust luminance of the test stimulus for a chromaticity fixed. The luminance limit was calculated under the same color illuminants. It was found that, under a white illuminant, the transition luminance and the luminance limit showed a similar variation across the chromaticity. However, under chromatic illuminants, they were found to be quite different. When chromatic illuminants, desaturated than the real illuminants, were used for the calculation the luminance limit became quite similar to the transition luminance. The present results suggest that the visual system might use the luminance limit of a surface under a desaturated illuminant to determine the transition luminance.

C18 340 A sub-cortical locus for brightness filling in

Elaine Anderson[1] (e.anderson@fil.ion.ucl.ac.uk), Steven Dakin[1], Geraint Rees[1]; [1]Wellcome Trust Centre for Neuroimaging

The perceived brightness of a uniform region can be profoundly altered by the presence of a light-dark luminance gradient along its border, inducing the Craik-Cornsweet-O'Brien effect (CCOB). Dakin & Bex (2003; "Natural image statistics mediate brightness "filling-in". Proc Roy Soc, 270) proposed that such illusory changes in brightness arise as a result of the visual system reconstructing the image most likely to have elicited a particular series of responses from a bank of isotropic band-pass filters. The model effectively boosts the low spatial frequency (SF) structure of the image and suggests an early, possibly pre-cortical, mechanism for 'filling-in'. Here we sought to assess the role of low SFs in driving the CCOB and to identify the neural site of brightness filling-in. In a block design fMRI study, healthy human volunteers viewed (a) the CCOB illusion (b) CCOB with low SFs scrambled (c) CCOB with high SFs scrambled or (d) an identical pattern containing physical luminance change (psychophysically) matched to the perceived contrast of the CCOB. Stimuli in conditions (a-c) had identical power spectra. All conditions phase reversed at 1Hz and blocks were interleaved with a fixation baseline. Using high-resolution fMRI (1.5mm3 at 3T) we imaged the lateral geniculate nucleus (LGN) and primary retinotopic visual areas. The LGN preferentially responded to the CCOB illusion. Scrambling low SFs destroyed the illusion and significantly reduced LGN activity. V1 showed a qualitatively similar pattern of responses. To test whether these observations might reflect monocular signals we examined whether perception of the illusion changed under dichoptic viewing conditions. When only the light or dark portion of the CCOB is visible to each eye the illusory percept disappears; the CCOB effect is strictly monocular. Taken together these findings suggest that brightness filling-in may be a sub-cortical phenomenon, contingent on the presence of low SF structure.

Acknowledgement: Supported by The Wellcome Trust

C19 341 Correlation of fMRI responses to absolute luminance changes in visual cortex

Hiroshi Horiguchi[1,2] (hhiro@jf6.so-net.ne.jp), Satoshi Nakadomari[1,2], Ayumu Furuta[3], Kunihiro Asakawa[1,4], Yoichiro Masuda[1,5], Kenji Kitahara[1], Takeshi Abe[6], Shigeyuki Kan[6], Masaya Misaki[6], Satoru Miyauchi[6]; [1]Ophthalmology, The Jikei University School of Medicine, Tokyo, Japan, [2]Ophthalmology, Kanagawa Rehabilitation Hospital, Atsugi, Japan, [3]Maeda Ophthalmic Clinic, Aizuwakamatsu, Japan, [4]Institute for Physiological Sciences, Okazaki, Japan, [5]Psychology, Stanford University, Stanford, CA, [6]National Institute of Information and Communications Technology, Kobe, Japan

Purpose: Even though luminance information is important, there are few papers that focus on brain activity elicited by pure luminance changes without form information (Ganzfeld). We previously reported the responses of visual cortex to Ganzfeld stimuli using functional magnetic resonance imaging (fMRI). We found that the cortical responses varied as a function of eccentricity in spite of using achromatic borderless stimuli. We proposed that this eccentricity dependence might be caused by a different proportion of sustained versus transient response. Here, we address this hypothesis again using a stimulus paradigm optimized for this question.

Methods: We controlled subjects' pupils with mydriatics and placed semi-transparent, hemisphere-shaped covers on their eyes in order to achieve large uniform visual fields and eliminate form information. With this Ganzfeld stimulus, subjects viewed only spatially uniform brightness changes in the following: The illumination increased gradually from the lowest luminance level to the highest in 24 seconds, and decreased gradually to the lowest level in 24 seconds (sustained change). Then it switched to the highest level instantaneously (transient change). Next, it decreased gradually to the lowest level in 24 seconds, and increased gradually to the highest level, and then it switched to the lowest. In summary, one cycle was 96 seconds and was repeated. We used two regressors; one for the transient signal changes and the other for sustained signal changes.

Results and discussion: The responses in a relatively anterior region of the calcarine sulcus correlated more strongly with transient signal changes. In contrast, posterior regions of the calcarine sulcus correlated more strongly with sustained signal changes. In conclusion, we confirmed transient responses in peripheral representations of visual cortex and sustained responses in central representations, respectively.

C20 342 FMRI responses in V1 represent the perceived rather than physical stimulus contrast

Kathryn Murray[1] (kdmurray@ucsd.edu), Geoffrey Boynton[1,2]; [1]Neurosciences, UCSD, [2]Salk Institute

Introduction: The contrast of a stimulus appears lower in the presence of a high-contrast background. Electrophysiological measurements in monkeys and fMRI responses in humans are typically suppressed in the presence of a surrounding contrast background. This leads to the hypothesis that neuronal responses in early visual areas represent the perceived, and not the physical contrast of a stimulus. We tested this hypothesis by comparing contrast matching measurements with fMRI responses in early visual areas. Methods: We acquired fMRI-contrast-response functions and psychometric contrast matching data simultaneously using an event-related fMRI design. Subjects viewed checkerboard targets presented to the left and right of fixation, superimposed on a graded checkerboard background so that one target was surrounded by high contrast and the other by low contrast. Different combinations of target contrasts were presented on each trial while subjects indicated which target had the higher apparent contrast. Results: Psychophysically, more contrast was needed for a target imbedded in a high contrast background to perceptually match a target surrounded by a low contrast background. FMRI contrast-response functions in V1 for targets surrounded by high contrast were suppressed compared to those surrounded by low contrast. FMRI and psychophysics data were compared by assuming that an equal BOLD response to the two targets should result in a perceptual contrast match. Contrast response functions in V1 were affected by the background in a manner that predicts the effects of the background on perceived contrast. Conclusions: The neuronal basis of perceptual illusions are often associated with extrastriate visual areas, consistent with the idea that early visual areas maintain a veridical representation of the stimulus, whereas higher visual areas represent what is perceived. However, with surround suppression, it appears that perceived, rather than physical contrast may be represented by neuronal responses as early as the primary visual cortex.

Acknowledgement: Support: NIH EY12925

C21 343 Brightness Induction in Human V3

Maria Pereverzeva[1] (mariape@u.washington.edu), Scott Murray[1]; [1]Department of Psychology, University of Washington, Seattle, WA 98195

When a static gray surface is embedded in a temporally modulated in luminance surround, its brightness appears to change over time. The magnitude of the illusory brightness modulation is inversely related to the border contrast between the surface and the time-averaged surround luminance. Specifically, the perceived brightness modulation is largest when the contrast is zero, and gets progressively smaller as the contrast is increased. We used this inverse relationship between contrast and perceived (illusory) brightness in an fMRI experiment designed to identify the visual areas that underlie brightness perception.

Five subjects viewed static test surfaces of different contrast (0.0,0.2,0.5,1.0) created by changing the luminance of the surface (both increments and decrements) with respect to a time-averaged luminance of surround. The surround was modulated in luminance from 1050 to 1700 cd/m2 sinusoidally, at 1Hz. We analyzed retinotopic visual areas V1,V2, and V3 separately, using multiple regions-of-interest corresponding to different portions of the visual stimulus. If the region corresponding to the center of the test surface in a particular visual area is driven primarily by the border contrast (e.g.,Cornelissen et al,2006), we expected a progressive increase in the fMRI signal as we increased the contrast. However, if the visual area is primarily sensitive to perceived brightness we expected the opposite pattern – a progressive decrease in the fMRI signal with increasing contrast.

Increasing border contrast – thereby reducing the brightness induction – resulted in a progressive increase in the fMRI signal in V1 confirming this area's sensitivity to luminance contrast. In V3, however, we observed the opposite pattern – an inverse relationship between contrast and the fMRI signal that approximated the perceived change in brightness. Area V2 showed an intermediate response. The data suggest that a progressive recoding of contrast to brightness information occurs in early retinotopic visual areas.

Acknowledgement: Supported by EY07031 from the NEI to MP and HM1582-05-C-0037 from National Geo-Spatial Intelligence Agency to SM

C22 344 Target luminance modulates saccadic behavior and visual sensory responses in the superior colliculus

Robert Marino[1] (rmarino@biomed.queensu.ca), Ron Levy[1], Doug Munoz[1]; [1]Centre for Neuroscience Studies, Queen's University, Kingston, Canada

Oculomotor saccade tasks have been used as a behavioral tool for studying the neural processes underlying saccade initiation. However, the dependence of saccade latency on target luminance and the corresponding modulation of visual responses within oculomotor brain regions is not well understood. In this study we examined how neuronal sensory discharge related to the onset of visual targets is modulated by stimulus intensity in neurons within the Superior Colliculus (SC) and how this modulation affects saccadic performance. We recorded single and multi-unit cell activity in the SC of rhesus monkeys trained to perform oculomotor tasks designed to measure and dissociate visual and saccadic responses. Cells were classified by their respective visual and/or motor activity dissociated in the Visual Delay task. Each neuron's visual response was sub-characterized by its target related discharge after the onset of a visual stimulus that stochastically ranged in intensities from below 0.01 cd/m2 to11 cd/m2. Preliminary results show significant modulations in target related discharges in visually responsive SC neurons. Increases in target luminance lead to significant increases in the peak magnitude of the visual burst of neurons. Significant decreases were also seen in the visual response onset latency (ROL) and duration of the visual response with increasing target intensity. Paradoxical low frequency visual responses to ipsilateral targets were recorded that occurred later than the contralateral visual response in the SC. The timing of the luminance dependant ROL matched the expected onset times for express saccades determined from behavioral analysis. The consequences for express saccades imply that the later arrival and diminished response at dim targets can significantly affect express saccade latency and likelihood. From these data we conclude that target luminance can be used as a valuable tool for altering the timing and magnitude of sensory signals within the visual system leading to saccade initiation.

Acknowledgement: Supported by C.I.H.R.

C23 345 Rapid search for gross illumination discrepancies in upright but not inverted images.

P. George Lovell[1] (p.g.lovell@bristol.ac.uk), David Tolhurst[2], Michelle To[2], Tom Troscianko[1]; [1]Department of Experimental Psychology, University of Bristol. United Kingdom., [2]Deparment of Physiology, University of Cambridge, Cambridge. United Kingdom

Evidence from schematic stimuli (Rensink and Cavanagh, 2004 Perception) suggests that the detection of discrepant shadows in a visual search task is impaired in upright, but not inverted, images – hypothetically due to the discounting of shadows. The current study investigates this phenomenon with real objects and their shadows.

Sixty pebbles were photographed from directly above as they were rotated through four orientations with direct (ringflash) and indirect illumination that cast shadows. The visual difference between all pebbles (without shadows) was estimated using a visual difference predicting model (Párraga, et al 2005 Vis.Res. 45, 3145; Lovell et al 2006 ACMTAP, 3, 155). Classical multi-dimensional scaling was applied to the resultant confusion matrix and the two major axes, corresponding to size/color and orientation, were identified.

Visual search stimuli featuring 5, 10 or 15 pebbles were constructed. Distractor pebbles all cast a shadow in the same direction, while the target pebble's shadow was rotated by 180½. The heterogeneity (based upon the MDS axes) of the pebbles within each stimulus was also varied. Stimuli were viewed monocularly, and were presented in a fronto-parallel arrangement. However, texture gradients were added to induce a perception that the pebbles were upon a ground, ceiling or fronto-parallel surface. Stimuli were presented upright (light from above) or upside down (light from below). The observer's task was to locate the discrepant shadow.

There was a significant effect of image inversion: visual search was significantly slower in the light-from-below condition. There was also a significant effect of heterogeneity: search became slower when the heterogeneity of the pebbles was increased. Texture-gradient had little effect. The apparent discrepancy between the results of Rensink and Cavanagh (with small, 30½ changes in shadows) and ours (with 180½ changes) may illuminate characteristics of the mechanism that underlies shadow discounting.

Acknowledgement: Supported by EPSRC/Dstl (GR/S56405/01 & GR/S56399/01).

C24 346 The accuracy of observers' estimates of their ability to see and steer in low luminances

Johnell O. Brooks[1] (jobrook@clemson.edu), Richard A. Tyrrell[1], Benjamin R. Stephens[1]; [1]Department of Psychology, Clemson University

Drivers are comfortable overdriving their headlights at night. Leibowitz & Owens (1977) hypothesized that drivers are unaware of the "selective degradation" of focal visual functions (their ability to recognize objects and hazards at night) in part because ambient visual functions (including visual guidance / steering) are preserved at low luminances. Previous researchers have confirmed that the ability to steer – but not the ability to see details – is robust to lowered luminances (e.g. Brooks, Tyrrell & Frank, 2005; Owens & Tyrrell, 1999). However, no empirical investigations have directly explored the extent to which drivers are aware of how luminance affects steering and acuity. We asked 36 visually healthy, licensed drivers from three age groups (18-21, 35-50, and 65-78 years) to drive a fixed-base driving simulator (150° horizontal by 50° vertical) at a moderately high speed on an empty but continuously curvy road in a broad range of luminance conditions (-3 to 1 log cd/m2). First, participants were dark adapted and then, at each luminance, predicted both their ability to steer the vehicle and their ability to discern optotypes. Following another period of dark adaptation, at each of the 5 luminances observers spent five minutes driving the curvy road and had their acuity assessed. The older drivers overestimated their acuity while both young and middle-age adults underestimated their acuity. Importantly, participants correctly estimated that their high and low contrast acuity would decline as luminance decreased but were unaware that their steering capabilities would not. These results indicate that drivers fail to appreciate that acuity and steering are supported by separate visual mechanisms.

Acknowledgement: The first author was funded by a Dwight David Eisenhower Graduate Transportation Fellowship.

C25 347 Preferred Driving Speeds of Older and Younger Drivers under Varying Luminance Conditions

Ashley A. Martin[1] (csu20653@mail.claytonstate.net), Brooke C. Manger[1], Nathan D. Klein[1], Peggy J. Tyler[1], Johnell O. Brooks[1]; [1]Department of Psychology, Clemson University

Previous studies have found that steering is quite robust to reduced luminance; when traveling at a constant speed, older drivers' steering performance is poorer than younger drivers' (Owens & Tyrrell, 1999.) The current study examined the preferred driving speed of 11 older (M=72.5 years) and 10 younger (M=19.6 years) licensed drivers under 5 luminance conditions (-3 to 1 log cd/m2.) Participants drove a simulator on continuously-curvy rural roadways with a 55-mph speed limit. Each participant was encouraged to drive at his or her preferred speed while remaining within their lane; at the conclusion of each trial, workload was rated on a 0-150 scale. The drivers' steering ability was robust; the percentage of the trial the vehicle was entirely within the lane ranged from 92% in the maximum luminance condition to 71% in the darkest condition, despite a 4-log-unit luminance reduction. While there was no difference between the older and younger drivers' steering ability, age differences were present for preferred driving speed. Averaged across the luminance conditions, the older drivers traveled more slowly (39.5 mph) than the younger drivers (52.5 mph.) Averaged across age groups, speed decreased from 51.3 mph in the maximum luminance condition to 37.6 mph in the darkest condition. The speed gap between the age groups increased as luminance decreased, with the smallest difference (8.1 mph) in the maximum luminance condition and largest difference (16.5 mph) in the minimum luminance condition. As luminance decreased, the drivers' workload significantly increased from 36.2 in the maximum luminance condition to 84.5 in the darkest. There was no difference between the age groups' self-reported workloads.

Acknowledgement: This work was supported by the National Science Foundation and the Department of Defense ASSURE Program under Grant No. SES-0353698.

C26 348 The effects of fog on driving speed

Yarbough N. Miller[1] (yarmiller@student.morris.edu), Anna L. Hilpert[1], Nathan D. Klein[1], Peggy J. Tyler[1], Johnell O. Brooks[1]; [1]Department of Psychology, Clemson University

Previous research studies provide contradictory results in investigating driving speeds under foggy conditions. Therefore, a series of three simulator studies were conducted to examine the impact of fog on driving speed. In all of the studies, 12 participants drove along continuously-curvy roads with a 55-mph speed limit under 6 fog conditions (visibility distances of

496, 179, 70, 31, 18 & 6m.) In Study 1, drivers were encouraged to maintain a speed between 50 and 60 mph and were able to use the speedometer. The participants drove a mean speed of 55 mph for all conditions except the foggiest (6m) where speed dropped to 51 mph. In the remaining two studies, participants were encouraged to drive at a self-chosen "comfortable" speed. The participants could use the speedometer in Study 2, but not in Study 3. In Study 2, the drivers' speed was at or near the speed limit until the foggiest two conditions (18 & 6m), when mean speeds decreased to 48 and 38 mph, respectively. In Study 3, the mean speed was 60 mph or above for all but the foggiest two conditions, when speeds decreased to 56 and 44 mph, respectively.

Acknowledgement: This work was supported by the National Science Foundation and the Department of Defense ASSURE Program under Grant No. SES-0353698.

Spatial Vision: Contrast and Masking

Author Presents: 4:00 - 5:45 pm

C27 349 Anisotropic contrast gain inferred from broadband masking

Andrew M. Haun[1] (amhaun01@louisville.edu), Edward A. Essock[1]; [1]Department of Psychological and Brain Sciences, University of Louisville

When viewing oriented broadband visual structure, subjects typically will report that oblique patterns appear to have higher contrast, and that horizontal patterns have least perceived contrast; furthermore, detection thresholds for oriented broadband patterns are worst for horizontal, and best for obliques. This "horizontal effect" has previously been explained as the result of anisotropic contrast gain control, whereby the disproportionately large numbers of horizontally tuned neurons in visual cortex results in a larger signal to an orientation-tuned gain control mechanism. We questioned whether this effect would be evident in a detection task using single frequency gratings combined with broadband masks. Results showed that with 1/f frequency spectrum, narrow orientation-band masks, contrast thresholds were identical for all orientations, implying that the gain control mechanism is isotropic. However, when these same masks were summed together to produce broad orientation-band masks, increment thresholds were much lower for horizontal than for other orientations, indicating that the response to the horizontal mask was much smaller than the response to the masks at other orientations. We interpret this effect as being due to disproportionately larger contrast gain control for horizontal, specifically as an effect on the semisaturation constant of the underlying response function. Subsequent results through an adaptation paradigm, using broadband masks as adapting stimuli, lend some support to this interpretation, showing that adaptation causes lower increment thresholds for horizontal, and elevates horizontal detection thresholds. We conclude that the horizontal effect can indeed be explained in terms of basic contrast sensitivity mechanisms, though the effect is a non-linear process, where anisotropies in normalization are only significant with respect to broad, but not narrow, distributions of oriented content.

C28 350 Collinear facilitation: effects of additive and multiplicative visual noise

Pi-Chun Huang[1] (pi-chun.huang@mail.mcgill.ca), Robert F. Hess[1]; [1]McGill Vision Research, Dept. Ophthalmology, McGill University, Canada.

Purpose. 1) To assess whether collinear facilitation is limited to absolute detection threshold, we investigated the influence of additive 2-D visual noise. 2) to assess whether collinear facilitation is limited to 1st order processing pathways, we assessed whether it occurs for 2nd order stimuli. Methods. In a standard collinear facilitation paradigm, we used a standard 2 AFC procedure to measure the detectability of Gabor stimuli to which visual noise was either added or multiplied. Results. 1) we found that collinear facilitation is limited to at or around absolute threshold, not being present for stimuli with significant amounts of added visual noise, 2) 2nd order stimuli can show collinear facilitation, but of a reduced magnitude, and 3) we found no crossed facilitation from 1st to 2nd order stimuli or visa versa. Conclusion. Collinear facilitation is not ubiquitous throughout the contrast range and does occur for some 2nd order stimuli. Neither result is consistent with it having a pivotal role in contour integration.

C29 351 An absence of orientation selectivity for visual masking

Stanley Govenlock[1] (govenlock@mcmaster.ca), Patrick Bennett[1,2], Allison Sekuler[1,2]; [1]Psychology, Neuroscience, and Behaviour at McMaster University, [2]Center for Vision Research at York University

The visual system contains mechanisms that are tuned for orientation. One technique for measuring the bandwidth of tuning is to measure detection thresholds for a target presented simultaneously with a high-contrast mask. For example, Campbell & Kulikowski (1966) measured detection thresholds for a sinewave grating masked by a second grating that varied in orientation. Thresholds were highest when the target and mask had the same orientation, and declined significantly when the target and mask orientations differed by as little as 10 deg. This result has been interpreted as showing that the grating target is detected by a quasi-linear filter that is narrowly tuned to orientation. Here we show that the estimate of orientation bandwidth depends critically on the nature of the mask

We first replicated Campbell & Kulikowski (1966). Detection thresholds were measured for a horizontal Gabor (3 cpd) masked by a grating of a similar spatial frequency and a fixed, suprathreshold contrast. Mask orientation was offset from the target's orientation by 0, 15, 30, 45, 60, 75, or 85 deg. Thresholds declined with increasing orientation offset; estimated bandwidths (full-width at half-amplitude) were 20 deg. Next, we measured thresholds for targets masked by two suprathreshold gratings that were symmetrically offset from the target orientation by 0, 15, 30, 45, 60, 75, or 85 degrees. Surprisingly, thresholds were nearly constant for orientation offsets ranging from 0 to 75 deg; the resulting estimates of channel bandwidth were approximately 150 deg. Control experiments ruled out the possibility that the different results were due to differences in the contrast energy in the mask. Similar results were obtained with younger (~22 years) and older (~65 years) observers.

We currently are conducting experiments examining the nature of the non-linearity that produces the very broad orientation bandwidths found with two-component masks.

Acknowledgement: This work was supported by NSERC, CIHR, and the Canada Research Chairs program

C30 352 The effects of collinearity on contrast discrimination tasks.

Michael Kramer[1] (kramerml@muohio.edu), Lynn Olzak[1]; [1]Department of Psychology, Miami University

The role of collinearity in psychophysical tasks involving contrast has not yielded clear answers. Collinear facilitation has been found in contrast detection tasks (Solomon & Morgan, 2000), while apparent contrast tasks have yielded no differences when using targets with collinear versus non-collinear surrounds (Cannon & Fullenkamp, 1991). The present study was performed to find out more about the effects of collinearity in regards to contrast discrimination tasks. It has been shown that other spatial discrimination tasks (orientation and spatial frequency) are more strongly influenced by collinear surround than by non-collinear surrounds, even when using surrounds of up to two-thirds the size of a full surround (Kramer & Olzak, 2006). However, this had yet to be shown for contrast discrimination tasks. The tasks used are fine contrast discriminations (centered around a contrast of 0.1) between 40-minarc, circular center patches of 4 cpd sinusoidal grating. Surrounds were vertical sinusoidal grating rings, also 4 cpd, with a ring width of 40-minarc. BOW-TIE stimuli (Cannon & Fullenkamp, 1991) were used to modulate surround size and location in order to create both collinear and non-collinear surrounds of varying sizes around the target. Discriminability was measured using a 6 point response scale from which d' values were calculated. Our results suggest that, like results found with orientation and spatial frequency discriminations, collinear surrounds have a stronger inhibitory effect on contrast discrimination tasks when compared to the effects of non-collinear side-flanks of equal size.

Acknowledgement: Supported by NEI EY13953 to LAO.

C31 353 **Cross-orientation interactions in second-order mechanisms**

Lynn Olzak[1] (olzakla@muohio.edu), Michael Kramer[1]; [1]Department of Psychology, Miami University of Ohio

The output of linear mechanisms comprising the "first-order", or Fourier mechanisms is known to be followed by at least two nonlinearities and by higher-level circuits that sum outputs of first-level mechanisms with very specific tuning characteristics, to form specialized edge and texture detectors (Olzak & Thomas, 1999). On the other hand, the system(s) thought to process static second-order, or non-Fourier stimuli, are already specified as linear-nonlinear-linear cascades. They are known to be tuned with respect to spatial frequency and orientation, albeit with some differences from the first order system. The question we ask here is what happens to the output of second-order mechanisms with very different orientation tuning. We created second-order sinusoidal patterns by contrast-modulating binary random noise. In each condition of three different experiments, observers discriminated between two very similar second-order patterns on the basis of small differences in orientation, spatial frequency, or contrast in the second-order modulation. In two separate control conditions, stimuli were simple sinusoids orientated either vertically or horizontally. Potential nonlinear processes were isolated in two masking conditions, which added a non-varying second-order mask of orthogonal orientation to the control patterns. Potential combining mechanisms were tested for in configural-effect conditions. In these, cues to discrimination were present in both the vertical and horizontal components of plaid second-order patterns. They were combined in two different ways. Any difference in performance in the two conditions signals a combining of information. The nature of the configural effect signals whether the combination is additive or differencing. Our results show significant masking by an orthogonal component, possibly indicating the presence of a widely-inclusive gain control pool, and a configural effect that suggests higher-level summing circuits. We conclude that the linear-nonlinear-linear process is iterative within the visual processing system.

Acknowledgement: This work was suppored by NIH Grant EY13953 to LAO

C32 354 **Analysing spatiotemporal dynamics in contrast detection by Classification Images**

Ilmari Kurki[1,2] (ilmari.kurki@helsinki.fi), Aapo Hyvärinen[1], Jussi Saarinen[2]; [1]HIIT, Department of Computer Science, University of Helsinki, [2]Department of Psychology, University of Helsinki

It is known that spatial and temporal properties have a complex interplay in processing of the visual stimulus. Here, we investigated the effect of the temporal duration of the signal by Classification Image method.

Classification Images were measured using a yes/no detection task. Target was a 1-D Gaussian spatial profile (s.d. 0.25 deg) in a symmetric Gaussian temporal envelope having s.d. of 10, 20 or 40 ms. Stimulus was masked by spatiotemporal white noise lasting for 600 ms, shown at 100 Hz on a monitor with a fast phosphor.

Classification images for four stimulus-response categories (hit, miss, correct rejection, false alarm) were analysed separately. In all conditions, linear analysis of noise masks in target-present trials reveal a compact template, slightly elongated in time compared to the target stimulus. In the 40 ms condition, linear analysis of the noise masks in target-absent trials showed a template roughly corresponding to the target. However, Classification Images for shorter presentation times were featureless (flat).

Next, Classification Images based on Fourier energy were investigated. Noise masks were windowed with a Gaussian profile roughly corresponding to the greatest extent of the linear effects. Mean amplitudes of the Fourier components were computed for each stimulus-response category. Analysis of false alarm trials, whose ordinary CI's were flat, revealed a Fourier energy template having a tuning close to the target in all durations. This indicates that observers detect signals in phase-insensitive manner.

Our results show that subjects are able to use both the spatial and temporal information of the stimulus remarkably well. However, when detecting short duration targets, they cannot utilize target phase information. Furthermore, spatial tuning of the detecting mechanisms was found to be very stable across the target duration, as no differences in the spatial profiles of the CI's were found.

C33 355 **A technique for measuring single-item identification efficiencies**

Jason Gold[1] (jgold@indiana.edu), Brianna Conrey[1], Ami Eidels[1]; [1]Indiana University, Bloomington

Identification thresholds and corresponding efficiencies (ideal/human thresholds) are typically computed by collapsing data across an entire stimulus set within a given task in order to obtain a 'multiple-item' summary measure of performance. However, some individual stimuli may be processed more efficiently than others, and such differences are not captured by conventional multiple-item threshold measurements. Here, we present a simple technique for measuring 'single-item' identification efficiencies. The technique involves measuring identification performance for both human and ideal observers at a range of contrast levels using the method of constant stimuli. Each stimulus is shown the same number of times at a fixed set of contrast levels, randomly permuted across trials. The data are sorted conditional upon stimulus identity, allowing a single-item psychometric function to be computed for each individual stimulus. Human and ideal single-item thresholds are then compared for each stimulus in order to obtain single-item efficiencies. The resulting single-item efficiencies describe the ability of the human observer to make use of the information provided by a single stimulus item within the context of the larger set of stimuli. We applied this technique to the identification of several different classes of complex patterns embedded in noise, including 3-D rendered objects and human faces. Our results show that efficiency can vary markedly across stimuli within a given task, demonstrating that single-item efficiency measures can reveal important information lost by conventional multiple-item efficiency measures.

C34 356 **A new subtractive normalization model for contrast processing of visual stimuli**

Velitchko Manahilov[1] (vma@gcal.ac.uk), Gael Gordon[1], Julie Calvert[1], William Simpson[2]; [1]Vision Sciences Department, Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA, UK, [2]School of Psychology, University of Plymouth, Drake Circus, Plymouth, Devon, UK

The responses of V1 simple cells are determined by different mechanisms: linear feedforward excitation from LGN neurones, rectification, and nonlinear suppression proportional to the pooled activity of a large number of other neurons. The nonlinear properties of cortical cells were accounted for by normalization models (Albrecht and Geisler, Visual Neuroscience, 7, 531-546, 1991; Heeger, Visual Neuroscience, 9, 181-197, 1992) which propose a divisive suppression mechanism whose neural correlate is associated with the process of shunting inhibition. However, shunting inhibition may not be the main mechanism mediating intercellular inhibition (Berman et al., J. Physiology., 440, 697-722, 1991).

We propose that the linear responses of cortical cells are normalized by subtractive suppression which is proportional to a nonlinear (power) quantity of the pooled activity of neurones selective to a wide range of spatial frequencies and orientations. This model predicts successfully the saturation of the responses at higher contrast levels and the "divisive" behaviour of the contrast-response functions (downward shift in log-log coordinates) for gratings superimposed on a test grating, as the spatial frequency or orientation vary from the optimal values. Model predictions are also consistent with data from psychophysical studies (Foley and Boynton,

Saturday Posters

SPIE Proceedings, 2054, 32-42, 1994) which measured threshold-contrast functions for the detection of a Gabor patch superimposed on a masking grating for various orientation differences between stimuli.

Subtractive suppression can be implemented by hyperpolarising inhibition which is a fundamental property of cortical neurones. The proposed subtractive-suppression model conforms to the known physiology of cortical cells and can account for the non-linear properties of early visual stages. This model provides an alternative explanation of cortical mechanisms processing visual information.

C35 357 Cross-orientation masking in the red-green isoluminant and luminance systems

Jose Medina[1] (jose.medinaruiz@mcgill.ca), Tim Meese[2], Kathy Mullen[1]; [1]McGill Vision Research, Department of Ophthalmology, McGill University, Montreal, Quebec, Canada, [2]School of Life & Health Sciences, Aston University, Birmingham

Purpose: Cross-orientation masking (XOM) is defined psychophysically as the phenomenon whereby detection of a test grating is masked by the presence of a superimposed stimulus at an orthogonal orientation. A previous study found that XOM for achromatic stimuli is strongest at mid-high temporal and low spatial frequencies, the putative M cell range (Meese and Holmes, Proc. R. Soc. B., 274, p127, 2007). Here we investigate whether color vision can support XOM by using red-green isoluminant stimuli, and achromatic stimuli for comparison with the luminance system.

Methods: Horizontal Gabor stimuli (Gaussian contrast envelope, Û=2 degrees) were modulated at two spatial (0.375 & 0.75cpd) and two temporal frequencies (2 & 4Hz). An orthogonal vertical Gabor patch with the same spatio-temporal configuration was superimposed (i.e. a plaid). Binocular contrast detection thresholds were determined using a temporal 2AFC staircase method over a wide range of mask contrasts (scaled in multiples of detection threshold).

Results: We find three new results for color vision: 1. robust XOM for color vision for the spatio-temporal frequencies tested over a wide range of mask contrasts; 2. greater cross-orientation facilitation at low mask contrasts for chromatic than for achromatic stimuli, and 3. significantly greater masking for the chromatic than the achromatic stimuli when mask contrast is high.

Conclusions: Such robust and distinct chromatic masking effects indicate that M cells do not exclusively support cross orientation masking in this spatio-temporal range and suggest differential constraints on chromatic compared to achromatic cross-orientation suppression along the cortical or subcortical streams.

Acknowledgement: Support: CIHR grant MOP-10819.

C36 358 Temporal characteristics and surround modulation of contrast masking

Toni Saarela[1] (toni.saarela@epfl.ch), Michael Herzog[1]; [1]Laboratory of Psychophysics, Brain Mind Institute, Ecole Polytechnique Fédérale de Lausanne (EPFL)

The spatial characteristics of contextual modulation in visual processing have been widely studied, but much less is known about its temporal properties. We measured contrast detection thresholds for a brief, 40 ms Gabor target, masked with a 100 ms grating of 40% contrast. The mask was either a circular center mask spatially overlapping the target (diameter 4 cycles), an annular mask surrounding the target (inner and outer diameters 4 and 32 cycles, respectively), or a combination of the two. Masks were either iso-oriented with the target or orthogonal to it. Stimulus onset asynchrony between the target and the mask was varied, ranging from backward masking to forward masking. With the orthogonal center mask, masking was strongest (i.e., thresholds were highest) when the target onset coincided with either the mask onset or offset. With the iso-oriented center mask, however, unexpectedly strong masking occurred when the target offset coincided with the mask onset or vice versa. That is, masking was strongest when the mask immediately preceded (forward masking) or immediately followed (backward masking) the target. Further, adding a surround to the iso-oriented center mask had no effect on forward masking, but it greatly reduced the backward masking effect. Backward masking is often considered counterintuitive as a subsequently presented mask can suppress the target. The present results indicate that spatial interactions in the processing of the mask can also take place before backward masking occurs.

C37 359 The effect of glare on visibility depends on spatial frequency

Rolando Aguirre[1,2] (raguirre@herrera.unt.edu.ar), Jose Barraza[1,2], Elisa Colombo[1,2]; [1]Department of Luminotecnia, Luz y Visión - Facultad de Ciencias Exactas y Tecnología - Universidad Nacional de Tucumán - Tucumán - Argentina, [2]CONICET - Consejo Nacional de Investigaciones Científicas y Técnicas

Purpose. The increment of contrast threshold due to glare is modeled by adding a uniform veiling luminance (Lv) to the stimulus. This veil imitates the masking effect produced by the scattering of light in the ocular media. We showed that the effect of glare on reaction times depends on the spatial frequency of the stimulus. We wondered whether this dependence is linked with the contrast sensitivity. In this study, we investigated the reduction of contrast sensitivity (CS) produced by glare. Methods. Experiment 1: we measured the CS for mesopic achromatic sinusoidal gratings for four glare intensities. We performed an orientation discrimination experiment with an adaptive 2AFC procedure to determine the contrast thresholds. Experiment 2: we determined the Lv that added to the stimuli produced the same thresholds for each spatial frequency. Two subjects participated in this experiment. Viewing was monocular with natural pupil. Results. Contrast threshold measurements show that the effect of glare is strongest for those spatial frequencies whose CS is maximal. The effect almost disappears for high spatial frequencies. The same effects are obtained when glare is replaced by the equivalent Lv. Conclusions. First, we show that the effect of glare on visibility cannot be only explained by intraocular scattering because this optical effect does not depend on stimuli spatial frequency. Second, the Lv catches the dependence of the effect of glare on spatial frequency suggesting that there is not a unique value of Lv for each glare intensity. Third, the effect of glare on contrast thresholds suggests that RTs are closely related to contrast sensitivity.

C38 360 Lateral masking with contrast- and luminance-modulated patterns

Chien-Chung Chen[1] (c3chen@ntu.edu.tw); [1]Department of Psychology, National Taiwan University

The visibility of a target stimulus canbe affected by the presence of other stimuli on different parts of the visual fields. This lateral effect depends on many spatiotemporal properties, such as orientation or spatial frequency but is less affected by phase. The lack of phase effect suggests a possible involvement of phase-independent second order mechanisms. We investigated the role of second order information in lateral effects by studying lateral masking between patterns modulated in luminance or contrast. The luminance modulation stimuli (LM) were vertical 2 c/deg Gabor patches. The contrast modulation stimuli (CM) were vertical or horizontal 16 c/deg carrier waves whose contrast was modulated by a vertical 2 c/deg Gabor function. We measured contrast detection threshold for LM or contrast-contrast threshold for CM target with or without the presence of another stimulus (mask). The distance between the target and the mask varied from 0 to 4 degrees. We used a 2AFC paradigm and the PSI algorithm to measure threshold. When a target was superimposed on a mask, the detection threshold was elevated regardless the type of the target and the mask. The threshold elevation decreased as the mask moved away from the target. The lateral LM mask facilitated LM target detection with maximum facilitation occurred at a distance of three wavelength units but had little, if any, effect on CM target detection at any distance. The lateral CM mask facilitated CM target regardless the orientation of the carrier wave but had no effect on LM target detection. The lateral masking is specific to the type of stimuli. Our result suggests that the lateral effect for LM patterns is unlikely a result of feedback from the second order or complex mechanisms. The lack of phase effect may be due to rectification on the first order responses.

Acknowledgement: Supported by NSC 95-2413-H-002-001

C39 361 **The human contrast response function: overcoming experimental pitfalls.**

Mikhail Katkov[1] (mikhail.katkov@gmail.com), Misha Tsodyks[2], Dov Sagi[2]; [1]Department of Psychology, New York University, New York, [2]Department of Neurobiology/Brain Research, The Weizmann Institute of Science, Rehovot 76100, Israel

There were several attempts to characterize the human contrast-response-function (CRF) and the corresponding internal noise amplitudes (NA), but there is no commonly accepted solution. Our theoretical analysis of the Two-Alternative Forced-Choice (2AFC) task, using Signal Detection Theory (SDT), identified several important cases where an experimental solution is impractical due to the large number of trials required. Here we estimate the human CRF and NA for a Gabor stimulus (0-60% Michelson contrast of carrier grating), using the Category Rating Task and assuming a simple SDT model. Rating results showed large variations between experimental sessions which could not be explained by sampling error only. Nevertheless, some properties derived from the session data, such as CRF and NA were relatively stable. Threshold vs. Contrast (TvC) curves, computed from CRF and NA, generally agreed with the independently measured TvC curves using 2AFC methods and were similar across sessions and observers. In experiments with stable (across sessions) estimates, CRF and NA could be well described as having two regimes: (1) below the detection threshold - NA were decreasing function of contrast (in some sessions NA were constant or slightly increasing with contrast), with CRF having a high gain; (2) above the detection threshold - NA was relatively constant, and CRF had low gain with practically constant slope. We show that such CRF and NA can successfully fit data obtained from 2AFC experiments, including previous results described in Kontsevich, Chen and Tyler (Vis Res, 2002). Estimated NA is compatible with some models that assume stimulus uncertainty, but not with models that assume a maximum response decision-rule (Pelli, JOSA, 1985). It is possible that, in cases of uncertainty, decision is based on the summed activity within a population of detectors having properties defined by the uncertainty range, with uncertainty range decreasing with increasing input level.

C40 362 **Effect of signal strength on attentional blink**

Sung Jun Joo[1] (sjjoo@yonsei.ac.kr), Sang Chul Chong[1, 2]; [1]Department of Cognitive Science, Yonsei University, [2]Department of Psychology, Yonsei University

Attentional blink (AB) is a transient deficit in reporting second target (T2) when the first target (T1) is successfully reported in RSVP. The current study investigated how the signal strength ratio of T1 to T2 influenced the amount of AB. We tested this hypothesis using either simple orientation discrimination task or letter identification task. In Experiment 1, we wanted to test whether AB occurred even for discriminating ±45° gratings. Using QUEST, we first measured each participant's contrast threshold for deciding what would constitute for targets and distractors. The targets were ±45° gratings and the distractors were either horizontal or vertical gratings. The contrast of all stimuli was twice of the threshold. We found AB occurred even in this simple orientation discrimination task. In Experiment 2, we used the same stimuli and the task as in Experiment 1, but varied T2 contrast. The amount of AB was the largest when T2 contrast was half of T1 contrast, whereas it became smaller as T2 contrast increased up to twice of T1 contrast. In Experiment 3, we used the letter identification task and again varied the contrast ratio of T1 to T2. Consistent with the results of Experiment 2, we found that the amount of AB decreased as T2 contrast increased. Our findings suggest that the signal strength ratio could modulate the effect of AB regardless of the task type.

Acknowledgement: This research was supported by the Cognitive Neuroscience Research Program of the Korea Ministry of Science and Technology.

Adaptation and Aftereffects

Author Presents: 2:00 - 3:45 pm

C41 363 **Adaptation and Afterimages: A model of inverse multiplicative sensitivity adjustment.**

Thaddeus B. Czuba[1] (tczuba@ucsd.edu), R. Dirk Beer[1], Donald I. A. MacLeod[1]; [1]Department of Psychology, University of California at San Diego, La Jolla, CA

Previous experiments have suggested that afterimages originate from an inverse multiplicative sensitivity adjustment in the long (L), medium (M), and short (S) wavelength cones of the retina. Our experiments with traditional CRT monitors indicate significant shortfalls from reciprocity in the regulation of sensitivity, but current experiments employ a high intensity Maxwellian View projector (BIGMAX) to provide more complete adaptation and reciprocity in afterimage saturation. We propose a color afterimage model according to which the afterimage can be matched by inverting the log excitation profile of the inducing stimulus for the L, M, and S cones, and we provide data supporting this model over an alternative additive model. Methods: Stimuli were displayed on a BIGMAX display capable of producing image intensities up to 7000 cd/m^2. In the initial experiment, stimulus consisted of a central fixation point on an equal energy grey background while either an equiluminant color- or intensity-defined blob was displayed 4° to the right of fixation. Upon adaptation, subjects matched the color and intensity of a response blob to the afterimage seen after a momentary return to background (200 milliseconds) at the location of the adapted blob. The second experiment compared the multiplicative adaptation model with an alternative additive model. Subjects adapted to and matched luminance blobs as in the first experiment, but instead of removing the adapted blob, the intensity of the entire image was briefly (200 milliseconds) increased in either a multiplicative or additive fashion. Results fell close to reciprocity predictions in the LMS color space for the luminance-defined and most color-defined blobs. In the second experiment, no afterimage was seen when the stimulus was multiplicatively changed, while additive changes did result in obvious afterimages. Predictions based on the multiplicative model accounted for the additively formed afterimages with only minor deviations.

C42 364 **More about "Buffy adaptation"**

S. Sabina Wolfson[1] (sabina@psych.columbia.edu), Norma Graham[1]; [1]Department of Psychology, Columbia University

Last year we reported a new kind of contrast adaptation, which we called "Buffy adaptation" (Graham & Wolfson VSS 2006). We explain it as adaptation of a contrast comparison level in a "Buffy channel." Our original stimuli were large: each was a 15x15 grid of Gabor patches. This year we show that the same phenomena exist with much smaller stimuli (presented foveally). After adapting for a short time (1 sec) to a 2x2 grid of Gabors all at the same contrast (e.g. 50%), a test stimulus is presented briefly (82 msec), and then the adapting stimulus is shown again (1 sec). In this 2x2 test stimulus, the Gabor patches in the first row (or column) have one contrast (e.g. 40%), and those in the second row (or column) have another contrast (e.g. 60%). Thus the test stimulus contains horizontal (or vertical) contrast-defined (a.k.a. second-order) stripes. The subject's task is to identify the orientation of these stripes. When the test stimulus' contrasts (e.g. 40%,60%) STRADDLE the adapting contrast (50%), subjects perform very poorly; but when the contrasts are ABOVE (50%,60%) or BELOW (40%,50%) the adapting contrast, subjects perform very well. On the other hand, subjects perform poorly on all three of these stimuli after adapting to a blank gray field (0% contrast). That these effects are seen with small stimuli (2x2) as well as large (15x15) means they can occur within a small region and do not require extensive spatial pooling. Furthermore, the effect is found when the small stimuli are presented peripherally (inner edge at 1, 3, or 5 deg eccentricity) in spite of the differences

Saturday Posters

between foveal and peripheral processing. In addition to showing that our "Buffy channel" explanation works, we will show that a number of other explanations do not.

Acknowledgement: Supported by NIH grant EY08459

C43 365 The effect of contrast on adaptation to compound patterns

David McGovern[1] (david.mcgovern@gmail.com), Jonathan Peirce[1]; [1]Nottingham Visual Neuroscience, School of Psychology, University of Nottingham

The presence of neural mechanisms selective to particular combinations of Fourier energies, namely plaids, have previously been shown through a compound adaptation procedure (Peirce and Taylor, 2006). Rather than responding to individual sinusoidal gratings, these mechanisms respond to particular conjunctions of them. Using a similar, but simpler, method we investigated the role of probe contrast in the compound adaptation effect. Subjects were adapted to two alternating component gratings in one visual hemi-field; while a plaid, constructed of the same components presented together, was adapted in the other hemi-field. Subjects then compared the contrast of a probe at the same retinal location of the compound adaptor (test probe) with one at the location of the component adaptors (reference probe). An adaptive staircase homed in on the point of subjective equality (PSE) for contrast at these two locations. Reference probes took one of 5 fixed contrast values, ranging between 0.15 and 0.6. Our results indicate that the compound adaptation effect was strongest when the reference probe's Michelson contrast fell between 0.2 and 0.3, consistent with a plaid-selective mechanism, whose contrast response function rises most steeply in this region.

Acknowledgement: BBSRC grant held by JWP (BB/C50289X/1)

C44 366 Frame-contingent density aftereffects: A closer look

Kristina Simmons[1] (ksimmon1@swarthmore.edu), Frank Durgin[1]; [1]Department of Psychology, Swarthmore College

Some models of adaptation assume that aftereffects represent a subtractive inhibition of a sensory signal that improves the dynamic range of sensory coding (Barlow & Földiák, 1989). In contrast, texture density aftereffects have been described as multiplicative, rather than additive, changes in perceived density (Durgin, 1995). Here we use precise quantification of one contingent density aftereffect to suggest that, rather than being additive or multiplicative with respect to density, these effects are additive with respect to perceived inter-dot distance. Texture displays were presented in gray boxes to the left and right of fixation, with a frame surrounding the boxes. Subjects were adapted to a correlation between surround color and relative density (e.g., dense on right when frame was green and on left when red) and then tested for frame-color contingent adaptation at several levels of density using a staircase procedure. Gaze was tracked to prevent artifacts of refixation. Points of subjective equality (PSE) were computed for each standard density and frame color. If the aftereffects resulted from a simple subtraction, then the difference between PSE and standard density should have been constant for all levels of density. Alternatively, if the aftereffects involved multiplicative changes (as if operating on log density), then the deviations should have been constant across standard density in logarithmic space. In our data, however, both linear and logarithmic deviations increased with standard density. A better fit for our data was provided by a subtractive model applied to average inter-dot distance. Only in this model were the deviations constant across standard density. Thus, it appears that the frame-contingent density aftereffect (and perhaps density aftereffects more generally) may operate on neural codes representing linear spacing rather than density itself. Density aftereffects may be a form of tuning to the locally prevailing spatial scale.

Acknowledgement: Supported by HHMI

C45 367 Adaptation and contrast constancy in natural images

Kyle McDermott[1] (mcdermo6@unr.nevada.edu), Saloni Sharma[1], Michael Webster[1]; [1]Department of Psychology, University of Nevada Reno

Many perceptual judgments have a well defined norm that can be biased in predictable ways by adaptation, so that the adapting stimulus appears more neutral and thus induces a negative aftereffect in the original neutral stimulus. We examined how adaptation affects the norm for judgments of contrast in natural images, in order to examine how perceived contrast is calibrated by experience and how norms are established for intensive dimensions like contrast that do not have a qualitatively distinct perceptual null (e.g. as in color or motion). Stimuli were grayscale images of natural scenes with contrast titrated over a wide range. The level in successive images was varied in a forced-choice staircase to find the subjectively correct image, with settings repeated before or after adaptation to the same images at high (150%) or low (50%) contrasts. Subjects could reliably set the images to appear natural and thus had a well defined norm. Surprisingly, adaptation to the 50% contrast images shifted this norm to lower contrasts relative to the pre-adapt settings. That is, the original images appeared to have a higher contrast after adapting to their low-contrast versions than to a zero-contrast field, even though adaptation to any contrast in simple gratings reduces rather than increases perceived contrast (Georgeson, 1985). To directly test for changes in contrast sensitivity in the images, settings were repeated with an asymmetric matching task in which an unadapted image was adjusted to equal the perceived contrast in the adapted image. This showed only a weak effect for the 50% adapt level, implying that the renormalization may primarily reflect short-term shifts in criterion rather than sensitivity. These shifts may be important for understanding how visual appearance is recalibrated for changes in viewing conditions or the observer (cataracts) that alter contrast in the retinal image.

Acknowledgement: Supported by EY10834

C46 368 Perceptual Adaptation to Environmental Scale

Christine Ziemer[1] (christine-ziemer@uiowa.edu), Jodie Plumert[1], James Cremer[2], Joseph Kearney[2]; [1]Department of Psychology, University of Iowa, [2]Department of Computer Science, University of Iowa

We examined whether people perceive the same distances differently after exposure to environments that differ in scale. During adaptation, participants made 20 distance estimates in either a large, medium, or small "cave" in an immersive virtual environment. On each trial, participants saw a target 6-18 m away that disappeared after 4 s. Participants then attempted to move to the location using a joystick with either their eyes closed or open, after which they received visual feedback about their estimate. During test, all participants made estimates about the same five distances in the medium cave with their eyes closed and without feedback. Distance estimates made during adaptation did not differ across the three caves. At test, however, participants who had initially experienced the large environment judged the same distances as longer than did participants who had initially experienced the small environment. Explanations for this perceptual adaptation effect are discussed.

Acknowledgement: This work was supported by grants awarded to J. Plumert, J. Kearney, and J. Cremer from the National Center for Injury Prevention and Control (R49/CCR721682) and the National Institute of Child Health and Human Development (R01-HD052875).

C47 369 Blur adaptation and induction in the fovea and periphery

Sara Haber[1] (sara_haber@hotmail.com), Nicole Ballardini[1], Michael Webster[1]; [1]University of Nevada, Reno

The perception of image focus can be strongly affected by prior adaptation to blurry or sharpened images or by simultaneous contrast from blurred or sharpened surrounds (Webster et al, 2002). We compared these interactions in the fovea and periphery to examine how they influence spatial judgments across the visual field. Stimuli were grayscale images of natural scenes filtered by increasing or decreasing the slope of the original amplitude spectrum to form a series of images ranging from moderately blurred (slope=-.5) to sharpened (slope=+.5). The displayed image level was varied in a staircase to find the point of best subjective focus, after adapting to the

+.5 or -.5 image or in the presence of these images arranged as a spatially contiguous surround. The images subtended 4 deg and were presented at eccentricities ranging from 0 to 16 deg. Adaptation aftereffects were strong but did not show a consistent effect of retinal location, while induction effects were maximal for images in the near periphery (4 or 8 deg). The falloff at larger eccentricities may reflect a loss of sensitivity to the spectral differences in the stimuli rather than a loss of induction strength. Preadapt focus settings were similar in the fovea and periphery, suggesting that peripheral losses in contrast sensitivity are compensated to allow perceptual constancy for focus (e.g. Galvin et al, 1997). We examined whether this compensation reflected a reweighting of spatial sensitivity at different loci, by testing for the neutral stimulus level for the adaptation and induction (i.e. the level that does not bias the focus settings). These remained close to the physically focused slope, suggesting that sensitivity at different loci is calibrated for the losses in spatial resolution with eccentricity, and thus that variations in the intrinsic sensitivity may underlie the spatial constancy.

Acknowledgement: Supported by EY10834

C48 370 Exploring the dynamics of light adaptation by measuring sensitivity against a flickering background

Peter Smith[1] (peter.smith@ngc.com), Leon McLin[2], Laura Barnes[2], Bret Rogers[1]; [1]Northrop Grumman Corporation, San Antonio, Texas, [2]Air Force Research Laboratory, San Antonio, Texas

Introduction. Previous studies of the dynamics of light adaptation have used a probe-sinewave paradigm, where the threshold for detecting a probe flash is measured at various phases with respect to a sinusoidally modulated background. Our interest is in the temporal changes in visual adaptation that occur during exposure to a train of brief, high intensity flashes. To investigate this we have used a flash-probe paradigm, where the sinusoidally modulated background is replaced with a flashing background. Methods. Increment thresholds were measured for a test stimulus (10 ms) presented at various times (phases) during a periodic flickering background (10 ms, 1 to 64 Hz) while the average power in the flickering background was held constant (2.8 Þ 108 td). The results can be plotted as threshold for probe detection versus phase curves, from which summary measures, such as the peak-to-trough distance and the dc level, can be derived. Results. In general, probe threshold varied sinusoidally and the effects of the flickering background frequency on the summary measures were very similar to those from other laboratories where the background was modulated sinusoidally: as pulse frequency increased, the average threshold for detection of the probe increased and the peak-to-trough distance decreased. Conclusions. In traditional probe-sinewave experiments the duty cycle for the pulses is 50%. In our experiments, the pulse duration was held constant and so the duty cycle increased with frequency. Despite these differences the summary data patterns are very similar. These data are being used to test existing models of visual adaptation.

Acknowledgement: This work was sponsored by the Air Force Office of Scientific Research and the Air Force Research Laboratory under contract number number F41624-02-D-7003.

C49 371 Two timescales of orientation-contingent color adaptation.

Erin Krizay[1] (ekrizay@ucsd.edu), Edward Vul[2], Erin Shubel[1], Donald I A MacLeod[1]; [1]Department of Psychology, University of California San Diego, [2]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology

The McCollough effect (McCollough, 1965) is an orientation-contingent color aftereffect: adaptation to (e.g.) red vertical and green horizontal gratings causes subsequent vertical and horizontal gratings to appear greenish and reddish, respectively. A peculiar trait of the McCollough effect is its unique persistence. Most aftereffects decay quickly after induction stops, persisting for not much more than the induction duration. But the McCollough effect can persist for weeks after induction. Some have attempted to explain the bizarre phenomenon of an aftereffect outlasting the adaptation period by several orders of magnitude by supposing that it is not a true aftereffect, but rather associative learning. Nonetheless, the relatively quick, constant buildup of the aftereffect suggests a more traditional process of adaptation. Here we show that the McCollough effect is a result of adaptation at two distinct timescales. The fast timescale saturates quickly and appears to have a time constant of roughly 80 seconds, much like contrast adaptation. The slow time scale shows no signs of saturation or decay in the time we measured. The existence of a second, apparently infinite, time scale suggests that the aftereffect is the sum of quick dynamic network adaptation, and permanent synaptic plasticity. The effect indeed appears to be both associative learning and a form of dynamic adaptation.

Acknowledgement: Supported by EY0171 and Sigma Xi G20059142126341817 to EV

C50 372 Spatial properties of curvature encoding revealed by the shape-frequency and shape-amplitude after-effects.

Elena Gheorghiu[1] (elena.gheorghiu@mcgill.ca), Frederick A. A. Kingdom[1]; [1]McGill Vision Research, Department of Ophthalmology, McGill University

Aim: The shape-frequency and shape-amplitude after-effects, or SFAE and SAAE, are the phenomena in which adaptation to a sine-wave-shaped contour causes a shift in respectively the apparent shape-frequency and shape-amplitude of a test contour in a direction away from that of the adapting stimulus. We have examined whether the SFAE and SAAE manifest selectivity to (a) local curvature, (b) curvature polarity (or sign), and (c) whether the contours were selective to local orientation. We also investigated (d) whether curvature encoders are arranged in a curvature-opponent manner and (e) whether the high- and low-shape-frequency shape components of complex shapes are processed independently or not. Methods: These included measuring SFAEs/SAAEs for adapting and test contours that were either the same or different in a given spatial property (e.g. same-polarity or opposite-polarity half-wave rectified sinusoidal curves to test for curvature-polarity specificity) the rationale being that if the after-effects were smaller when adaptor and test differed along a particular spatial property then curvature encoders must be selective for that property. Results: SFAEs and SAAEs (i) are mediated by mechanisms sensitive to contour fragments that have a constant sign of curvature (i.e. half-a-cycle of the test contour in ± cosine phase); (ii) show a degree of selectivity to curvature polarity (or sign); (iii) show a degree of selectivity to local orientation; (iv) reveal some evidence for curvature-opponency, and (v) reveal that the high and low shape-frequency shape components of a complex shape are separately adaptable. Conclusion: Curvature is encoded by mechanisms that are selective to a variety of spatial properties.

Acknowledgement: This research was supported by a Natural Sciences and Engineering Research Council of Canada (NSERC) grant # OGP01217130 given to F.K.

URL: http://www.mvr.mcgill.ca/Fred/research.htm#contourShapePerception

C51 373 Adaptation to circular patterns influences the perception of distorted squares

Isabelle Legault[1] (zabellegault@hotmail.com), Remy Allard[1], Jocelyn Faubert[1]; [1]School of optometry, University of Montreal

It as been argued that an adaptation paradigm can be used to establish links between neural activity and perception. The purpose of the present study was to determine if three adaptation patterns influence the shape perception of distorted squares. The adaptation stimuli were circular and contained radial (circular), angular, or plaid (2 sine waves) spatial frequencies. The target stimuli were squares with contours varying in amplitude. The adaptation stimulus was presented for 5 seconds followed by the target for 500ms. Thresholds were obtained with a forced choice paradigm where the subject had to indicate whether the stimulus was curved inward or outward. Results show that the adaptation patterns influenced the responses in different ways. Radial adaptation patterns caused a significant threshold increase while the other adaptation patterns had no influ-

Saturday Posters

ence. This suggests that mechanisms involved in processing circular patterns share common neural pathways with those that process distorted squares.

C52 374 **A Rotational Aftereffect Induced By Context**

Alexander Zotov[1] *(alexander.zotov@gmail.com), Jon Grossmann*[1]*, Allan Dobbins*[1]*;* [1]*Dept. of Biomedical Engineering, University of Alabama at Birmingham*

A rotational aftereffect can be induced in an ambiguously rotating kinetic dot object (KDO) following a period of viewing in which stereo or perspective cues have caused the object to appear to rotate unambiguously (Nawrot & Blake, 1989; Petersik, 1984). In addition an ambiguously rotating, transparent KDO appears to rotate unambiguously when immersed in a plane of dots translating parallel to the dots of the object (front surface against planar flow; Sereno & Sereno, 1999). For many observers it is sufficient to surround the KDO with an annulus of translating dots to induce a consistent percept of rotation against the direction of the annulus dots. We conducted two experiments in which observers viewed an ambiguous KDO in combination with either a whole field or annulus of translating dots. After 20 seconds of viewing, during which observers report seeing the KDO rotate opposite to the surrounding field, the observers viewed and reported the direction of rotation of the KDO in isolation. In control trials, the KDO appeared on a field of twinkling dots in the first part of the trial, or a translating field was present without the KDO in the first portion of the trial. These latter trials give rise to a brief conventional aftereffect in which the KDO appears to rotate with front surface motion opposite to the direction of field translation seen earlier. In the experimental conditions, we find there is a rotational aftereffect that is against the direction of rotation reported during the first part of the trial, and in the direction of the unambiguously translating field. In the case of the trials with an annulus, the object is not in the same retinal region as the neurons experiencing motion adaptation. Therefore, this is a rotational aftereffect that cannot be attributed to local motion detector adaptation.

C53 375 **TMS "instant replay" validated using novel double-blind stimulation technique**

Daw-An Wu[1,3] *(daw-an@caltech.edu), Neil Halelamien*[1,3]*, Fumiko Hoeft*[2,1]*, Shinsuke Shimojo*[1,3]*;* [1]*California Institute of Technology,* [2]*Stanford University School of Medicine,* [3]*JST/ERATO Shimojo Implicit Brain Research Project*

Transcranial magnetic stimulation (TMS) can elicit the re-perception of recently presented visual stimuli, possibly reflecting access to nascent neural representations (Wu et. al. VSS 2001, 2002, 2004, Jolij & Lamme, VSS 2006). However, it is difficult to rule out the contributions of subject bias or confabulation. Here, we employ a custom-built stimulation device to validate the effect under psychologically double-blind conditions.

Our previous "instant replay" experiments employed the commonly used Magstim dual-pulse setup and figure-8 coil. In the modified setup, we take advantage of the fact that the optimal stimulus to stimulate visual cortex involves a lateral-to-medial orientation of the induced electric field. Thus, a horizontally oriented coil placed at the midline can bias the level of stimulation to the left or right hemisphere based on the direction of current flow.

We employ a custom switch and coils validated for their physical, physiological and psychological effects. It was found that subjects and experimenters could not discriminate between the forward and reversed current conditions (Hoeft et. al., in press).

We apply this technique to a natural image replay protocol (see abstract by Halelamien et. al. for details). Subjects (N=4) were presented with mirror-symmetric images and then stimulated with TMS of a polarity determined by the computer. Subjects judged whether the replay percept was more vivid on the left or the right side, rated the level of imbalance on a 10-point analog scale, gave verbal reports and made drawings on the screen.

Ratings, verbal reports and drawings all showed clear and significant differences between trials employing different stimulus polarities. Stronger stimulation to the left hemisphere resulted in more vivid percepts in the right visual hemifield, and vice versa. This provides double-blind validation that cortical representations are being activated directly by TMS, and demonstrated the usefulness of this new device.

C54 376 **TMS induces detail-rich "instant replays" of natural images**

Neil Halelamien[1,2] *(neilh@caltech.edu), Daw-An Wu*[1,2]*, Shinsuke Shimojo*[1,2]*;* [1]*California Institute of Technology,* [2]*JST/ERATO Shimojo Implicit Brain Research Project*

We have previously demonstrated that transcranial magnetic stimulation (TMS) can cause the re-perception of recently presented visual stimuli. Here we find that such replays can be experienced for natural scene stimuli, with a level of detail suggesting low-level rather than iconic representations.

TMS was administered using a Magstim dual-pulse setup sending pulses with 50 ms separation through a figure-8 coil. The coil position over occipital cortex was optimized to elicit vivid flashes of brightness (phosphenes) in a darkened room. We screened subjects to find those that perceived large, bright phosphenes near fixation. To these subjects (N=7), we presented pictures of natural scenes and animals for 100 ms, followed by TMS at various ISIs. Subjects provided verbal descriptions, subjective ratings, and drew figures on the screen.

While TMS in a stable visual environment generally elicits phosphenes that are consistent across trials, colorless, and internally featureless, we found that TMS delivered shortly after image presentation led to the perception of clearly defined forms that varied according to the content of the flashed image.

In this experiment, five out of the seven subjects reported percepts that drew from the preceding images. In the most vivid cases, these would appear to be nearly photographic repetitions in portions of the display. In other cases, subjects would perceive uniformly-filled, phosphene-like figures whose outlines matched, in detail, contours drawn from the preceding image (abstract by Wu et. al. describes double-blind validation of these effects). In early trials, subjects experienced the most vivid replay effects within narrow time windows, which varied from subject to subject between 150-250 ms. With continued stimulation, longer ISIs (as much as one second) became effective.

This study indicates that rich, detailed visual information remains encoded well after visual perception has ended, and that TMS can allow conscious access to these nascent low-level representations.

C55 377 **Cortical dynamics of negative afterimages: Spatial properties of the inducer**

Joshua Wede[1] *(jwede@purdue.edu), Gregory Francis*[1]*;* [1]*Purdue University*

Last year Wede & Francis (VSS 2006) showed that Grossberg's FACADE theory explained why attentional focus to an inducing stimulus reduced the strength of the resulting negative afterimage. The model also correctly predicted that attentional focus would increase afterimage strength for a two-stimulus afterimage. In the model, attention is hypothesized to strengthen oriented responses and the resulting orthogonal after-responses that feed in to a filling-in stage. Orthogonal after-responses are unable to contain filling-in and so must fade away before a filled-in afterimage percept can be generated. We now show that the same mechanisms explain how the strength of afterimages vary with the spatial properties of the inducing stimulus. Georgeson & Turner (1985) reported that negative afterimages induced by square wave gratings were weaker than afterimages induced by sine wave gratings. We treated the model as a subject in the experiment and identified a cancellation stimulus that was able to minimize any resulting afterimage. The contrast of the cancellation image in the simulation highly correlated with contrast of the cancellation image from the experimental results, with sine wave inducers requiring a higher contrast cancellation stimulus. The model explains the data as due to differences in the strength of oriented responses. The sharp edges of a bar grating lead to stronger orientation after-responses, which lead to weaker negative afterimages and a weaker cancellation stimulus.

C56 378 **Switch color afterimages suggest cortical mechanisms**

Daniel R. VanHorn[1] (dvanhorn@purdue.edu), Gregory Francis[1]; [1]Purdue University

We used a two-stimulus afterimage to explore color afterimages. An oriented bar grating followed by a bar grating of the opposite orientation leads to an afterimage that is perceived as the same orientation of the first grating. Previous work on the reported color of these afterimages (Francis & Schoonveld, VSS 2004) found that most of the time the reported afterimage was the color complement of the bars of the first bar grating. This suggested that the mechanisms involved in negative color afterimages were contributing to the percept of the two-stimulus afterimages. We now report new experimental results that demonstrate the involvement of additional mechanisms. We varied the colors of the first bar grating, whose alternating bars were not color complements, and asked observers to report the afterimage color behind a fixation mark. Reports consistent with a negative color afterimage were sometimes reported, however the most common report was that the afterimage color had switched from the bars of the first grating. Thus, a blue/white bar grating led to an afterimage that was colored white/blue, with the color switching between bars. We hypothesize that opponent mechanisms at retinal (negative afterimage) and cortical (switch afterimage) levels both contribute to the afterimage percept with some situations favoring one over the other.

C57 379 **Neural correlates of perceptual filling-in of an artificial scotoma in humans**

Rimona Weil[1,2] (r.weil@fil.ion.ucl.ac.uk), James Kilner[1], John-Dylan Haynes[3], Geraint Rees[1,2]; [1]Wellcome Trust Centre for Imaging Neuroscience, Institute of Neurology, University College London, [2]Institute of Cognitive Neuroscience, University College London, [3]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig

When a uniformly illuminated surface is placed eccentrically on a dynamic textured background, after a few seconds it is perceived to disappear and is replaced by the background texture. Such texture filling-in is thought to occur in retinotopic visual cortex, but it has proven difficult to distinguish the contributions of invisible target and visible background to signals measured in these areas. Here, we used magnetoencephalography (MEG) to measure time-dependent brain responses in human observers experiencing texture completion. We measured responses specifically associated with the filled-in target, by isolating neural population signals entrained at the frequency of flicker of the target. When perceptual completion occurred and the target became invisible, there was significant reduction in the MEG power at the target frequency over contralateral posterior sensors. However, even a subjectively invisible target nevertheless evoked frequency-specific signals compared to a no-target baseline. These data represent evidence for a persistent target-specific representation even for stimuli rendered invisible due to perceptual filling-in.

Acknowledgement: This work was supported by the Medical Research Council (RW) and the Wellcome Trust (GR, JDH, JK).

C58 380 **Attentional load modulates time-to filling-in of an artificial scotoma.**

Victoria Wykes[1] (v.wykes@gmail.com), Rimona Weil[1], Geraint Rees[1]; [1]Institute of Cognitive Neuroscience, 17 Queen Square, London, WC1N 3AR, UK

A figure presented in the near periphery on a background of dynamic noise will become filled-in by its background, after a few seconds of central fixation. Neurophysiological, imaging and behavioural studies suggest that this process is likely to take place in early visual cortex. However, it has been recently shown (PDW, JOCN 2006) that directing spatial attention to features of the figure increases the probability of filling-in, suggesting a possible role for top-down attentional signals. To investigate these, we manipulated attentional load in a central task while participants reported the occurrence of perceptual completion for an achromatic target on a textured background in the periphery. Both time to filling-in and duration of filling-in were dramatically and significantly modulated by central attentional load. This suggests that availability of attentional resources influences the occurrence and duration of perceptual completion. We further explore how the nature of the central task influences perceptual completion, and discuss our findings in the context of Lavie's load theory of attention (Lavie TICS 2005). Taken together, our findings provide further evidence that this early visual phenomenon is subject to modulation by higher cognitive processes.

C59 381 **The effect of sensorimotor adaptation on chromatic judgments.**

David Richters[1] (daverichters@mac.com), Rhea Eskew[1]; [1]Northeastern University

When a body movement systematically co-occurs with a stimulus, a change in perception to "correct" for this correlation may occur. Sensorimotor adaptation of this kind was demonstrated in an intriguing recent study by Bompas & O'Regan (2006). Our procedure was similar to that of Bompas & O'Regan. In the adaptation phase, which lasted approximately 40 minutes, we induced a correlation between leftward eye saccades and a red stimulus, and rightward eye saccades and a green stimulus. In this adaptation phase, observers performed an incidental task involving judgments of the shapes of the spots. In a subsequent test phase, observers compared the color of two stimuli after leftward and rightward saccades. The major result was that stimuli tended to look greener after a leftward saccade and redder after a rightward saccade, like Bompas & O'Regan's result. This finding is consistent with sensorimotor adaptation. Unlike Bompas and O'Regan, we used a white rather than dark background, and the colored stimuli were approximately equiluminant with that background. Contrasts were measured in cone contrasts to better quantify the magnitude of the effect, rather than using distance in CIE space. The spots we used were smaller than the 10 deg diameter spots of Bompas & O'Regan. We always had a red-green neutral (yellow) stimulus as one of the two spots presented in each trial of the test phases. Using the criteria set forth by Bompas & O'Regan, we obtained sensorimotor adaptation even with stimuli having no luminance contrast with the background. Bompas & O'Regan reported that 9 out of 10 of the observers showed the effect of sensorimotor adaptation, whereas we our effects were weaker. However, we also saw idiosyncratic biases in the initial test phase, before adaptation, that complicate the interpretation of these data.

3D Perception: Space

Author Presents: 2:00 - 3:45 pm

C60 382 **On judging surface slant using haptic (palm-board) and verbal-report tasks**

Zijiang J He[1] (zjhe@louisville.edu), Ji Hong[1], Teng Leng Ooi[2]; [1]University of Louisville, [2]Pennsylvania College of Optometry

Recent studies (e.g., Proffitt et al, 1995) showed the judged geographical slant of the ground is exaggerated with the verbal-report task, and is more veridical with the palm-board task. Is there a correlation between the two tasks? Our observers viewed a 1.5x2.4m checkerboard texture-surface with varying slants (5, 10, 20, 30, 45deg) relative to the horizontal ground from either 1m or 4m. In task-1, the observer judged the slant of the texture-surface relative to the ground; by adjusting the slant of the palm-board to match the perceived slant of the ground, and separately, to the perceived slant of the texture-surface. The difference between these two measurements reveals the judged slant of the texture-surface. For each set of measurements, the angular position of the observer?s arm to the palm-board was fixed at 0, 30, or 60deg from the horizontal. We found that judged slants were significantly affected by the arm angle. A larger arm angle caused a smaller measured slant. In task-2, the observer verbally reported the slant of the texture-surface. Consistent with Proffitt et al, the verbal judgment was less accurate (overestimated) than with the palm-board task. To reveal the scaling relationship between tasks 1 and 2, we tested the same observers in task-3, where the observers blindly rotated the palm-board to a verbally instructed slant angle (0, 5, 10, 20, 30, or 45deg). We found that the adjusted slant of the palm-board relative to the instructed slant was less. We then used this relationship to predict the data in task-1 from the empirical data in task-2. We found a linear relationship between the predicted and empirical data in task-1 (y=0.91x+1.77, r=0.987), which suggests a lawful relationship between tasks 1 and 2. An independent, but noteworthy finding from task-1 is that the horizontal ground was judged as slanted upward (~3.8deg).

Acknowledgement: Supported by a grant from NIH (R01 EY 014821)

C61 383 Accurate perception of visual space from live-video in a head-mounted display

Mikio Akagi[1] (makagi1@swarthmore.edu), Frank Durgin[1]; [1]Department of Psychology, Swarthmore College

Even when geometrically accurate displays are used in virtual reality (VR), most labs report substantial compressions of perceived distance. That is, it is hard to effectively simulate large-scale spaces in VR; they look small. There have been reports that pre-exposure to the space that is being simulated (e.g., in a VR rendering of a lab space) produces accurate scaling. We sought to measure whether pre-exposure to our experimental hallway had an effect on locomotor distance judgments when that hallway was viewed in a head-mounted display (HMD) with a correctly scaled live video image. The task was to walk, without visual or auditory feedback, to a pre-viewed target. Subjects had never been to the experimental hallway before. Distances were in the range of 3 to 7 meters. There were three conditions of the experiment. In the normal vision condition, subjects simply wore the HMD as a hat (to match any postural influences) and viewed each target directly before closing their eyes and walking to it. In the live-video-only condition, subjects performed the same task while wearing an HMD without any pre-exposure to the hallway environment. In the pre-exposure condition, subjects were allowed to view the hallway directly from a single vantage point prior to donning the HMD and beginning the experiment using live video. Surprisingly, although the average proportional distance (walked/actual) with pre-exposure did not, in fact, differ from that with normal vision, proportional distances walked in the live-video-only condition were actually greater (M = 1.00) than those in the other two conditions (M = 0.87), $t(18) = 2.13$, $p < .05$. While it is possible that subjects were actively compensating for a mismatch between perceived size and expected size of a generically familiar scene, the HMD itself is probably not primarily responsible for distance compression.

C62 384 Visual search on the ground-like surface defined by texture gradients in chimpanzees (Pan troglodytes) and humans (Homo sapiens).

Tomoko Imura[1] (imura@pri.kyoto-u.ac.jp), Masaki Tomonaga[2]; [1]Kwansei Gakuin Univrsity, Japan Society for the Promotion of Science, [2]Primate Research Institute, Kyoto University

Previous studies of visual search have shown that in humans, visual attention is distributed over a three-dimensional surface defined by binocular disparity (He and Nakayama, 1995), and pictorial depth cues (Morita and Kumada, 2003). Although nonhuman primates are sensitive to pictorial cues (Imura and Tomonaga, 2003), few studies explored the relationship between pictorial depth perception and visual attention from the comparative perspective. In this study, we examined how chimpanzees and humans searched on the ground-like surface defined by texture gradients.

Experiment 1 tested the effects of ground surface on visual search. Participants were required to touch a cube with odd color (target) among those arranged at an imaginary ground-like surface. Under the top-difference condition, a cube with dark gray top face defined as target and distractor cubes with white top face were presented as a search display. Under the side-difference condition, a cube with dark gray side face (target) and cubes with white side face (distractors) were presented. Both chimpanzees and humans detect the target faster under the top-difference condition than under the side-difference condition, suggesting that a ground-like surface defined by texture gradients was effective for a search in both species. Experiment 2 assessed the effects of ceiling-like surface consisted of upside-down cubes on search performances. Both species showed faster detection of the target in the side-difference condition than in the top-difference condition, suggesting that asymmetry of the search for top faces to side faces disappeared on the ceiling-like surface.

The findings of these two experiments indicate that in both chimpanzees and humans, a ground-like surface defined by texture gradients facilitated the search for objects on it, while a ceiling-like surface did not. Our findings suggest the ground dominance effect for search in both species.

C63 385 How much can vision tell us about where we are? Measuring the channel capacity between visual perception and spatial layout

Sahar Nadeem[1] (sahar@mail.utexas.edu), Brian Stankiewicz[1]; [1]University of Texas at Austin

When navigating through large-scale spaces visual cues play an important role for localization and path selection. In order for these cues to be useful, the navigator must associate the cues with specific states (positions and orientations) within the environment. The current studies investigate the channel capacity of the association between the visual information and the states within the environment.

To investigate the issue of spatial channel capacity we trained and tested subjects in six computer generated environments with different amounts of information. This manipulation was achieved by varying the number of states that had unique views within an environment. Visual landmarks were placed within the environment, such that each state generated a unique visual signature. The smallest environment consisted of two hallways with 12 states (3.5 bits of information). The largest environment consisted of 40 hallways with a 132 states (7.04 bits of information). To measure the mutual information between the visual input and spatial layout, participants were shown a single view from one of the states within the environment. We calculated the mutual information for each participant in each environment as a function of the participant's state response and the view presented. We found no evidence of a capacity limitation for up to 7.04 bits of information. However, we did find that humans consistently lose about 1.25 bits of information regardless of the size of the environment. We have replicated this study with naïve participants who were not trained in any of the environments and found similar results.

Acknowledgement: AFOSR FA9550, DOD 5710001865, NIH EY 016089

C64 386 The position of objects relative to the horizon affects size-distance invariance

Kerem Ozkan[1] (kozkan@uci.edu), Myron Braunstein[1]; [1]University of California, Irvine

We reported previously (VSS, 2006) that the higher of two objects equal in projected size in a 3D scene was judged larger when it was at or below the implied horizon but was judged smaller when it was above the horizon. The present study examined effects of location of objects relative to the horizon on distance judgments and on the relation between size and distance judgments. In the first experiment the scenes consisted of line drawings in which the simulated distance to the horizon and the separation between the visible texture and the horizon were varied. Observers judged the relative distance of two objects that were either both below the horizon, both above the horizon or one at the horizon and one above or below the horizon. Unlike the results found with size judgments, the higher object was always judged more distant, regardless of its position relative to the horizon. The relation between size and distance judgments for objects varying in position with respect to the horizon was investigated directly in two additional experiments, one using line drawings and one using photographs of real scenes, with separate blocks of size and distance judgments. With the higher object at or below the horizon, it was judged larger in size judgment blocks and more distant in distance judgment blocks, as would be expected according to size-distance invariance. The effect was reversed, however, when the higher object was above the horizon. In that case, the higher object was judged smaller and further back than the lower object.

This is the type of paradoxical size-distance relation found, for example, in the moon illusion. These results suggest that the relation between judged size and judged distance for objects in a 3D scene depends on the positions of the objects relative to the horizon.

C65 387 Arousal Influences the Perception of Height

Jeanine Stefanucci[1] (jkstef@wm.edu), Justin Storbeck[2]; [1]College of William & Mary, [2]University of Virginia

Previously, we found that the slant of a hill was overestimated when participants were asked to imagine skating down the hill on a skateboard (Stefanucci, Proffitt, & Clore, 2005). In addition, we showed that vertical extents (or heights) were overestimated when viewed from the top and that this overestimation was correlated with observers' self-reported fear of heights (Stefanucci & Proffitt, 2006). In a series of experiments, we extend the previous work by showing that the perception of height from the top is influenced by manipulations of arousal. Specifically, in Experiment 1, we gave observers either dangerous (highly arousing) or neutral written information about a height. Observers' perceptions of height were then assessed with two measures: visually matched estimates of the apparent distance and visually matched estimates of apparent size (an indirect measure of distance). Observers in the dangerous condition overestimated height more than observers in the neutral condition. In Experiment 2, we replicated these results using a different manipulation of arousal. We presented observers with either arousing or neutral images from the IAPS (International Affective Picture System) standardized library (Lang, Bradley, & Cuthbert, 2005). After viewing the pictures, all observers estimated the height as in Experiment 1. Participants who viewed arousing images overestimated height more than participants who viewed neutral images. The results suggest that arousal plays a role in the overestimation of heights from the top.

C66 388 Exocentric Pointing in Depth

Andrea van Doorn[1] (a.j.koenderink-vandoorn@io.tudelft.nl), Jan Koenderink[1], Astrid Kappers[1], Michelle Doumen[1], James Todd[2]; [1]Physics and Astronomy, Universiteit Utrecht, [2]Psychology, The Ohio State University

An exocentric pointing task was used to compare the indicated pointing directions under exchange of target and pointer. A pair of pointing directions, together with the pointer and target locations, specifies a unique cubic arc. Such an arc may assume one of two qualitative shapes, namely a "C-arc" (constant sign of curvature) or an "S-arc" (containing a point of inflection between the endpoints). We show that human observers most often produce S-curves. This is of fundamental importance, since–in case one interprets the curve as an empirically determined "pre-geodesic" ("shortest connection", or "straight" connection in visual space)–it would imply that "visual space" in the strict geometrical sense is a nonentity. The experiments were performed in the outside environment, under normal daylight conditions, for distances ranging from one to over thirty meters. The implications of these data are discussed and possible ways to extend the restricted notion of "visual space" (e.g., as advocated by Luneburg) such as to allow one to account for the present results are suggested. Such extensions of the visual space concept include the local adjustment of geometrical structure in regions adjacent to the fixation direction.

Acknowledgement: We thank Hans Kolijn for his technical assistance.

C67 389 Homonymous hemianopia alters distribution of visual fixations in 3-dimensional virtual environments

Meghan Riley[1] (meghan_riley@urmc.rochester.edu), Kristin Kelly[2], Tim Martin[2], Mary Hayhoe[3], Krystel Huxlin[2,4]; [1]Department of Neuroscience, University of Rochester, [2]Center for Visual Science, University of Rochester, [3]Brain & Cognitive Sciences, University of Rochester, [4]Department of Ophthalmology, University of Rochester

Homonymous hemianopia, a consequence of unilateral damage in early visual cortex, is associated with abnormal gaze distributions. However, to date, hemianopic saccade and fixation patterns have been investigated with search tasks and static, two-dimensional displays. The goal of this study was to assess whether abnormal hemianopic gaze patterns also occur when visual tasks are performed under more naturalistic circumstances. We compared fixation patterns of four, long-standing hemianopes with those of four visually-intact controls when immersed in a virtual, three-dimensional environment. Eye position was recorded and categorized under both static and ambulatory conditions. For all conditions tested, hemianopes fixated significantly more frequently into the half of the virtual field of view corresponding to their blind hemifield. But while fixation distributions and dynamics were fairly similar between the two subject groups when subjects were stationary, hemianopic fixation distributions were significantly narrower than those of controls in the walking condition. Our results suggest that hemianopes' compensatory eye movements towards the impaired hemifield when examining static, two-dimensional images also occur in a naturalistic, three-dimensional environment. However, the abnormally narrow range of exploratory fixations observed under ambulatory conditions suggests a potentially maladaptive strategy that could explain many of the difficulties experienced by this patient population when immersed in dynamic, real-life environments.

Acknowledgement: The authors wish to thank Terry Schaeffer and Dorothea Castillo for performing visual field tests on the hemianopic subjects, Keith Parkins for programming the virtual environment, and Brian Sullivan and Kelly Chajka for their help in data collection. This research was supported by grants from the RPB Foundation, the Pfeiffer Foundation, the Schmitt Foundation, and from NIH grant EY05729 (to MH). KRH is an RPB Robert E. McCormick Scholar.

C68 390 Depth perception of real objects and virtual objects when they are presented at the same depth defined by binocular retinal disparity

Masahiro Suzuki[1] (msuzuki@ctr.kanagawa-it.ac.jp), Kazutake Uehira[1,2]; [1]Human Media Research Center, Kanagawa Institute of Technology, [2]Department of Network Engineering, Faculty of Information Technology, Kanagawa Institute of Technology

In order to investigate depth perception in the situations, in which real objects and virtual objects coexist (i.e., Mixed Reality), we examine depth perception of the real objects and the virtual objects when they are presented at the same depth defined by binocular retinal disparity. Experiment was conducted in a lit room. A white plate (16 cm of width, 16 cm of height) was located in front of an observer whose head was fixed by a chinrest. The observation distance was 90, 100, or 110 cm. (The distance to the plate defined by binocular retinal disparity was the same as the observation distance.) A virtual object was generated with a workstation. A stereogram was displayed on a rear projection screen (81 cm of width, 61 cm of height) with a DLP projector. The image for the left eye and that for the right eye appeared alternatively with 120 Hz of temporal frequency, and were given to the suitable eyes with a pair of LCD shutter glasses. The screen was located to the left of the observer. By placing a beam splitter (20 cm of width, 20 cm of height) in front of the observer, the stereogram was projected onto the observer's eyes. The distance from the observer to the screen via the beam splitter was 100 cm. A white rectangle (17 cm of width on the screen, 13 cm of height on the screen) was presented to the left of the plate. The distance to the rectangle defined by binocular retinal disparity was 90, 100, or 110 cm. The observers estimated the amount of depth between the plate and the rectangle. The results showed that the rectangle was perceived slightly closer than the plate when they were presented at the same distance defined by binocular retinal disparity.

Acknowledgement: The authors are grateful to Hitoshi Sakai who helped to make the apparatus.

C69 391 Golf performance makes the hole look as big as a bucket or as small as a dime

Jessica Witt[1, 2] (jwitt@virginia.edu), Sally Linkenauger[2], Jon Bakdash[2], Dennis Proffitt[2]; [1]University of Western Ontario, [2]University of Virginia

Golfers often comment on how their perception of the hole varies with performance. On good days, the hole can look as big as a bucket or a basketball hoop. On bad days, the hole can look as small as a dime or an aspirin. The optical information received by the eye is the same regardless of how

Saturday Posters

well the golfer is playing, so does a golfer really see the hole differently? We measured apparent hole size for golfers after they played a round of golf, and found a negative correlation between course score and judged hole size: Golfers with a better score judged the hole to be bigger. This result expands on earlier research with softball players where we showed that batters who were hitting better recalled the softball to be bigger (Witt & Proffitt, 2005). In addition, we showed that apparent hole size is related to golf performance that day (as assessed by course score) but not to how good a player is (as assessed by handicap). In other words, our results imply that a highly skilled player such as Tiger Woods does not always see the hole as bigger just because he is a better player, but rather, any person can see the hole as being bigger on days that he or she is playing well. Finally, apparent size is not related to subjective measures of performance. Players who think they are playing better do not necessarily see the hole as being bigger. We ran two follow-up experiments in the laboratory to show that performance affects judgment of hole size when the hole is out of sight and within sight during the judgment. Our results demonstrate that people's perception of the environment is influenced by their current abilities to act effectively in the environment.

Visual Control of Movement: Neural Mechanisms

Author Presents: 2:00 - 3:45 pm

C70 392 A comparison of saccade and pointing topography between medial and lateral areas in the human posterior parietal cortex

John Zettel[1] (johnzettel@hotmail.com), Tutis Vilis[2], Jody Culham[3], Doug Crawford[1,4]; [1]Centre for Vision Research, York University, [2]Department of Physiology and Pharmacology, University of Western Ontario, [3]Department of Psychology, University of Western Ontario, [4]Department of Psychology, York University

Previous functional magnetic resonance imaging (fMRI) studies identified areas in the posterior parietal cortex (PPC) that are active during memory-guided saccades and pointing to visual targets. Both the areas for saccades and pointing are lateralized, showing higher activation for actions directed toward the contralateral hemifield (Medendorp et al., 2003, Journal of Neuroscience; Fernandez-Ruiz et al., in press, Cerebral Cortex). The purpose of this study was to clarify topographical areas of activation in the PPC related to saccading to and pointing to remembered targets as well their activity in an anti-pointing task.

fMRI was used to measure the blood oxygenation level-dependent response while right-handed individuals either made saccades or pointed to remembered visual targets in a blocked design. Subjects also performed an anti-pointing task. Contrasts between right- and left-visual targets revealed topographic areas related to each effector.

The saccade task produced lateralized activation in the medial intraparietal sulcus (IPS; left Talairach coordinates (TC): -23, -60, 43). The pointing task produced topographic activation in a medial region of the PPC (left TC: -12, -82, 32), near the superior parieto-occipital sulcus, as well as the IPS region activated by saccades. These two regions are consistent with previous studies. In addition, a previously unidentified area in the precuneus also demonstrated topography for pointing (left TC: -8, -59, 57).

These results show that a region in the IPS has topographic activity for visually directed saccades and pointing, while a more medial region is topographically activated by pointing alone. Examination of activity in these and other topographically organized areas during an anti-pointing task are expected to provide further insight into their role in visuospatial behavior.

C71 393 TMS over posterior parietal cortex disrupts the integration of initial hand position information into the reach plan

Michael Vesia[1,2,5] (mvesia@yorku.ca), Denise Henriques[1,2,5], Xiaogang Yan[1,2], Lauren Sergio[1,2,3,5], JD Crawford[1,2,3,4,5]; [1]Centre for Vision Research, York University, [2]Canadian Institutes of Health Research Group on Action and Perception, [3]Department of Psychology, , York University, [4]Department of Biology, York University, [5]Department of Kinesiology and Health Science, York University

We previously reported that induction of a focal current using single-pulse transcranial magnetic stimulation (TMS) reveals a hemispheric asymmetry in the early stages of the putative spatial processing in the human dorsal posterior parietal cortex (PPC). Moreover, we postulated that this brief TMS pulse modifies the output of the right PPC in motor coordinates downstream from an adapted visual-motor reversal, rather than modifying the upstream visual coordinates of the memory representation (Vesia et al., J. Neurophysiol, 2006). Alternately, TMS could have altered the perception of the initial hand position. To test this hypothesis, we investigated the memory-guided pointing accuracy in six subjects during TMS of the left and right PPC while varying visual information of the effector. We tested three conditions: 1) initial and final vision of hand positions (IFV); 2) full vision of hand position (FULV) and; final vision of hand position (FV). In accordance with previous findings, subject's pointing errors/biases varied as a function of stimulation site - left parietal stimulation significantly increased endpoint variability, while right parietal stimulation produced a significantly systematic leftward directional shift in both visual fields during the FV condition. In addition, these systematic pointing error/biases significantly decreased during both the IFV and FULV conditions. These results suggest that the PPC integrates the target and effector (e.g. the hand) position in a gaze-centered representation of space to compute the movement vector at this early stage in the visuomotor transformation.

C72 394 Inferior parietal recordings and behavioral effects of shifting prisms on visually guided reaching.

Anushree Karnik[1] (anu@cortex.rutgers.edu), Barbara Heider[1], Ralph M. Siegel[1]; [1]Center for Molecular and Behavioral Neuroscience, Rutgers University, Newark, NJ

The relationship between motor and visual representations in area 7a and the dorsal prelunate (DP) is explored by perceptually shifting the visual field. The monkey was required to fixate a point at one of nine positions on a touch screen while a visual stimulus (expansion optic flow, diameter 8½) appeared behind the fixation point. This phase of the task was considered 'perceptual.' The change from structured to unstructured motion cued the monkey to make a ballistic hand movement towards the target. The monkey held his hand on the touch screen (reach phase). Three dimensional hand position was monitored in some experiments. Neural activity was recorded contralateral to the reaching arm. For neurons with spatial tuning properties, Fresnel prisms with a 10½ shift opposite to the preferred location were placed in front of the monkey's eyes. Under this condition, the visual input was distorted whereas the motor output had to be maintained by the monkey; the monkey was required to reach to the physical, not perceived, location of the target. With the prism the animal correctly reached to the target within a few trials, although the kinematics remained affected. The shifting prisms significantly altered the neural representation in areas 7a and DP. The gain field and the reach field tuning thus far appears the same even with the prisms. This is surprising given the sensorimotor mismatch introduced by the prisms. This suggests that in posterior parietal cortex, visual and reach responses might represent separate inputs and do not affect each other.

C73 395 Foveal and peripheral reaching activity in the macaque cortical area V6A

Patrizia Fattori[1] (pfattori@biocfarm.unibo.it), Rossella Breveglieri[1], Nicoletta Marzocchi[1], Daniela Filippini[1], Claudio Galletti[1]; [1]Department of Human and General Physiology, University of Bologna, Bologna, Italy

In a previous work, we demonstrated a spatial tuning for reaching activity in the majority of V6A cells, suggesting that V6A reach-related neurons could be able to code the direction of movement of the arm and the position of the hand/arm in space (Fattori et al, 2005, Eur. J. Neurosci). In that work, the animals reached foveated targets placed in different spatial locations. As V6A neurons are strongly modulated by the direction of gaze (Galletti et al., 1995, EurJ Neurosci), it could be that the above described spatial tuning of reaching activity is due to a gaze modulation of neural activity. Thus, we here study the coding of directions of reach with a constant-gaze task.

The monkey reached central or peripheral locations while looking constantly towards a central fixation point. The task was performed in complete darkness except for the very small and barely visible fixation point. The monkey always started the reaching movement with the hand near the chest, then reached and held the target location in peripersonal space, and finally went back to the home button.

We tested 101 V6A neurons from 1 monkey with this constant-gaze reaching task. We found that 65% of them showed a neural modulation during the execution of reaching movements towards foveal and peripheral targets. Some of them showed activities preferring the reaching movement to the foveated target, others to the ipsilateral, and others to the contralateral one. A similar percentage of neurons (60%) was modulated during hand holding among different spatial locations, again with the gaze fixed in the straight ahead direction.

We suggest that the visuomotor area V6A plays a key role in the fronto-parietal loops monitoring and/or controlling goal-directed voluntary arm movements both towards foveated and peripheral ones.

Acknowledgement: This work was supported by European Union Commission, FP6-IST-027574-MATHESIS and by MIUR and Fondazione del Monte di Bologna e Ravenna, Italy.

C74 396 Target selection for visually-guided reaching in macaque

Joo-Hyun Song[1] (jhsong@ski.org), Robert McPeek[1], Naomi Takahashi[1]; [1]The Smith-Kettlewell Eye Research Institute

Most real-world visual scenes are complex and crowded: instead of a single isolated object, there are often several different objects competing for attention and directed action. The majority of our knowledge of the neural mechanisms underlying the selection of visual targets for action has come from studies of eye movements. However, vision is also used to guide other actions such as manual reaching movements. To examine the mechanisms involved in target selection for visually-guided reaching, we trained two rhesus monkeys to perform a search task in which they were rewarded for making a reaching movement to an odd-colored target presented with multiple distractors. The color of the target was randomly selected in each trial to be either red or green, and the distractors were of the opposite color. We found that as the number of distractors increased, reaching times decreased and accuracy improved, presumably due to stronger perceptual grouping of the homogenous distractors. Furthermore, reaches were completed more quickly and accurately when the target color remained the same from trial to trial than when it switched, indicating that cumulative color priming across trials facilitates target selection for reaches in monkey. Reaching errors were usually directed to a distractor adjacent to the target, suggesting a spatially coarse-to-fine progression during target selection. These results are very similar to what has been observed for reaching movements in humans (Song and Nakayama 2006), providing a basis to examine the neural underpinnings of reach target selection in the monkey. Similar effects of distractor number and color priming are also seen for saccadic eye movements in both humans and monkeys (Findlay 1997; McPeek et al. 1999; Bichot and Schall 1999, 2002; McPeek and Keller 2001; Arai et al. 2004), suggesting a common neural mechanism of visual selection for both reaching and eye movements.

Acknowledgement: NIH R01-EY014885

C75 397 Selectivity of human mirror system responses during observation and execution of congruent versus incongruent hand actions

Trevor Chong[1] (trevorc@unimelb.edu.au), Ross Cunnington[2], Mark A. Williams[1,3], Jason B. Mattingley[1]; [1]School of Behavioural Science, University of Melbourne, [2]Neuroimaging and Neuroinformatics, Howard Florey Institute, [3]McGovern Institute for Brain Research, MIT

The mirror neuron system is thought to underlie the human ability to recognise the actions and gestures of others. It does so by providing a neural mechanism through which a perceived action can be directly matched with its corresponding representation within the observer's own motor repertoire. For this direct matching mechanism to mediate action understanding, a subset of mirror neurons should be more active when perceived and executed actions are identical, relative to when they are different. This strict correspondence has been demonstrated in monkeys, but the degree of correspondence required for activation of human mirror areas remains unclear. Here, we used fMRI to determine if areas within the mirror system are more active during the observation of matching (congruent) hand gestures compared to those that are non-matching (incongruent). Participants performed a series of pantomimed hand actions, while simultaneously observing either a congruent or incongruent action in separate, counterbalanced blocks. Crucially, the observed actions were irrelevant to participants, so any correspondence between observed and executed actions was incidental. Our analysis revealed that, while performing a specific action, particular nodes within the human mirror system were more active during the perception of congruent, relative to incongruent, actions. These findings indicate that areas within the human mirror system do indeed demonstrate a strict correspondence between observed and executed actions. We conclude that these mirror areas may be critical in the direct matching process that underlies action recognition.

C76 398 Spatial deficits in visuomotor control along the body midline in a patient with optic ataxia.

Carol Broderick[1] (carol.broderick@gmail.com), Danielle Striemer[1], Shayna Sparling[1], Keelan Murtha[1], Julie Corbett[2], Dwight Stewart[2], James Danckert[1]; [1]Department of Psychology, University of Waterloo, Ontario, Canada, [2]Stroke Unit, Grand River Hospital, Kitchener, Ontario, Canada

Patients with optic ataxia resulting from damage to the posterior parietal cortex display gross pointing deficits to targets in peripheral vision. Although performance in central vision is better when compared with peripheral vision, it may be possible to detect subtle deficits in movement kinematics. We analyzed visually guided pointing movements in patient ME, who suffered a right superior parietal lesion leading to optic ataxia. ME and a group of elderly controls made pointing movements with both hands to targets that varied in size on a trial-to-trial basis (i.e., a speed-accuracy trade-off task). Two axes of movement direction were contrasted, with subjects pointing to targets in a right/left sequence perpendicular to the body midline or in a near/far sequence aligned with the body midline. While ME spent more time than controls decelerating prior to contacting targets for all directions of movement with each hand, her pattern of performance differed for each axis of movement. For right-left movements of either hand she showed a similar pattern to controls: in short, all participants spent more time decelerating prior to target contact for movements made towards contralateral space (e.g., right hand pointing leftwards). In contrast, for near-far movements, ME spent much more time decelerating for both near and far movements of either hand while controls showed an asymmetry in performance such that more time was spent decelerating for near than for far movements of either hand. In addition, ME spent more time overall in the deceleration phase of her movements made with left hand and in general, movements made along the near-far axis had longer deceleration phases than movements made along the right-left axis. For our patient then, optic ataxia has produced deficits of visually guided movement control throughout space and surprisingly, more so in near-far movements than in right-left movements.

Multisensory Processing

Author Presents: 4:00 - 5:45 pm

C77 399 Attention enhances visual contributions to multisensory integration for the perception of upright.

Jennifer E. Corbett[1] (jec12@nyu.edu), Marisa Carrasco[1,2]; [1]Department of Psychology, New York University, [2]Department of Neural Sciences, New York University

Goals: When determining the direction of gravitational upright we depend more on visual signals from the external environment than we do on vestibular and proprioceptive inputs about the orientation of the body. For example, a vertical rod surrounded by a tilted frame will appear tilted in the opposite direction of the frame, even when are we in an upright posture. Given that covert transient attention enhances the representation of visual signals and alters the appearance of stimuli, we examined whether transient attention also enhances the influence of the visual environment (frame) on perceived upright (rod).

Methods: Observers determined the orientation of a tilted rod surrounded by a tilted frame presented 8^o to the left or right of fixation. To engage attention, a 50 ms cue appeared to the left or right of fixation where the stimulus display (rod and frame) would appear. We compared performance with a neutral cue that appeared in the central region of the display. Following a brief ISI (50 ms), the rod and frame appeared on the left or right of fixation for 100 ms.

Results & Discussion: Observers perceived the orientation of the rod as a function of the frame to an increased extent in valid cue trials compared to neutral cue trials, as reflected by a significant reduction in the accuracy of their rod orientation judgments. These results indicate that attention enhances the influence of visual context on perceived upright, causing observers to see the rod as even more tilted in the opposite direction of the frame than it physically is. These findings further suggest that attention increases the degree to which observers favor visual input over vestibular and proprioceptive inputs when determining which way is "up."

Acknowledgement: This work was supported by a grant from the National Institute of Health awarded to Marisa Carrasco (R01 EY016200-01A2)

C78 400 A (nother) new way to measure up: the oblique derived subjective visual vertical

Richard Dyde[1] (richard_dyde@hotmail.com), Laurence Harris[1,2]; [1]Centre for Vision Research, York University, Toronto, Canada, [2]Department of Psychology, York University, Toronto, Canada

The direction of 'up' can be measured by judging the orientation of a line against gravitational vertical: the subjective visual vertical (SVV). An alternative method uses the perceived identity of a character whose identity depends on its orientation (the Oriented CHAracter Recognition Test (Dyde et al., 2006: Exp Brain Res. 173: 612). OCHART derives the perceptual upright (PU) from the average of the two orientations at which the character is maximally ambiguous. PU and SVV are differently influenced by the directions of gravity, the body and visual cues. However SVV is derived from a point of maximum certainty whereas PU is taken from points of maximum uncertainty. Could different results arise from differing methodologies?

Methods

SVV was measured in two ways, both using constant stimuli. The conventional method determined an orientation of maximum certainty ("was the line tilted clockwise or counterclockwise relative to gravity?"). The new method found two points of maximum uncertainty (making it more comparable with OCHART) by asking whether a tilted line appeared closer to vertical or horizontal - the average of these two orientations indicating another SVV. For eight observers both SVVs were calculated whilst placed against a background rich in polarity cues which was tilted through 360° in 22.5° steps.

Results

Both SVVs showed a complex but clearly similar influence of the visual background's orientation and the methods showed indistinguishable results when the background was either fully upright or fully inverted - both being within 1° of gravitational vertical. However the SVV derived from the two points of maximum uncertainty showed a significantly larger influence of the background and higher intra-observer variances.

Conclusions

Both methods generated comparable results, but have differing sensitivities to tilting the visual background with the reliability of the estimate of the orientation of the probe relating to the magnitude of the background effect.

Acknowledgement: Supported by NASA Cooperative Agreement NCC9-58 with the National Space Bio-medical Research Institute and grants from the Natural Sciences and Engineering Research Council of Canada and the Canadian Space Agency (CSA).

C79 401 Human fMRI of tactile spatial representations

Flavia Filimon[1] (ffilimon@cogsci.ucsd.edu), Jonathan Nelson[2,1], Martin Sereno[1]; [1]Department of Cognitive Science, University of California, San Diego, CA, [2]Computational Neurobiology Laboratory, Salk Institute, CA.

The neural bases of tactile space perception are poorly understood. While several neuroimaging studies have investigated the "what" pathway of tactile object perception, little is known about how the brain represents external spatial locations as perceived via touch.

In this functional magnetic resonance imaging (fMRI) study, we set out to explore the neural representation(s) of target locations as felt by the hand in the absence of visual input.

Subjects explored rectangular Lego brick platforms on which targets (smaller Lego blocks) were located at various locations (e.g. middle of platform, bottom left corner of the platform, etc.). Subjects performed a one-back matching task in which they compared the location of one target on a platform with that of the next platform, and indicated if the locations matched or not. An experimenter presented the stimuli to subjects, who used their right hand. Targets could be narrow or wide, with subjects being instructed to ignore the width of the targets and focus on their location. Subjects were blindfolded and had no visual input during the experiment, relying solely on their haptic perception.

In a control condition, the subjects' task was to determine if the width of a target matched that of the next target in a one-back matching task, using the same stimuli as before.

During baseline, subjects rested their hand.

A fronto-parietal network of activations were observed during the spatial exploration task. Interestingly, many areas normally involved in visual spatial perception were activated during haptic spatial perception, including parietal cortex. Visual motion-related (MT+) areas were also activated. In some subjects, V1 activation was observed, despite the lack of visual input.

The observed activations in parietal areas which are also recruited during visual spatial perception suggest the presence of multisensory representations.

Acknowledgement: NSF BCS 0224321

C80 402 Equivalent stream/bounce effects in cyclopean and luminance defined displays

Philip Grove[1] (p.grove@psy.uq.edu.au), Kenzo Sakurai[2]; [1]School of Psychology, The University of Queensland, [2]Department of Psychology, Tohoku Gakuin University

When two objects move towards each other, coincide, then move away from each other, two possible perceptions can result: the objects can be seen to stream past one another or to bounce off of one another. In visual only displays, the predominant perception is streaming. If, however, a brief auditory stimulus is presented at or near the point of coincidence, the bias towards streaming is reversed and bouncing is predominantly reported. To the best of our knowledge, all previous studies on this phenomenon have employed luminance-defined motion displays (i.e. black discs or blocks on a light background). Here we show using dynamic random dot stereograms that stream/bounce audio-visual interactions are similar for luminance-defined and cyclopean displays. Observers viewed both types motion sequences (frame rate = 20Hz) in the presence or absence of a brief auditory tone. When present, the tone occurred 0, 100 or 250 ms before or after coincidence. At the end of each sequence observers indicated whether the targets appeared to stream past or bounce off of one another. Stimuli were presented 20 times each in random order. The presence of an auditory tone at or before the point of coincidence significantly promoted bounce perception in both cyclopean and luminance defined displays. Auditory tones presented 250 ms after coincidence failed to promote bouncing in luminance defined displays but continued to do so in cyclopean displays. Nevertheless, the pattern of responses was strikingly similar in both types of displays. Control experiments manipulating the duration of the post coincidence trajectory yielded virtually identical results for both display types and do not support a cognitive-bias explanation of the auditory induced bounce bias. Our data show, as has been previously conjectured, that auditory and visual cues are integrated to resolve stream/bounce motion displays at or beyond the point of binocular combination.

C81 403 **The relative contributions of the visual components of a natural scene in defining the perceptual upright.**

Laurence Harris[1] (harris@yorku.ca), Richard Dyde[1], Michael Jenkin[1]; [1]Centre for Vision Research, York University, Toronto, Ontario, Canada

The ambient visual information that contributes to self- and object-orientation includes frame, horizon, and visual polarity cues (derived from sources such as the direction of illumination, the relationship between objects, and intrinsic polarity cues). These cues can be ambiguous: the frame provides four possible directions of up; the horizon two; whereas polarity cues provide a unique up direction. We previously showed how these elements affect the perceptual upright using oriented gratings (http://journalofvision.org/5/8/193). Here we look at the relative contribution of each component in real world scenes.

Using the Immersive Visual Environment at York (IVY) we placed eleven observers in a virtual reality simulation of (i) a fully furnished room, (ii) just the furniture from this room, (iii) the room without furniture, (iv) a "room" comprised of random dots and (v) a wire-frame room. The environments were rendered in stereo using shutter glasses and could be tilted relative to the viewer. For each orientation of each environment, upright observers performed the Oriented Character Recognition Test (Exp Brain Res. 173: 612) to estimate the perceptual upright (PU). The PU was modeled as the sum of four vectors corresponding to the body/gravity (one vector) and the three visual components (frame, horizon, and polarized cues).

The contribution of the wire-frame and dot rooms was dominated by the frame. Interestingly the relative contribution of the frame was similar when all the other cues were present (15% wireframe, 11% empty room, 19% furniture-filled room) but also when the frame was only implied in the furniture-only display (13%). The effect was largest for the furniture-filled room (83% of the body+gravity cue, furniture alone 74%, empty room 47%, wire-frame 14%, random dot 5%).

The different components of a visual scene make differential contributions to the perceptual upright that can be quantified precisely.

Acknowledgement: Supported by NASA Cooperative Agreement NCC9-58 with the National Space Bio-medical Research Institute, the Canadian Space Agency, and grants from the Natural Sciences and Engineering Research Council of Canada and the Canadian Space Agency (CSA).

C82 404 **Meaningful association of a sound with a target facilitates visual search.**

Lucica Iordanescu[1] (l-iordanescu@northwestern.edu), Marcia Grabowecky[1], Satoru Suzuki[1]; [1]Department of Psychology, Northwestern University

In natural circumstances, the visual objects we search for may be accompanied by characteristic sounds. The hiding cat may meow, or the keys in the cluttered drawer may jingle when moved. Do these characteristic sounds facilitate visual localization of objects even if the sound has no location information? To answer this question, we used a visual-search paradigm in which participants searched for a target named on each trial. Each search display contained a target object (e.g., a cat) and three distractor objects (e.g., a car, a mosquito, and a wine-glass). The display was presented simultaneously with a sound that was either associated with the target object (e.g., "meow"), associated with a distractor object (e.g., "clink"), or unrelated to any object in the search array (e.g., "jingle"). We used 20 objects and their associated sounds counterbalanced across target, distractor and unrelated conditions. Participants responded to the location of the target by pressing a key that corresponded to the quadrant in which the target appeared. Characteristic sounds of target objects significantly speeded their visual localization; for example, the "meow" sound significantly speeded visual localization of the cat. Search was slower in the other conditions regardless of whether the concurrent sound was associated with a distractor or was unrelated to any objects in the display; for example, visually localizing a cat was equally slow whether participants heard a "clink" or a "jingle". There was no evidence of a speed-accuracy trade-off. These results suggest that sounds associated with targets facilitate visual search, but that there is little cost to hearing a sound associated with an object that is not the focus of a current search. We thus demonstrated an object-based auditory-visual facilitation, going beyond location-based interactions. Our data add to the growing body of evidence that visual processes are enhanced by consistent information from other sensory modalities.

Acknowledgement: Supported by NIH Grant EY14110 to SS.

C83 405 **Visual perceptual learning enhanced with congruent sound**

Robyn Kim[1] (robynkim@ucla.edu), Aaron Seitz[2], Ladan Shams[1]; [1]Department of Psychology, University of California, Los Angeles, [2]Department of Psychology, Boston University

Numerous studies of perceptual learning have demonstrated the potential for neural plasticity in adult visual cortex; however, the effect of sensory input from other modalities on such learning has been largely neglected. Considering that the natural environment is largely multimodal, and that inputs from other modalities can affect visual processing as early as V1 (Watkins, Shams et al. 2006), multisensory interactions may play a role in perceptual learning. For example, we recently found that training with sound facilitated coherent motion detection and discrimination (Seitz, Kim & Shams, 2006). In the current study, we trained subjects over five days on a visual motion coherence detection task with either visual, congruent audiovisual, or incongruent audiovisual stimuli. Consistent with our previous findings, when comparing performance on trials containing only visual signals, subjects trained with congruent audiovisual stimuli demonstrated significantly better learning compared to those trained with only visual stimuli. Subjects trained with incongruent audiovisual stimuli, however, did not show such a learning enhancement, and in fact did not demonstrate any significant learning. Thus, congruency between the audio and visual stimulus modulates the effect of sound on visual learning, suggesting that the benefits of multisensory training are not merely due to increased attention or arousal during training, but may result from interactions at a perceptual level.

C84 406 **Musical Use of Visual Gestures: the importance of contextual information in sensory integration**

Michael Schutz[1] (schutz@virginia.edu), Michael Kubovy[1]; [1]University of Virginia

At VSS 2005 we reported that percussionists use visual gestures to alter audience perception of musical note length (Schutz & Kubovy). This conflicts with previous research suggesting vision does not alter auditory judgments of tone duration (Walker & Scott, 1981). In order to determine why our results differ from prior research, we built a point light simulation of a percussionist's movements tracking the long and short gestures used to strike percussion instruments. After pilot studies demonstrated the simulation to be successful, a series of four experiments revealed:

1) When using alternate sounds, the visual influence:

a. Persists with percussive sounds (piano).

b. Does not persist with non-percussive sounds (clarinet, trumpet, voice).

2) Visual influence is lost when the moving dot pauses at the moment of impact before rebounding.

3) Influence is lost when the motion path is rotated 180 degrees after impact to simulate moving "through the bar" rather than rebounding off of it.

4) A static dot presented simultaneously with the percussive sound produces effects similar to those observed with gestures.

We conclude our initial results were driven by the perceived causal relationship between modalities. Only sounds caused by impacts (e.g. percussive sounds) are influenced by visual impact gestures (Experiment 1). Manipulations which obscure the perception of a visual impact have no effect on auditory judgments (Experiments 2). The most important aspect of the gesture is the sudden change of direction at the moment of impact (Experiment 3). However, the motion itself is important only in that it depicts a change. A spatially static visual change (e.g. the appearance of a dot on a previously blank screen) alters perception as reliably as the original gestures (Experiment 4). Together these studies show the importance of the relationship between the auditory and visual information in understanding the nature of sensory integration.

Acknowledgement: This research was supported in part by a grant from NIDCD R01 DC 005636 (Michael Kubovy, PI)

C85 407 Integration of multi-sensory directional information during goal-directed pointing

Sascha Serwe[1] (sascha.serwe@psychol.uni-giessen.de), Knut Drewing[1], Julia Trommershäuser[1]; [1]University of Giessen, Department of General and Experimental Psychology

We studied multi-sensory integration of directional information during the execution of goal-directed pointing movements. Subjects pointed at a visual target of 6 cm diameter, presented at 35 cm from the starting position of the arm movement. Subjects performed the pointing movement under open loop conditions, i.e. visual feedback about finger and target position was removed during the movement. Proprioceptive directional information was provided by applying a small force pulse (amplitude 1 N, pulse duration 50 ms) orthogonal to the movement direction early in the movement. In some trials, a noisy visual directional cue was presented. Time and spatial location of presentation of the visual cue were matched to the force pulse. The direction of the visual cue was either consistent with the force pulse direction or differed by 30°, either clockwise or counterclockwise. Subjects were instructed to hit the target within 1200 ms following target presentation. We measured perceived direction of the proprioceptive cue when both cues were provided and perceived direction for each cue alone. In conditions in which both cues were presented simultaneously, we compared subjects' responses to the predictions of an ideal observer model. The model combines visual and proprioceptive direction estimates measured in single-cue conditions by weighted averaging. The weights depend on the reliability of each cue. In accordance with the predictions of the ideal observer model we find that subjects' responses were less variable when both visual and proprioceptive cues were available. In conditions in which the mean direction of proprioceptive cue and visual cue differed, subjects' responses exhibited a bias towards the direction of the visual cue. This bias was larger for more reliable visual cues and smaller for more reliable force pulse directions. These results are consistent with the idea of a reliability weighted combination of both cues.

Acknowledgement: Funded by DFG (Emmy-Noether-Programm, TR528 1-2/1-3)

C86 408 Superior Visual Detection Capabilities in Congenitally Deaf Cats

Lomber Stephen[1] (steve.lomber@uwo.ca), Kral Andrej[2]; [1]Centre for Brain and Mind, University of Western Ontario, London, ON, Canada, [2]Institute for Neurophysiology and Pathophysiology, University Clinic Hamburg-Eppendorf, Hamburg, Germany

Deaf individuals may compensate for the absence of hearing by superior performance in other modalities. We examined visual capabilities of adult congenitally deaf cats on a wide range of visual tasks in order to define which visual abilities are involved in cross-modal compensation. Congenital deafness in three adult deaf animals was demonstrated by a lack of acoustically-evoked brainstem responses. Performance on a battery of seven visual tasks was examined and compared to three adult hearing cats. All six animals were tested on visual acuity, contrast sensitivity, discrimination of direction of motion, velocity and orientation, and detection of movement and detection of a flashed visual stimulus. Overall, for none of the visual capabilities examined was performance of the deaf cats inferior to that of the hearing cats. For the tests of visual acuity, contrast sensitivity, direction of motion discrimination, velocity discrimination, and orientation discrimination performance in the deaf cats was not different from that of the hearing cats. However, for the two tests of visual detection (movement detection and detection of a flashed stimulus) the deaf cats demonstrated superior performance to that of the hearing cats. For the deaf cats, movement detection thresholds were <0.5deg/sec, while for the hearing cats thresholds were above >0.5deg/sec. Detection of a 100 msec flashed red LED stimulus was significantly better for the deaf cats than for the hearing cats. Both superior rates of detection and faster reaction times were identified in the deaf cats. This superior performance was only identified at the most peripherally tested positions, at eccentricities of 75 and 90 degs. Therefore, while the visual abilities of congenitally-deaf cats are similar to hearing cats on most psychophysical tests, the performance of deaf cats on visual detection tasks is superior.

Acknowledgement: This work is supported by CIHR, NIDCD and DFG.

C87 409 Light priors, learning and feedback

Erich W. Graf[1], (erich@soton.ac.uk), Wendy J. Adams[1], Samira Bouzit[1]; [1]University of Southampton

To interpret ambiguous shading information, observers use the 'light-from-above' prior. Previous work has shown that this prior can be modified in response to haptic (touch) feedback indicating that the light position has altered (Adams, Graf and Ernst, 2004). Here, we extend this work to investigate (i) the time-course of this learning, (ii) how long the effects persist, and (iii) whether learning is more efficient when more feedback (binocular depth information) is added.

Before training, observers viewed monocular disks with shading gradients at various orientations. Reported shape (convex or concave) as a function of stimulus orientation was used to recover each observer's assumed light position. During training, observers also 'touched' the disks. The haptic (felt) shape of the training stimuli was consistent with a light source shifted by ±30 degrees from the observer's original assumed light position. A second group of observers were given additional stereoscopic depth information during training that was consistent with the haptics (and the new, trained light position). After training, observers again judged the shape of the stimuli based purely on monocular shading information.

Initially, our observers assumed a light position that was roughly overhead. However, the observers who were given only haptic feedback, learned to use a shifted light direction for their prior. Most learning occurred during the first 2 hours of training and the learnt shift persisted at least 10 days. Interestingly, learning was significantly reduced in the group who were given both disparity and haptic feedback.

Acknowledgement: This work is supported by EPSRC grant # EP/DO33916/1

C88 428 Auditory stimuli elicit spatially specific responses in visual cortex

Santani Teng[1,2] (steng@ucdavis.edu), David Whitney[1,2]; [1]Center for Mind and Brain, UC Davis, [2]Department of Psychology, UC Davis

The retinotopic organization of information in human visual cortex is well known. However, it has become evident that some non-visual tasks also recruit early visual cortex, especially in blind subjects (e.g. tactile: Cohen et al., 1997; auditory: Gougoux et al., 2005). We sought to determine whether such cross-modal activity can also be found for sounds presented to sighted subjects, and whether, in accordance with the spatiotopic organization of early visual cortex, it is spatially specific. In an fMRI study, we scanned subjects at 3T while presenting pink-noise moving auditory stimuli through headphones. The stimuli simulated the effect of presentation from one of eight positions in a free-field environment and were calibrated individually to subjects' ears. In other runs, we presented visual stimuli to individual quadrants of subjects' visual fields. Consistent with previous studies, no overall amplitude change in BOLD response to auditory stimuli was found in visual cortex. However, position-selective patterns of activity were found when comparing individual spatial conditions. We found that visual cortex responses to auditory and visual stimuli were more closely correlated when the stimuli occurred in the same quadrants of visual space than when they occurred in disparate quadrants. Auditory stimuli simulating presentation behind the subject did not produce spatially specific patterns of activity, demonstrating that the sensitivity of visual cortex to auditory stimuli is restricted to those that overlap the visual field.

Sunday Talk Sessions

Sunday, May 13, 2007

Grouping and Segmentation I

Sunday, May 13, 8:30 - 10:00 am, Hyatt Ballroom South
Moderator: Ruth Rosenholtz

8:30 410 **Persistence of the neural border ownership signal indicates short-term memory in perceptual organization**

Philip O'Herron[1,2] (poherro1@jhmi.edu), Rudiger von der Heydt[1,2]; [1]Krieger Mind/Brain Institute, Johns Hopkins University, [2]Department of Neuroscience, Johns Hopkins School of Medicine

The responses of neurons in visual cortex generally decay rapidly after the stimulus is turned off. To study persistence of figure-ground organization we studied border ownership (BO) selective neurons in situations where a figure-ground display changed to an ambiguous display. Cells were recorded in macaque V2 under behaviorally induced fixation. A square figure with one side centered in the receptive field (giving a particular BO assignment) was presented for 0.5s and followed by 1s presentation of an ambiguous edge - a contrast border that appeared behind a circular aperture. The local contrast in and around the receptive field remained constant. We measured the duration of the BO signal (the difference in firing rates between conditions with the two initial sides of figure). We found that during the ambiguous edge presentation, the BO signal decayed slowly, with a time constant of around 600 ms. In contrast, when, after the same initial display, the figure was flipped to the opposite side, the signal reversed quickly, with a time constant of 30 ms. Controls in which the colors of figure and ground were alternated rapidly during the initial display showed that the persistence of the BO signal was not due to an afterimage. When the display was switched to 'figure' again after the ambiguous edge period, the BO signal assumed the corresponding value rapidly, as observed for figures flipping sides. In summary, in the absence of figure-ground cues, the BO signal persists with slow decay, but it is reset quickly when new figure-ground information is presented. These features indicate a mechanism of short term storage, which may contribute to the stability of figure-ground organization despite the rapid fluctuations that characterize the retinal image in normal vision.

Acknowledgement: NIH Grant EY02966, and Training Grant EY07143

8:45 411 **Attention and figure-ground status produce separate steady-state VEP effects in human cortex**

Joseph Brooks[1,2] (joseph.brooks@ucl.ac.uk), Stephen Palmer[2]; [1]Institute of Cognitive Neuroscience, University College London, [2]Department of Psychology, University of California, Berkeley

Figure-ground organization determines perceived shape and relative depth along edges in visual scenes. We report a continuous neural measure that reflects the figure-ground status of image regions from image onset through behavioral response. The contrast of the texture in figure and ground regions, as determined by the presence of the extremal edges figure-ground cue (Palmer & Ghose, VSS 2006), was reversed at 6.25 Hz and 10 Hz, respectively, to cause steady-state visual evoked potential (SSVEP) responses at corresponding harmonic frequencies in the scalp electroencephalogram. Because figural regions are known to attract attention (Nelson & Palmer, in press) and attention affects the SSVEP response (Muller, et al., 1998, Nature Neuroscience), the location of spatial attention was also manipulated to dissociate these factors. While observers fixated a central point, they continuously directed their attention to either the left or right side, as instructed, and reported whether they perceived that region as figure or ground. Both attention and figural status increased SSVEP amplitude, but their effects differed in scalp distribution: Whereas the attention effect was strongest over the hemisphere contralateral to the attended location, the figural assignment effect on the SSVEP was equally strong over both hemispheres. Importantly, the time course of the figural SSVEP effect was strongly correlated with the response time of behavioral figure-ground judgments, suggesting that the neural activity causing this effect is linked to the conscious representation of figural status.

Acknowledgement: This research was partially supported by a NIMH Cognitive Neuroscience training fellowship to J.B.

9:00 412 **Cortical network dynamics of figure/ground categorization**

Lora T. Likova[1] (lora@ski.org), Christopher W. Tyler[1]; [1]The Smith-Kettlewell Eye Research Institute

Introduction: FMRI of asynchronous figure/ground structures has revealed a mechanism of top-down suppression from hMT+ to the stimulated background-representation in V1/V2 in the human brain (Likova & Tyler, 2005).

Purpose and Methods: In order to (i) analyze the whole-brain figure/ground network and (ii) understand its neural dynamics, we employed a novel instantaneous-stimulation paradigm: We find that instantaneous refreshes in subregions of random-dot fields create distinct and prolonged percepts of spatial structure. Different transient spatial-configurations were generated by refreshing (i) only the figure region, (ii) only the background, (iii) the whole stimulus field, or (iv) figure then background in asynchronous fashion. FMRI responses were obtained throughout the brain in a GE Signa 3T scanner at 1.5 sec TR. The dynamics of the neural activation was determined by deconvolution of the BOLD signal with the standard estimate of the hemodynamic response function (HRF, defined as the transform from the neural response to the BOLD activation waveform).

Results: Inter-condition comparisons revealed remarkable differences in one or more properties of the response waveform (latency, width, polarity, and number of phases), not only between, but within each individual cortical area. The instantaneous-stimulus paradigm generated a wide variety of BOLD signal waveforms and corresponding neural response estimates throughout a distributed network extending through the occipital, parietal and frontal cortex.

Conclusions: Such distinct response waveforms within a given cortical region evoked by different conditions assure that the differences could be securely attributed to the neural dynamics, not to spatial variations in the HRF. Integrated analysis of the neural response reconstruction throughout the cortex enabled us to quantify the neural dynamics of the involved cortical areas. The activation pattern specific to figure/ground categorization implies a distributed recurrent architecture with functional feedback loops.

Acknowledgement: NIH/NEI 13025

9:15 413 Filtering in feature space: a computational model of grouping by proximity and similarity

Ruth Rosenholtz[1] (rruth@mit.edu), Nathaniel Twarog[1], Martin Wattenberg[2]; [1]Dept. of Brain and Cognitive Sciences, MIT, [2]IBM Research

We present a model of perceptual grouping which uses the type of low-level information available to simple and complex cells in V1 to identify likely meaningful image segments. The model is applicable both to natural images as well as artificial displays. It can deliver a hierarchical segmentation of an image, and allows for quite general segmentations: segments may overlap, for instance, or be separated in space. The algorithm neither needs to know in advance the number of groups, nor learn this number. While many segmentation algorithms work on a two-dimensional image space, our model first identifies segments in a higher-dimensional space and then projects back to the original image space.

The model begins by extracting, at each image location, a vector of image features, f, such as luminance, chrominance, and/or local orientation. The image is then represented in a multi-dimensional (x, y, f) space. Blurring in this space with an appropriate kernel creates a function on the n-D space in which connected regions with a higher value contain pixels clustered by a combination of proximity and similarity. Finally, these regions are projected back down to the original (x, y) image space to yield groups in the image. The corresponding 2-D image regions often mimic Gestalt groupings, and in natural images often correspond to connected segments of the same object.

The model is computationally and mathematically simple, particularly compared to current alternative segmentation algorithms. In addition, the major operation necessary for the algorithm, blurring, can easily be modeled by a neural network, and closely parallels the spreading activation behavior found throughout the brain. Finally, the convolution kernel itself can naturally be defined in terms of statistics gathered from segmentations of natural images.

9:30 414 Second-order perceptual grouping

Timothy J. Vickery[1] (tim.vickery@gmail.com), Yuhong V. Jiang[1]; [1]Department of Psychology, Harvard University

Grouping principles such as proximity and similarity allow a complex scene to be parsed into a simpler description. Is grouping local, differentiating only those items to which these principles directly apply, or does it "spread" to other elements in a scene? We found that when a set of undifferentiated items is situated adjacent to items that are paired by Gestalt grouping factors (similarity, proximity, etc.), the undifferentiated items appear to be paired. We term this transitive grouping effect 'second-order grouping.' This study investigates how second-order grouping affects visual attention using a method adapted from Beck and Palmer (2002). Subjects searched through a row of mostly alternating squares and circles (target items) for the repeated pair of shapes. An irrelevant set of red and green cross-shaped distracters appeared above or below the targets. The distracters were either ungrouped or they were grouped pair-wise by color. When distracters were ungrouped, detection of the repetition of the target items took equally long whether the distracter items alternated in color or were all in one color. However, when the distracters were grouped, target repetition detection was substantially slower if the repeated targets aligned with two distracters of different colors than if they aligned with two distracters of the same color. Thus, grouping from the adjacent distracter row spreads to the target row. This effect was eliminated by inserting a line between the target and distracter rows, showing that the spread of grouping was not simply attributable to the proximity of the grouped distracters to the target items. We propose that Gestalt grouping factors are extended by transitivity, and such higher-order effects can strongly impact the allocation of attention during visual search.

Acknowledgement: Supported by NIH 071788 and NSF 0345525

9:45 415 Learning static Gestalt laws through dynamic experience

Yuri Ostrovsky[1] (yostr@mit.edu), Jonas Wulff[2], Pawan Sinha[1]; [1]Dept. of Brain and Cognitive Sciences, MIT, [2]RWTH Aachen University

The Gestalt laws (Wertheimer 1923) are widely regarded as the rules that help us parse the world into objects. However, it is unclear as to how these laws are acquired by an infant's visual system. Classically, these "laws" have been presumed to be innate (Kellman and Spelke 1983). But, more recent work in infant development, showing the protracted time-course over which these grouping principles emerge (e.g., Johnson and Aslin 1995; Craton 1996), suggests that visual experience might play a role in their genesis. Specifically, our studies of patients with late-onset vision (Project Prakash; VSS 2006) and evidence from infant development both point to an early role of common motion cues for object grouping. Here we explore the possibility that the privileged status of motion in the developmental timeline is not happenstance, but rather serves to bootstrap the learning of static Gestalt cues. Our approach involves computational analyses of real-world motion sequences to investigate whether primitive optic flow information is correlated with static figural cues that could eventually come to serve as proxies for grouping in the form of Gestalt principles.

We calculated local optic flow maps and then examined how similarity of motion across image patches co-varied with similarity of certain figural properties in static frames. Results indicate that patches with similar motion are much more likely to have similar luminance, color, and orientation as compared to patches with dissimilar motion vectors. This regularity suggests that, in principle, common motion extracted from dynamic visual experience can provide enough information to bootstrap region grouping based on luminance and color and contour continuation mechanisms in static scenes. These observations, coupled with the cited experimental studies, lend credence to the hypothesis that static Gestalt laws might be learned through a bootstrapping process based on early dynamic experience.

Acknowledgement: John Merck Foundation and NEI (NIH) R21 EY015521-01

Eye Movements: Mechanisms

Sunday, May 13, 8:30 - 10:00 am, Hyatt Ballroom North
Moderator: Scott Stevenson

8:30 416 Superior colliculus (SC) neural activity codes visually guided head-unrestrained gaze movements in retinal coordinates.

Joseph DeSouza[1] (desouza@yorku.ca), Gunnar Blohm[1], Xiaogang Yan[1], Hongying Wang[1], J. Doug Crawford[1]; [1]York Centre for Vision Research, Department of Psychology, Toronto, Canada

Neural activity in the SC is highly correlated with gaze shifts composed of both eye and head movements (Freedman and Sparks, 1996; Munoz et al. 1991). Further, SC stimulation evokes eye and head gaze shifts that converge as a function of amplitude and initial gaze position, consistent with an eye-fixed motor code for gaze (Klier et al. 2001). We hypothesize that SC neural activity correlates best with gaze target location in retinal coordinates. This predicts that the optimal directional tuning of SC neurons will change as a specific function of amplitude tuning and initial gaze position (Smith and Crawford 2005). Electrical stimulation and/or visual receptive field examination are being used to estimate the optimal gaze amplitude and direction for each recording location. Monkeys randomly fixate one of three different initial gaze directions each separated by 20+/-10 degrees for 500 ms and then make their head-free gaze shift to one of five visual targets placed along a semi-circle of iso-amplitude targets (centered around the position of the receptive field maximum for straight-ahead gaze). We have recorded from eighty one SC neurons, sixty of these have been fully tested in the head-unrestrained paradigm. To date, analysis of 21 neurons shows that SC neurons do indeed show strong initial gaze position dependent firing changes during head-unrestrained gaze shifts. These responses cluster around the theoretical curve for an eye-fixed retinal code, as opposed to a fixed-vector or spatially-fixed coding scheme. Furthermore, some SC neurons show a position-dependent modulation of their firing rates as a function of the initial gaze position, as required for a non-linear transformation of retinal coordinates into gaze motor coordinates (Smith and Crawford 2005).

Acknowledgement: Canadian Institute of Health and Research (CIHR). JFXD supported by National Science and Engineering Council of Canada (NSERC) and CIHR Training Grant.

8:45 417 **Effects of visual salience on superior colliculus neural activity during visual conjunction search.**

Kelly Shen[1,2,3] (kelly@biomed.queensu.ca), Martin Paré[2,3,4]; [1]Neuroscience Graduate Program, [2]Centre for Neuroscience Studies, [3]CIHR Group in Sensory-Motor Systems, [4]Departments of Physiology and Psychology, Queen's University, Kingston, Ontario, Canada

The guidance of visual behavior involves a sequence of processes in which a target stimulus must first be discriminated from amongst several alternatives followed by the programming of an appropriate response. We have shown how visual search behavior is influenced by the composition of the scene and how search strategies are particularly affected by stimulus salience (Shen and Paré 2006). Here, we investigated the neural mechanisms underlying these contextual effects by recording 37 visuo-motor neurons from the intermediate layers of superior colliculus (SC) while three monkeys performed a visual conjunction (color+form) search task, in which color was the most discriminable feature. The target appeared pseudorandomly with 11 distractors in a concentric search array, in which the number of distractors sharing the color of the target was varied between three distractor ratios (2 same-color: 9 different-color; 6:5; 9:2). As previously observed, monkeys' search strategies changed flexibly depending on the display that was presented. Saccades were biased toward distractors sharing the target color when there were few of them within the display (i.e., when they were salient) and away from those distractors when they were numerous. The initial (first 25ms) neuronal response to the search target or a same-color distractor was invariant with distractor ratio and saccade bias. However, at the time neurons discriminated the target from distractors, neuronal activity associated with a same-color distractor was proportional to saccade bias: the greater the activity, the stronger the attraction to same-color distractors. That SC neurons represented stimulus salience was further evidenced by the target-related activity being similarly related to saccade bias. These preliminary results suggest that the sensitivity of SC neurons to visual salience reflects the allocation of attentional resources suitable for the current visual context.

Acknowledgement: This work was supported by the Canadian Institutes of Health Research, the J. P. Bickell Foundation, and the EJLB Foundation.

9:00 418 **fMRI BOLD signal reveals neural correlates of microsaccades**

Peter Tse[1] (Peter.U.Tse@dartmouth.edu), Florian Baumgartner[2], Mark Greenlee[2]; [1]Dartmouth College, [2]University of Regensburg, Germany

Microsaccades are small, conjugate, involuntary eye-movements made while voluntarily fixating, which play a role in minimizing perceptual fading. The goal of this research was to determine the neural correlates of microsaccade occurrence in early visual areas of cortex using fMRI. This is an important issue for fMRI researchers because so far no laboratory has controlled for the possibility that microsaccade events, rates or magnitudes are correlated with experimental conditions. If microsaccades are found to generate BOLD signal changes in the cortex, many past fMRI results may have arisen as a result of this confound. Methods: We recorded both involuntary microsaccades, and voluntary saccades from one eye in the spatiotemporal domain of microsaccades using a Limbus infrared eyetracker (1000Hz sampling), while collecting fMRI data in a mixed, event-related/block design (3T Siemens Allegra scanner, TR=402ms, 11 slices along calcarine, TE=30ms, FA=35°, 800 volumes, n=6, 6-8 runs per subject). In two blocks per run subjects executed small voluntary saccades (0.16°, 12 pseudorandom events per block), maintained fixation on a small point jumping left and right. A long fixation-only period separated these blocks. The fixation point was centered on a 1° wide horizontal white band laid over a polar grating. Retinotopic mapping used standard methods (TR=2000ms, TE=30ms, FA=90°, 30 slices, 152 volumes). Results: BOLD signal is greater in early visual areas for very small voluntary saccades, relative to fixation epochs, which are as small as true microsaccades. An event-related deconvolution analysis of true microsaccades that occurred during fixation-only epochs revealed upward modulation of the BOLD signal in V1 and V2 after the occurrence of a microsaccade. We conclude that, to the extent that microsaccades may be correlated with experimental conditions, the results of fMRI studies may arise because of microsaccades, and not the experimental variables under consideration, forcing a reevaluation of many past fMRI results.

Acknowledgement: This research was supported by the Alexander von Humboldt Foundation (Bessel Award to PT)

URL: http://www.dartmouth.edu/~psych/people/faculty/tse.html

9:15 419 **Dynamic receptive field effects predicted by a saccade target theory of visual perception**

Fred H Hamker[1] (fhamker@uni-muenster.de), Marc Zirnsak[1], Markus Lappe[1]; [1]Psychology, Westf. Wilhelms-University Muenster

Theories of visual stability have emphasized either the need to construct a continuously accurate, retinocentric representation of visual space or a relative localization based on landmarks, specifically the saccade target or nearby objects (Currie et al., 2000 Perception & Psychophysics; Deubel, 2004 Visual Cognition). Although both theories may rely on corollary discharge (Sommer & Wurtz, 2006 Nature, Hamker, 2005 Visual Cognition), the first theory has been linked to the observation of predictive remapping of receptive fields (RFs), whereas an electrophysiological manifestation in terms of dynamic RF changes has not been proposed for a saccade target theory. We have developed a quantitative computational model related to the saccade target theory of visual perception. The observation that objects, located around the saccade target, are special is explained by a spatially selective corollary discharge signal that is directed to the location of the saccade target in multiple visual areas. This occulomotor feedback signal changes the gain of neurons and thus, in addition, affects the RF structure. Our model makes quantitative predictions about perisaccadic RF dynamics depending on the RF center and the saccade target location. Interestingly, the computed model RF shifts are similar to those of predictive remapping when the direction of the vector from the RF center to the saccade target is in the same direction as the saccade vector. However, both theories offer completely different predictions when the vector from the RF center to the saccade target points in the opposite direction than the saccade vector. Thus, we suggest testable experiments that allow to determine the cause of perisaccadic RF effects in different brain areas, which may lead to a deeper understanding of perisaccadic perception and of the subjective experience of visual stability.

Acknowledgement: This work was supported by the German Science Foundation DFG HA2630/4

9:30 420 Spontaneous oculomotor oscillations induced by delayed visual feedback

Jeffrey B. Mulligan[1] (jmulligan@mail.arc.nasa.gov), Scott B. Stevenson[2]; [1]NASA Ames Research Center, [2]University of Houston College of Optometry

The use of visual motion signals in the control of eye movements can be investigated by "opening the loop" linking eye movements and retinal image motion. Goldreich, Krauzlis and Lisberger (1992) introduced artificial delays in visual feedback during pursuit in monkeys, and observed oscillations in velocity, whose frequency varied systematically with delay. Using a dual-Purkinje image eye tracker equipped with stimulus deflectors, we have applied the delayed feedback paradigm to humans. By feeding back the eye movement signals to the stimulus deflectors, we are able to transiently stabilize a target, delivering the effect of the eye movement after a delay period. For moderate delays (greater than 100 msec), this results in sinusoidal oscillations of the eyes, with the period of oscillation varying linearly with the artificial delay. Although feedback is applied in all four dimensions (vertical and horizontal vergence and version), the oscillations are attracted to horizontal version, presumably because this type of movement has the highest pursuit gain. Extrapolating the period-vs-delay function to its x-intercept allows estimation of the internal delay, while the slope of the function is indicative of the control mechanism. Goldreich et al. observed slopes between 2 and 4, which are consistent with their model in which eye acceleration is controlled by a combination of retinal velocity and acceleration signals. In our data, on the other hand, the period of oscillation increases much more slowly with delay, with slopes around 1.5. The results can be explained by a model in which eye acceleration is controlled by a mixture of velocity and position errors.

Acknowledgement: Supported by NASA Aviation Safety Program and NEI RO1-EY12986

URL: http://scanpath.arc.nasa.gov/presentations/vss07

9:45 421 Competition between exogenous and endogenous signals revealed by saccade latency and saccade curvature in the monkey

Brian White[1] (brianw@biomed.queensu.ca), Susan Boehnke[1], Robert Marino[1], Durk Talsma[2], Laurent Itti[3], Jan Theeuwes[2], Douglas Munoz[1]; [1]Center for Neuroscience Studies, Queen's University, Kingston, Ontario, Canada, [2]Vrije Universiteit, Amsterdam, Netherlands, [3]University of Southern California, Los Angeles, California

Natural visual environments contain multiple stimuli competing for our attention, only one of which is selected at a given moment. The processes underlying this competition may be reflected in the time required to generate a saccade to the goal stimulus (Walker et al., 1997), and the nature of the saccade trajectory (McPeek et al. 2003). We trained two monkeys on an oculomotor capture paradigm (Theeuwes et al. 1999) in which one of six homogenous stimuli becomes a target singleton through a color change in the other five items. The monkeys had to make a saccade to the odd colored target. Simultaneously on half the trials an additional distractor suddenly appeared either near or far from the saccade goal. We found that correctly directed saccades showed longer latencies when the distractor was present versus absent. In contrast, latencies were shorter when the eyes were overtly captured by the distractor. In addition, the proportion of capture was always greatest when the distractor appeared near the goal of the saccade. On correct trials, saccades were often curved in the direction of the near distractor. Furthermore, the eyes were also captured by other items more often when the distractor was near the saccade goal suggesting that efforts to avoid the sudden onset occurred at a cost of capture by other non-targets. The results are consistent with the idea that the activity associated with exogenous and endogenous signals combine locally (Trappenberg et al. 2001).

Acknowledgement: Supported by HFSP grant.

Early Visual Processing: Receptive Fields

Sunday, May 13, 10:30 am - 12:15 pm, Hyatt Ballroom South
Moderator: A.B.Bonds

10:30 422 Lateral Interactions in Outer Retina Disclosed by High Resolution Dynamic Optical Imaging of Neural Activation

John George[1] (jsg@lanl.gov), Xin-cheng Yao[1,2]; [1]Biological and Quantum Physics, Los Alamos National Laboratory, [2]CFD Corporation, Huntsville, AL

We have recently demonstrated the feasibility of dynamic near-infrared imaging of fast intrinsic optical changes directly associated with the electrophysiological response in isolated frog retina activated by visible light. High Resolution CCD image sequences acquired with transmitted light (bright field) illumination disclosed large fractional responses and showed evidence of multiple response components with both negative and positive-going signals with different timecourses. Dark field imaging further enhanced the contrast and sensitivity of optical measures of neural activation. High resolution imaging disclosed optical responses in single pixels often exceeding 5%, of background light, allowing dynamic imaging at the resolution of single cells, in single passes. Based on cell location and response dynamics (including correspondence with identified components of the ERG), we identified responses consistent with photoreceptors, horizontal and bipolar cells. Some cells were classified according to functional criteria, including ON, OFF and ON/OFF responses. Optical responses showed complex but consistent spatiotemporal dynamics from frame to frame and trial to trial. Following photoreceptor activation we observed a rapid diffuse response of opposite polarity in the surrounding retina, distant regions of punctate activity and development of an enhanced response associated with the perimeter of the stimulated region. Our experimental results and theoretical analysis suggest that the optical responses may result from dynamic volume changes corresponding to ion and water flow across the cell membrane. Transient intrinsic optical responses associated with neural activation offer an attractive strategy for studying the computation performed by extended neural networks such as the retina. Our studies and theoretical analysis of optical responses in other neural systems suggest that such fast light optical responses can be detected with high sensitivity in reflected light and therefore might enable non-invasive methodology for diagnostic imaging of retinal function.

Acknowledgement: Supported by the DOE Artificial Retina Project

10:45 423 Neural decoding reveals the orientation-selective properties of early human visual area

Stephenie Harrison[1] (stephenie.harrison@vanderbilt.edu), Yukiyasu Kamitani[2], John Dewey[1], Frank Tong[1]; [1]Psychology Department, Vanderbilt Vision Research Center, Vanderbilt University, [2]ATR Computational Neuroscience Laboratories

Although much is known about the orientation-selective properties of visual cortex in animals, such selectivity has proven difficult to measure non-invasively in humans. Previously, we have shown that ensemble fMRI activity in the human visual cortex allows for accurate neural decoding of seen and attended orientations (Kamitani & Tong, VSS, 2004, Nature Neuroscience, 2005). Our method capitalizes on the fact that random variations in the spatial distribution of orientation-selective neurons or columns could lead to weak local biases, which remain detectable at coarse spatial resolutions. By pooling the information from many coarse-scaled voxels, we can obtain robust measures of ensemble orientation selectivity. Here, we investigated whether visual areas differ in ensemble orientation selectivity across variations in stimulus contrast and spatial frequency. In the first experiment, bilateral sine-wave gratings of ±45 degrees were presented at 4%, 20%, or 100% contrast. Whereas orientation selectivity was somewhat greater in V1 than in higher extrastriate areas at high stimulus contrasts, this pattern reversed at low contrasts. Thus, orientation-selective responses became more contrast invariant at higher levels of the visual hierarchy. In the second experiment, oriented gratings were presented at varying spatial frequencies of 0.25, 1.0 and 4.0 cycles/degree. Although areas V1–V3 showed robust orientation selectivity at low and moderate spatial frequencies, only V1 continued to show strong orientation selectivity at high spatial frequencies. Taken together, it appears that human V1 shows greater spatial sensitivity but also greater contrast dependence than higher areas, consistent with neurophysiological studies in animals. Results reveal that our measures of ensemble orientation selectivity are sufficiently sensitive to detect key functional differences between visual areas. Since all stimuli were well above threshold, variations in orientation selectivity cannot be explained by whether the observer perceived a global oriented pattern. Instead, these ensemble responses seem to depend primarily on local orientation processing.

Acknowledgement: Research support: NEI R01-EY14202 to FT and NSERC graduate fellowship to SH

11:00 424 Responses of Striate Cortex Neurons to Transient Changes in Local Contrast and Luminance

Wilson Geisler[1] (geisler@psy.utexas.edu), Duane Albrecht[1], Alison Crane[1]; [1]Center for Perceptual Systems, University of Texas at Austin

During normal saccadic inspection of natural images the receptive fields of cortical neurons are bombarded with frequent simultaneous changes in local mean luminance and contrast, yet there have been no systematic studies of how cortical neurons respond to such stimulation. The responses of single neurons in the primary visual cortex of the cat were measured for 200 ms presentations of sine wave gratings confined to the conventional receptive field. Both local mean luminance and contrast were parametrically and randomly varied over the 1-1.5 log unit ranges that are typical of natural images (Frazor & Geisler 2006, Vis Res., 46, 1585-1598). We find that responses are strongly modulated by both the local mean luminance and contrast, but in an approximately separable fashion—the contrast response function is approximately invariant except for a scale factor that depends upon the local mean luminance. The shapes of the temporal response profiles were found to be approximately invariant with contrast (in agreement with Albrecht et al. 2002, J. Neurophys., 88, 888-913), but were strongly affected by the local mean luminance. The results suggest that most, if not all, cortical neurons carry substantial local luminance information. The powerful non-linear effects of transient changes in local luminance on the contrast responses of cortical neurons may help explain why standard methods of characterizing receptive fields do a poor job of predicting responses to natural stimuli.

Acknowledgement: Supported by NIH grant EY02688

11:15 425 Is Synchrony a reasonable coding strategy for visual areas beyond V1 in primates?

Walter Jermakowicz[1, 2] (walter.j.jermakowicz@vanderbilt.edu), Xin Chen[2], Ilya Khaytin[1, 2], Chris Madison[2], Zhiyi Zhou[4], Melanie Bernard[4], AB Bonds[4], Vivien Casagrande[2, 3]; [1]Medical Scientist Training Program, Vanderbilt University, [2]Department of Cellular and Developmental Biology, Vanderbilt University, [3]Department of Ophthalmology and Visual Sciences, Vanderbilt University, [4]Department of Biomedical Engineering, Vanderbilt University

If neural synchrony provides a meaningful code then one would predict that higher order visual cortical neurons would show robust synchrony when the feedforward signals from lower order neurons are strong and stimulus appropriate. We examined this using a 100 electrode array placed across V1, V2 and DM/V3 (confirmed by histology) in anesthetized, paralyzed bush babies (Otolemur garnetti). Well-isolated units (~50-60 cells/case) were tested with moving gratings differing in orientation, spatial and temporal frequency. Preferred parameters were determined and receptive fields were individually mapped. 1905 cell pairs with overlapping receptive fields were analyzed with joint peristimulus time histograms (JPSTH) (Aertsen, 1989). Neurons were classified as synchronous when the peak duration of the cross-correlation histogram (CCH) was less than 7.0 ms. A neuron was considered to be driving another neuron when the peak duration was more than 7.0 ms. Synchrony was over 19X greater between neurons within a visual area compared to neurons across visual areas and was significantly more frequent between pairs in V1 than between pairs in V2 or DM/V3. The strength of synchrony, reflected by the CCH peak, however, was significantly greater for synchronized pairs in higher then in lower visual areas. There also was a strong correlation between driving efficacy and synchrony, suggesting that the amount of synchrony among neurons in lower areas may determine how effectively spikes are evoked in higher areas. Interestingly, in cases where neuron A appeared to be driving neuron B there often appeared to be two synchronous peaks of similar lag time but opposite sign. We hypothesize that these peaks could reflect feedforward and feedback signals between visual areas. Our results suggest that neuronal synchrony becomes more sparse but stronger in higher visual areas and is strongly correlated with the degree of cooperation between networks within and between these areas.

11:30 426 Heterogeneity in the Responses of Adjacent Neurons to Natural Stimuli in Cat Striate Cortex

Shih-Cheng Yen[1] (shihcheng@alumni.upenn.edu), Jonathan Baker[2], Charles Gray[2]; [1]Dept. of Electrical and Computer Engineering, National University of Singapore, [2]Center for Computational Biology, Montana State University

When presented with simple stimuli like bars and gratings, adjacent neurons in striate cortex exhibit shared selectivity for multiple stimulus dimensions, such as orientation, direction and spatial frequency. This has led to the idea that local averaging of neuronal responses provides a more reliable representation of stimulus properties. However, when stimulated with complex, time-varying natural scenes (i.e. movies), striate neurons exhibit highly sparse responses. This raises the question of how much response heterogeneity the local population exhibits when stimulated with movies. We investigated this question by simultaneously recording the responses of groups of neurons in cat striate cortex to the repeated presentation of movies using silicon probes in a multi-tetrode configuration. We found, first, that the responses of striate neurons to movies were rare and brief - significant response events in single cells occurred approximately only 5% of the time, with a median duration of 53 ms. Significant joint response events in pairs of nearby cells were even more rare, occurring 0.3% of the time, with a median duration of 39 ms. Secondly, striate neurons exhibited both high lifetime and high population sparseness, with median values of 81% and 70% respectively. Nearby cells appeared to contribute fairly uniformly to the coding of visual stimuli, as revealed by an average value of 0.5 for the area under the scree plot. Thirdly, the PSTH correlation between pairs of adjacent neurons recorded on the same tetrodes (median: 0.18) and pairs recorded by different tetrodes (median: 0.11) were found not to be significantly different (p=0.132), indicating that pairs of adjacent neurons exhibited as much heterogeneity in their responses as pairs separated by 150 um. These findings demonstrate that complex natural scenes evoke highly heterogeneous responses within local populations, suggesting that response redundancy in a cortical column is substantially lower than previously thought.

Acknowledgement: This work was supported by the National Eye Institute.

11:45 427 Neural dynamics of surface processing in V1

Arash Yazdanbakhsh[1] (arash_yazdanbakhsh@hms.harvard.edu), Margaret Livingstone[1]; [1]Neurobiology Dept., Harvard Medical School

Visual information processing requires the grouping of different parts of an image into discrete objects; one key step in this is surface segmentation. Surface segmentation and figure-ground segregation require integration of information across large distances in the visual field, yet they occur early in the perceptual process. In order to reconcile the requirement for integration across the visual field with the small receptive fields of cells in early visual areas, it has been suggested that a process of filling-in occurs early in the visual system, by which edge information propagates cell-to-cell from cells representing the borders of a surface towards cells representing its center. The existence or absence of filling-in in primary visual cortex, however, is controversial (Zipser, Lamme et al. 1996; Lee, Mumford et al. 1998; Friedman, Zhou et al. 1999; Lamme, Rodriguez-Rodriguez et al. 1999; Sasaki and Watanabe 2004; Heinen, Jolij et al. 2005; Cornelissen, Wade et al. 2006). Here by constructing a neural population response to edges and their enclosed surfaces using a novel reverse correlation method, we measured the spatio-temporal evolution of responses across a surface and its background. For small figures, responses to the inside versus the outside differed, suggesting a surface representation resembling filling-in. Increasing the surface size, however, eliminated the difference. Convolving the local receptive-field properties of cells with the different surfaces showed that what appeared to be a filling-in phenomenon could arise from the first order spatio-temporal kernel of V1 cells rather than from mechanisms dedicated to diffusion processes or filling-in. We suggest a biologically plausible model based on the receptive field spatio-temporal kernel of V1 cells. Predicting surface and edge responses based on such a kernel indicates that the surface representation and contour processing arise from the same mechanism.

Acknowledgement: Supported by NIH (EY13135)
URL: http://livingstone.med.harvard.edu/arash/

12:00 174 **Response to motion and motion boundaries in monkey V2**

Haidong Lu[1] (haidong.lu@vanderbilt.edu), Anna Roe[1]; [1]Department of Psychology, Vanderbilt University

In primates, neural processing of motion information starts at V1 layer 4, where many directional selective cells are found. In V2, directional selective cells are mostly found in thick stripes. The functional role of these V2 directional cells, however, is not well understood. Given the known role of V2 in real and illusory contour processing, we studied the possibility that motion cues may contribute to encoding of visual contours in V2.

Using intrinsic optical imaging technique, we imaged V1 and V2 response to moving stimuli (gratings and random dots) in awake, behaving monkeys. Our preliminary results showed that: 1) V2 thick stripes have higher motion sensitivity than thin or pale stripes. 2) Directional selectivity in thick stripes is organized in a topographic pattern. 3) V2 orientation domains respond to the motion boundaries in a similar way as to the luminance boundaries (cue-invariance). Based on these and other findings, we suggest a new view of V2's role in form and motion processing.

Object Recognition

Sunday, May 13, 10:30 am - 12:15 pm, Hyatt Ballroom North
Moderator: Sabine Kastner

10:30 429 **Functionally and anatomically distinct regions for processing form and texture in the human ventral stream revealed by fMR-adaptation**

Jonathan S. Cant[1,2,3] (jcant@uwo.ca), Stephen R. Arnott[1,3], Melvyn A. Goodale[1,2,3]; [1]CIHR Group on Action and Perception, [2]Neuroscience Program, University of Western Ontario, [3]Department of Psychology, University of Western Ontario

In a previous study (Cant & Goodale, 2007) we demonstrated that attending to an object's form and attending to that same object's surface properties (particularly texture) engages functionally and anatomically distinct regions of occipito-temporal cortex. Specifically, attending to form activated the lateral occipital area (LO), whereas attending to texture activated the parahippocampal gyrus (PG) and collateral sulcus (CoS). Although these regions seemed to be specialized for processing one particular stimulus dimension (e.g. form in area LO), the pattern of results observed in each 'specialized' region demonstrated that there was also activation to the other, non-preferred stimulus dimensions (e.g. texture in area LO). This led us to question whether the activation to texture in area LO, for example, represented texture processing per se, or represented activation to changes in form while people were attending to texture. To investigate these possibilities, we conducted an fMR-adaptation experiment which allowed us to examine the response properties of regions specialized for processing form, texture, and colour when participants were not explicitly attending to a particular stimulus dimension. Participants passively viewed blocks where only one dimension varied (form, texture, or colour) and blocks where no dimensions varied, while fixating a cross in the centre of the display. Area LO was most sensitive to variations in form, whereas the PG and CoS were most sensitive to variations in texture. As in our previous study, no regions were found that were more sensitive to variations in colour compared to other dimensions. Taken together, these results replicate the findings from our previous study but also suggest that area LO, the PG, and CoS can respond in a very stimulus-driven manner in the absence of task-dependent manipulations of attention. Furthermore, these results provide additional evidence for the functional and anatomical separation of form and texture processing in occipito-temporal cortex.

Acknowledgement: Supported by a grant from Canadian Institutes of Health Research to M.A.G.

10:45 430 **Attention can relieve crowding**

Jeremy Freeman[1] (jfreema2@swarthmore.edu), Denis Pelli[2]; [1]Psychology, Swarthmore College, [2]Psychology and Neural Science, New York University

Crowding occurs when nearby flankers hinder the identification of a target object. Crowding is feature integration over an inappropriately large region, but what determines the size of that region? According to bottom-up proposals the size is that of an anatomically determined isolation field. According to top-down proposals the size is that of the spotlight of attention. Here we investigate the role of attention in crowding using the change blindness paradigm. We measure capacity for widely and narrowly spaced letters during a change detection task, with or without an inter-stimulus cue. Consistent with both bottom-up and top-down accounts, we find that standard crowding manipulations – reducing spacing and adding flankers – impair uncued change detection performance. However, the same crowding manipulations fail to impair cued change detection. The cue relieves crowding. This has been sought but never found before. We suppose that object recognition consists of several steps: detection, segmentation, and integration. Perhaps feature detection is always followed by a coarse, pre-attentive segmentation, which is sometimes followed by a further, finer segmentation (triggered by an inter-stimulus cue), before the final integration of all the features within each segment.

Acknowledgement: Author Jeremy Freeman is a student at Swarthmore College, and this project was completed while he was a fellow of the 2006 Summer Undergraduate Research Program at the NYU Center for Neural Science. We thank Chiye Aoki (Director of the SURP program) and the Leadership Alliance for their support. Also supported by National Institutes of Health Grant EY04432 to DP.

11:00 431 **Finding Signals in Noise: The Neural Advantage of Prior Information**

Scott Gorlin[1] (gorlins@mit.edu), Jitendra Sharma[1,2,3], Hiroki Sugihara[1,2], Mriganka Sur[1,2], Pawan Sinha[1]; [1]Department of Brain and Cognitive Sciences, MIT, [2]Picower Institute for Learning and Memory, MIT, [3]Martinos Center for Biomedical Imaging, Mass. General Hospital

One of the least understood aspects of mammalian vision is the ability to recognize scenes through significant degradations in image quality. Neural receptive fields have traditionally been described with coherent structures - for example, oriented gratings in V1. However, this does not address how neurons respond to noisy, less coherent visual input, which is arguably more prevalent in the natural world. Previous studies with natural images show that recognition is highly non-linear with respect to noise, and more importantly, that recognition in noise is facilitated by prior experience with the stimuli (Sadr and Sinha, 2004). We extend these studies by using RISE sequences (Random Image Structure Evolution) to present structured images evolving from noise in an fMRI paradigm. Specifically, the direction of RISE evolution – ascending or descending in information content – allows us to control for low-level image features, such as luminance, while trending towards or away from a neuron's experimentally defined preferred stimulus. Any difference in response to ascending and descending stimuli thus reflects prior knowledge facilitating neural recognition in noise. In line with previous behavioral studies, we present evidence for this hysteretic facilitation throughout the visual hierarchy. Furthermore, we show a graded signature of hysteresis from V1 through IT, suggesting that prior knowledge affects lower and higher visual areas in different ways.

11:15 432 Object representations in the dorsal pathway: fMRI adaptation effects in topographically organized areas of the human posterior parietal cortex

Christina Konen[1] (ckonen@princeton.edu), Sabine Kastner[1,2]; [1]CSBMB, Princeton University, [2]Department of Psychology, Princeton University

The visual system is divided into two separate pathways, which are specialized for functionally distinct tasks (Ungerleider & Mishkin 1982). The dorsal stream is associated with visually guided action, while the ventral pathway is involved in object recognition.

Physiology studies in monkeys have shown that activity of area LIP in the posterior parietal cortex (PPC) is related to motor intention and visual attention. Moreover, many LIP neurons exhibit shape-selectivity (Sereno & Maunsell 1998). This result indicates that area LIP integrates information from both pathways. In contrast, less is known about the crosstalk between both pathways in humans. Here, we mapped the human PPC and used fMRI adaptation to assess object selectivity in this region.

Six subjects participated in 6 scanning sessions. In session 1 and 2, we applied retinotopic mapping and a delayed saccade task in order to define areas in occipital and parietal cortex, respectively. In the following sessions, we investigated adaptation effects to different categories of objects (2D-, 3D-objects; line drawings). Furthermore, we examined geometric objects under different viewing conditions.

The delayed saccade paradigm revealed 4 topographically organized areas along the intraparietal sulcus (IPS): 2 areas in the posterior part (IPS1/2) and 2 in the anterior branch (IPS3/4). Only IPS1/2, but not IPS3/4 showed object adaptation effects. The signal was reduced when identical objects were presented repetitively compared to an equivalent number of non-repeated objects. Furthermore, adaptation remained when object size and viewpoint were changed.

The adaptation profiles found in IPS1/2 were similar to those in LOC, an area of the ventral stream thought to be critical for object recognition. Together, the similar response patterns in IPS1/2 and LOC point to object representations in both pathways that might be further used for object recognition in the ventral system and object-related action in the dorsal system.

Acknowledgement: DAAD, NIMH

11:30 433 Recognition memory is better for less-occluded than for identical images of natural scenes and faces

Zili Liu[1] (zili@psych.ucla.edu), Hongjing Lu[1]; [1]Department of Psychology, University of California Los Angeles

Purpose: We aim to test the class of appearance-based object recognition accounts that predict that an image identical to the previously seen necessarily gives rise to better recognition than does an image different from (and hence less similar to) the previously seen. We assumed that two identical images are more similar to each other than two different images; and that the more similar an image is to a representation in memory, the more likely this image will be perceived as previously seen.

Method: In an old-new memory task, participants first rated the attractiveness of 30 grayscale images of natural scenes, with 50% of each image area occluded by randomly distributed red rectangles. Participants then rated how likely each of 60 images (30 old and 30 new) had been seen in the previous attractiveness rating. Ten of the occluded old images were identical to those seen previously. Ten was less occluded (40% of image area) and 10 least occluded (30%). Reduced occlusion was achieved by reducing the sizes of the red rectangles. Occlusion of the new images was identically manipulated. A separate experiment used faces as stimuli.

Results: For both natural scenes and faces, the less-occluded old images were rated as more likely to be old than the originally-seen occluded images ($p = 0.01$). This result could not be attributed to bias favoring less occluded images, because sensitivity (when new images were considered) showed the same effect ($p = 0.05$). The least-occluded old images were rated as less likely to be old than the originally-seen ($p < 0.01$). These results indicate that a visual scene is not remembered like a snapshot for subsequent recognition. Rather, perceptual completion behind occlusion was apparent. Such completion appears to be limited in spatial extent, since further removing occlusion did not facilitate recognition of old images.

Acknowledgement: Supported by NSF grant BCS 0617628

11:45 434 Breaking multiple forms of view invariance

Guy Wallis[1] (gwallis@hms.uq.edu.au); [1]University of Queensland

Object recognition based solely on spatial characteristics can only hope to provide limited tolerance to variations in appearance. In everyday life natural objects may alter their appearance quite dramatically as a result of changes in viewpoint, distance, orientation and illumination etc. To combat this shortcoming, it has been proposed that the visual system may learn to associate disparate views of objects on the basis of their temporal rather than spatial characteristics. The reasoning behind this suggestion is that views which regularly occur in close temporal proximity are likely to be views of a transforming object. Previous experimental work has confirmed that invariance learning across depth rotations and changes in fixation is affected by the temporal characteristics of stimulus views. In this paper I describe how two other transformation types: fronto-parallel rotation and illumination are also affected by temporal association. Observers viewed sequences of faces undergoing rotation in the image plane or a change in illumination generated by running a light source around the face's vertical mid-line. Unbeknown to the observers, some of the faces changed their identity as the transformation took place. Two experiments were then run to ascertain whether the manipulation had lead to the two endpoint views becoming regarded as valid views of a single face. In the first test participants were required to discriminate true versus mixed identity transformation sequences. In the second, discrimination performance was measured via a two-view, same-different task. Both experiments revealed compelling evidence for the predicted effect of manipulating the temporal characteristics of the face views. The results establish the temporal association mechanism as a general purpose heuristic for coping with a diverse range of invariance learning. They also serve to undermine models of human object recognition which propose the existence of any general purpose view transformation or shape reconstruction system.

12:00 435 Competition between domains of expertise in a visual search paradigm

N Rankin Williams[1] (rankin.williams@vanderbilt.edu), Thomas J McKeef[2], Frank Tong[1], Isabel Gauthier[1]; [1]Department of Psychology, Vanderbilt University, Nashville, [2]Department of Psychology, Princeton University, Princeton

When concurrently processing stimuli from two domains of expertise, perceptual interference is reflected as competition for shared resources. McKeeff, Tong and Gauthier (VSS 2007 submitted) found that car experts were slower than car novices to identify a face amongst irrelevant cars when all objects were presented in an RSVP stream at fixation. Here we ask whether task-irrelevant distractors from a category of expertise can also compete in the context of a visual search task where stimuli are distributed in space and observers control their eye movements. Car experts and novices searched for a target (face or sofa) in a mixed array of face, car and/or sofa distractors. The number of distractors from the target category remained constant (5), while the number of distractors from the irrelevant category varied (2, 4, or 8 distractors). Car expertise impeded search for a target face among car distractors; experts' reaction times increased as a function of the number of car distractors, while novices' reaction times remained stable regardless of distractor load. Indeed, search slopes were correlated with a quantitative measure of car expertise. Importantly, our results cannot be due to car distractors grabbing attention in car experts because we found no expertise effect when experts searched for sofas among car distractors. In car-absent conditions (searching for faces or sofas among face and sofa distractors) experts and novices also behaved similarly. Together, these data support the notion that objects of expertise automatically compete for resources supporting face processing, even when these objects are task irrelevant, visually distinct from faces, and separated in space from faces.

Acknowledgement: This work was supported by a grant from the James S. McDonnell

Attention Modulation of Sensory Signals: Physiology

Sunday, May 13, 2:00 - 3:30 pm, Hyatt Ballroom South
Moderator: Robert McPeek

2:00 436 Non-equivalence between attentional modulation and increases in signal contrast for superior colliculus neurons

Miguel Eckstein[1] (eckstein@psych.ucsb.edu), Dorion Liston[2], Richard Krauzlis[2]; [1]Department of Psychology, University of California, Santa Barbara, [2]Systems Neurobiology Lab, Salk Institute

Visual attention in detection tasks is typically manipulated by the presence of a cue that predicts the position of the signal with some validity (i.e., 75 %). A large number of studies have shown how attention modulates neuronal activity in a variety of areas including V1, V2, V4, and FEF (Reynolds & Chelazzi, 2004). A current concept is that attention affects the neuronal response in a similar manner to changes in signal contrast. This statement has been mostly based on measurements of average spike rate but most typically without a Receiver Operating Characteristic (ROC) analysis assessing how a neuron's ability to discriminate between target and distracter is affected. Here, we analyze activity of saccade-related neurons in the superior colliculus (SC) in a cueing task with three signal contrast levels to determine whether attention alters neurons' abilities to discriminate between signal and distracter in a similar way to changes in signal contrast. We recorded from eighty five saccade-related neurons in the SC of two monkeys during a luminance discrimination task (2 alternative forced choice) with a 75% valid cue. Saccade performance (percent correct) increased with signal contrast and was higher for the trials in which the signal appeared at the cued location (valid cue trials) vs. the uncued location (invalid cue trials). Session to session cueing effect amplitudes predicted using ROC analysis of SC neuronal activity correlated with the measured behavioral cueing effects. Consistent with previous studies, SC neuronal activity (average spike rate) increased with both attention and signal contrast. However, ROC analysis indicated that the ability of the individual neurons to discriminate between signal and distracter varied with signal contrast but did not with attention (cue presence). We conclude that for the present task and for SC neurons attentional modulation is not equivalent to variations in signal contrast.

Acknowledgement: Support NIH grant EY12212 to RK & NSF 0135118 to ME

2:15 437 Superior colliculus activity related to reflexive and top-down shifts of attention

Robert M. McPeek[1] (rmm@ski.org); [1]The Smith-Kettlewell Eye Research Institute

Saccades and covert shifts of attention are used to improve perception of peripheral stimuli. The primate superior colliculus (SC) plays a central role in saccades, and recent evidence suggests its involvement in visuo-spatial attention. To test the role of the SC in attention, we recorded single-unit activity as monkeys remained fixated and discriminated the orientation of a briefly-presented peripheral target embedded in an array of distractors. The target could appear in one of six isoeccentric locations, and distractors appeared in the other locations. In some blocks of trials, attention was reflexively cued to the target location by a color-oddity cue that preceded the target. In other blocks, top-down control of attention was tested by making the target more likely to appear in one location than in the others. Both the reflexive and top-down manipulations had significant effects on the accuracy of discriminating the target's orientation, indicating that they influenced attention. Activity in a subpopulation of visually-responsive SC cells was strongly modulated by reflexive precues, showing a sustained increase in activity when attention was cued into their receptive fields. This attention-related activity continued until the onset of the discrimination target. In contrast, none of the SC cells was modulated by the top-down attention manipulation. These results indicate that during fixation, SC activity is correlated with the locus of reflexively-cued attention, and suggest that the SC is involved in controlling reflexive shifts of attention, but not in controlling top-down shifts of attention.

Acknowledgement: Supported by NIH R01-EY014885.

2:30 438 The inhibitory surrounds of neurons in the lateral intraparietal area (LIP) of the monkey can be activated and modulated by top-down processes.

Annegret L. Falkner[1,2] (alf2111@columbia.edu), B. Suresh Krishna[1,2], Michael E. Goldberg[1,2]; [1]Columbia University Department of Neurobiology & Behavior, [2]New York State Psychiatric Institute

LIP represents a salience map composed of bottom-up visual, and top-down oculomotor and cognitive components. This salience map is considered to play a role in spatial attention and oculomotor processing. We have recently demonstrated that neurons in LIP have inhibitory surrounds: a maintained saccade plan to a stimulus presented outside the receptive field of a neuron can significantly suppress the visual activity evoked by a task-irrelevant distractor presented in the cell's receptive field during the delay period of the planned saccade (Falkner, Krishna, and Goldberg, SFN 2006). Here we show that this suppression can be modulated by purely cognitive, non-visual (top-down) processes in two distinct ways. First, the response to a distractor is reduced when the monkey plans a memory-guided saccade to the inhibitory surround, indicating that the saccade plan is sufficient to evoke suppression even in the absence of a visual saccade target. Second, when the monkey plans a saccade to the inhibitory surround, the suppression of the distractor response is strongly modulated by the expected reward following the completed saccade. We used the color of the saccade target to indicate the amount of reward to expect on that trial, and ascertained that the monkey learned the reward contingencies since he made shorter latency saccades to earn high rewards than he did to earn low rewards. In accordance with previous studies (Platt and Glimcher, 1999, Sugrue et al. 2004), we also find that signaling a higher reward evokes increased activity in neurons representing the saccade goal. Thus, the salience map in LIP, which determines the locus of attention at a given moment, is sharpened by cognitive factors that increase the activity of behaviorally relevant (highly rewarded) stimuli, and simultaneously suppress the neural response to competing objects in the surround.

2:45 439 Dynamic modulation of direction selectivity by task demands in prefrontal cortex

Cory Hussar[1] (Cory_Hussar@urmc.rochester.edu), Tatiana Pasternak[1]; [1]Dept. of Neurobiology & Anatomy and Center for Visual Science

Responses of neurons in the prefrontal cortex (PFC) have been shown to represent behaviorally relevant sensory information. Recent work revealed that PFC neurons exhibit direction selective (DS) responses to visual motion used in a delayed match-to-sample (DMTS) task in which the monkeys compared two directions of motion separated by a brief delay (Zaksas & Pasternak, J. Neurosci, 2006). We asked whether this directionality is preserved when the monkeys were asked to ignore stimulus direction. We compared responses of PFC neurons to identical visual motion stimuli presented during three different tasks. In separate blocks of trials the animals discriminated the direction or the speed of motion, or were rewarded for passively maintaining fixation. We found that DS responses were drastically attenuated under both conditions in which stimulus direc-

Sunday Talks

tion was irrelevant and that the nature of this attenuation was task dependent. When the monkey discriminated stimulus speed and ignored its direction, DS activity was strongly attenuated early in the response and emerged about 100ms later than during the direction discrimination task. This early reduction of DS activity resulted not from a decrease in the response to the preferred direction, but from an increase in the response to the anti-preferred direction, suggesting an active release from inhibition characteristic of direction selectivity in visual cortical neurons. In contrast, during the passive fixation task, reduction in DS activity resulted largely from the decrease in the response to the preferred direction, which unlike the more transient loss in DS during the speed task, persisted throughout the response. Our results demonstrate the existence of a dynamic gating mechanism by which PFC neurons can modulate direction selectivity characteristic of visual cortical neurons.

Acknowledgement: Supported by EY11749, T32 EY07125, P30 EY01319

3:00 440 **Figure-Ground, Proto-Objects, and Selective Attention: Understanding the Neural Mechanisms**

Rudiger von der Heydt[1,2] (von.der.heydt@jhu.edu), Fangtu T. Qiu[2]; [1]Department of Neuroscience, Johns Hopkins School of Medicine, [2]Krieger Mind/Brain Institute, Johns Hopkins University

As the Gestalt psychologists noticed, attention interacts with figure-ground organization: figures draw attention, while shapes of the ground seem to be ignored. Mechanisms of figure-ground organization have recently been demonstrated in areas V1 and V2 of the visual cortex. However, their role in selective attention remains unclear. In area V2 of the monkey visual cortex many cells are selective for border ownership, responding to the same local edge more strongly when the edge is part of a figure on one side of the receptive field than the other. We found that a majority of these neurons were also influenced by attention. Tests in which the border between two figures was placed in the receptive field revealed asymmetrical attention effects, with enhancement of responses on one side or suppression on the other. The side of attention enhancement tended to coincide with the neuron's preferred side of border ownership. This indicates that the same neural circuits that create border ownership selectivity also provide the structure for selective attention. We propose a model in which 'grouping cells' integrate co-circular contours, and, via feedback, increase the gain of the corresponding contour neurons. This creates selectivity for side of figure, as observed in the border ownership tests. Supporting the feedback model, we found that border ownership signals show pronounced hysteresis (O'Herron and von der Heydt, this meeting). We explain the attention effects by assuming that top-down attention signals activate selected grouping cells, thus enhancing the responses of the corresponding contour neurons. Our results demonstrate an intermediate cortical stage in which features are grouped to larger entities (proto-objects), providing an interface between the initial local feature representation and later object-related stages of processing.

Acknowledgement: NIH grant R01 EY02966

3:15 441 **Inhibitory tagging in an interrupted visual search**

Laura Thomas[1] (lethomas@s.psych.uiuc.edu), Alejandro Lleras[1]; [1]University of Illinois at Urbana-Champaign

Inhibition of return facilitates visual search, biasing attention away from previously examined locations (e.g., Thomas et al., in press). Prior research has shown that, as a result of inhibitory tags associated with rejected distractor items, observers are slower to detect small probes presented at these tagged locations than probes presented at locations that were unoccupied during a serial visual search task. However, this result is only consistently found when the search stimuli remain visible during the probe detection task. When the probe is presented in the absence of the search stimuli, there is no evidence of inhibitory tagging (Müller & von Mühlenen, 2000; Takeda & Yagi, 2000). Presumably, when search items are removed from a display, people do not maintain the inhibitory tags associated with these items. Using a modified version of an interrupted visual search task (Lleras, Rensink, & Enns, 2005), we show that participants can maintain inhibitory tags in the absence of the search display (during the interruptions of the search task). By alternating search displays with blank displays, we were able to bias participants to keep inhibitory tags associated with rejected distractors, even when the search display was not visible; participants were slower to detect probes presented in a location previously occupied by a distractor item than probes presented in previously unoccupied locations. These results suggest that it is the context of the visual search task that determines the presence or absence of inhibitory tagging and that inhibition of return facilitates interrupted visual search.

Spatial Vision I

Sunday, May 13, 2:00 - 3:30 pm, Hyatt Ballroom North
Moderator: Steve Dakin

2:00 442 **Multiplication of 1st-stage inputs to curvature detectors**

Frederick Kingdom[1] (fred.kingdom@mcgill.ca), Elena Gheorghiu[1]; [1]McGill Vision Research, Department of Ophthalmology, McGill University

Aim. How are 1st-stage inputs to the mechanisms that encode contour curvature combined ? One possibility is that they are multiplied, which would increase the mechanism's selectivity to curvature (e.g. Poirier & Wilson, Vis. Res. 2006, 46, 2443-2455). Here we demonstrate a method for revealing multiplication in curvature coding. Suppose a curvature-tuned mechanism receives a small number (say anywhere between 2 and 6) of 1st-stage inputs whose receptive fields are positioned along a curve and whose responses are multiplied. Consider how such a mechanism would respond to a matched curved line, but one broken into segments of equal length, with gap length equal to segment length. Simulations reveal a pronounced dip in the response of the mechanism to intermediate segment lengths, a dip that appears to only happen when the 1st-stage inputs are multiplied (or combined by an operation equivalent to multiplication). Methods. We tested for such a dip in two shape after-effects, the shape-frequency and shape-amplitude after-effects; these are the shifts one obtains in respectively the apparent shape-frequency and apparent shape-amplitude of a sinusoidal-shaped test contour following adaptation to a contour of a slightly different shape-frequency/amplitude. We have recently shown that both after-effects are mediated by mechanisms that encode curvature (Gheorghiu & Kingdom, 2007, Vis. Res., in press). Results. Using segmented adaptors of various segment lengths we found that both after-effects show a pronounced dip at similar intermediate segment lengths. Conclusion. 1st-stage inputs to curvature-tuned mechanisms are multiplied.

Acknowledgement: This research was supported by a Natural Sciences and Engineering Research Council of Canada (NSERC) grant # OGP01217130 given to F.K.
URL: http://mvr.mcgill.ca/Fred/research.htm#contourShapePerception

2:15 443 **Lines and dipoles are efficiently detected**

Albert Ahumada[1] (al.ahumada@nasa.gov), Lauren Scharff[2]; [1]Human Systems Interface Division, NASA Ames Research Center, [2]Psychology Department, Stephen F. Austin State University

Watson, Barlow, & Robson (1983 Nature) rated patterns by contrast energy threshold and found a 7 cpd Gabor to be best. Watson (2000 Optics Express) plotted the contrast energy thresholds for the 43 Modelfest stimuli and found a Gaussian spot with a standard deviation (SD) of 2.1 arc min was best. When he compensated for contrast sensitivity, the best spot was the smallest one (SD = 1.05 min) and the overall best stimulus was the "one octave" (window SD = 2.1 min) 16 cpd Gabor. When he accounted for spatial summation in addition to contrast sensitivity, the spots and the Gabors were similar in performance and the best stimulus (but not significantly different) was the long (window SD = 30 min), narrow (1 pixel = 0.5 min) line. Using Modelfest-like methods, we have measured the detectability of lines as a function of length (2, 6, 18, 54 min) and width (0.5, 1, 2 min) and also have compared the detectability of lines (8 x 0.5 min) with

Sunday Talks

that of dipoles (2 adjacent 8 x 0.5 min lines of equal and opposite contrast). We found that short lines can have contrast energy thresholds as low as those of spots, and that when contrast sensitivity is taken into account, dipole thresholds can be as low as those of lines. We also found that the introduction of fixation marks close to the small patterns could lower the thresholds as much as 3 dB, suggesting that spatial uncertainty may have played an important role in the detection of small patterns in the Modelfest experiments.

Acknowledgement: Supported by FAA/NASA DTFA-2045, NASA Airspace Systems, and the San Jose State University Foundation.

URL: http://vision.arc.nasa.gov/personnel/al/talks/07vss/handout.htm

2:30 444 Non-retinotopic crowding

Patrick Cavanagh[1,2] (patrick@wjh.harvard.edu), Alex O. Holcombe[3]; [1]Harvard University, [2]Université de Paris 5, [3]University of Sydney

Sixteen radial arms are presented, each with a test letter at the third location from the center, flanked by 2 distractors on each side. The display counterphases targets and distractors in the following way: in one frame, every even arm (2nd, 4th, ..) shows only the target without distractors, while the odd arms (1st, 3rd, ..) show only the distractors without the targets; in the other frame, odd arms show distractors while even arms show the targets. When attending to any one location, a flickering test is seen, surrounded by flickering distractors. However, when a guide (a faint radial sector) moves from arm to arm in phase with the alternation, it contains only the test letter and no flankers. Targets are presented either in normal or mirror reversed orientation. Subjects fixate the center of the array and report the orientation of the test. When attention is directed to one fixed location, there is substantial interference from the flanking letters. However, when following the guide, crowding is much reduced, suggesting that crowding is specific to the flankers, if any, that move with the target and not to the letters that surround each target locally in retinotopic coordinates.

URL: http://visionlab.harvard.edu/Members/Patrick/CrowdingMovies/

2:45 445 Equivalent noise reveals that visual crowding is not an attentional effect

John Cass[1] (jcass@physiol.usyd.edu.au), Peter Bex[1], Roger Watt[2], Steven Dakin[1]; [1]UCL Institute of Ophthalmology, London, United Kingdom, [2]Department of Psychology, University of Stirling, United Kingdom

Several theories propose that the phenomenon of visual crowding - the propensity for neighbouring objects to interfere with target recognition - is caused by a reduction in the spatial resolution of visual attention. We tested this hypothesis by examining the relative effects of visual crowding and attentional load on orientation discrimination. The task involved identifying the mean orientation (clockwise vs. anti-clockwise relative to vertical) of six spatially distributed orientation-filtered noise targets. These were arranged iso-eccentrically, either in isolation or in the presence of distractor objects (randomly oriented filtered noise), located at a constant distance between fixation and the targets. By measuring orientation-discrimination performance at various levels of target-orientation variability, equivalent noise analysis yields (a) the precision with which subjects can estimate the orientation of any one patch (local noise) and (b) the number of samples over which they are averaging (global sampling). In some conditions subjects also performed an attentionally demanding foveal "dual-task". This was to report the orientation of a white 'T' amongst a dynamic stream of randomly oriented black 'T's embedded in noise, the proportion of which was varied to maintain 75% correct foveal performance. We report a dissociation between the effects of crowding and attention: whereas crowding induces increases in local noise, attention produces global undersampling. A dual-pass experiment (ie. Two runs using identical stimuli) reveals that crowding does not disrupt the relationship between stimulus-specific-agreement (across runs) and percent-correct performance, indicating that crowding is stimulus-driven rather than an effect of attentional localisation. This psychophysical dissociation between crowding and attention suggests that they are mediated by distinct neural mechanisms.

Acknowledgement: Funded by the Wellcome Trust

3:00 446 Optimal feature integration across spatial-frequencies in central and peripheral vision

Anirvan Nandy[1] (nandy@usc.edu), Bosco Tjan[1,2]; [1]Department of Psychology, University of Southern California, [2]Neuroscience Graduate Program, University of Southern California

Objects in natural scenes are spatially bounded by sharp edges and comprise of narrow-band spatial-frequency components precisely aligned in phase. Early studies of feature integration using gratings suggested that integration across spatial frequencies is suboptimal. Here we re-examine this conclusion using a letter-identification task performed at fovea and 10° in the periphery. 26 lowercase letters with size twice the acuity at 10° were used for both fovea and periphery conditions. For each eccentricity, we determined the peak-tuning frequency (F) for the letters. We then measured the nominal letter contrast (Chung, Legge & Tjan, 2002) required to achieve 50% correct identification using octave-wide bandpass-filtered letters with center frequencies at ¾F and 2F, as well as letters comprised of both the ¾F and 2F components. The ratio of squared contrast sensitivity of the composite $(1/C_{3/4F+2F})^2$ to the sum of squared contrast sensitivities of the components $(1/C_{3/4F})^2+(1/C_{2F})^2$ is 1.0 if the components are extracted independently but integrated optimally. A ratio lesser than 1.0 would indicate sub-optimal integration, while a ratio greater than 1.0 would indicate "super-optimal" integration, in that the visual system exploits correlations in noise and spatial uncertainty between spatial frequency components. We found that for both fovea and periphery conditions, contrast sensitivity for the composite letters were higher than that for the components. We also found that feature integration in the fovea is optimal, with an integration ratio of 1.05 ± 0.13. Surprisingly, this optimality is preserved in the periphery (integration ratio = 1.11 ± 0.19). This bears out the recent findings that for non-crowded letters, the first-order templates and second-order features recovered from the periphery are comparable to those recovered from the fovea (Nandy & Tjan, 2006), and that the spatial tuning for letter identification in the periphery is optimal (Chung, Legge & Tjan, 2002).

Acknowledgement: Supported by: NIH EY016391

3:15 447 Reading is crowded

Katharine Tillman[1] (kat@villanelle.org), Denis Pelli[1], Jeremy Freeman[2], Michael Su[3], Tracey Berger[4], Najib Majaj[1]; [1]Psychology and Neural Science, New York University, [2]Swarthmore College, [3]New York University School of Medicine, [4]Northwestern University School of Law

The old discovery that readers make several fixations per second, rather than a continuous sweep across the text, suggests that reading might be limited by the number of letters that can be acquired in one fixation. That span has been measured in various ways, but remains unexplained. Here we prove that the "visual span" is simply the number of characters that are not crowded. We measure RSVP reading rates for text, in both original and scrambled word order, as a function of size and spacing at central and peripheral locations. As text size increases, reading rate rises abruptly from zero to maximum rate. This classic reading-rate curve consists of a cliff and a plateau, characterized by two parameters, critical print size and maximum reading rate. Joining two ideas from the literature explains the whole curve. These ideas are Bouma's law of crowding and Legge's conjecture that reading rate is proportional to "visual span". We show that Legge's visual span is the uncrowded span predicted by Bouma's law. This result joins Bouma and Legge to explain reading rate's dependence on letter size and spacing. This explanation is the uncrowded-span model of reading rate. Having explained the shape of the curve, we then predict its parameters. We use a "silent substitution" technique to measure the uncrowded span during reading. These substitutions spoil letter identification yet are undetectable when crowded. We find that the critical spac-

Sunday Talks

ing for letter identification predicts both the critical spacing and the perceptual span for reading. Thus, crowding predicts the parameters that characterize both the cliff and the plateau of the reading rate curve. In all conditions tested — all sizes and spacings, central and peripheral, ordered and scrambled — reading is limited by crowding.

Acknowledgement: EY04432

Memory

Sunday, May 13, 4:00 - 5:45 pm, Hyatt Ballroom South
Moderator: Barbara Dosher

4:00 448 Dual effects of emotion on perception: Emotional distractors impair selection but enhance consolidation

Steven B. Most[1] (most@psych.udel.edu), Nicholas B. Turk-Browne[2], Justin A. Jungé[2]; [1]Department of Psychology, University of Delaware, [2]Department of Psychology, Yale University

The impact of emotion on perception has received increased attention in recent years, with experiments yielding some discrepant findings. For example, whereas some studies have found that emotional distractors impair target detection (Most et al., 2005), others have found that they enhance sensitivity to targets (Phelps, Ling, & Carrasco, 2006). Reconciling instances where emotional distractors impair or facilitate target detection might best be accomplished by considering the impact of emotional stimuli on different stages of visual processing. For example, according to two-stage models of target detection, when people search through a rapid sequence of stimuli, target detection requires both (1) selection of a target from among distractors and (2) consolidation of the target representation for conscious report (e.g., Chun & Potter, 1995). In our experiments, emotional distractors appeared to have opposite effects on these different stages: selection of targets was impaired, whereas their consolidation was enhanced. In Experiments 1 and 2, emotional distractors retroactively impaired detection of targets appearing 100-ms beforehand but boosted detection of targets appearing 200-ms beforehand. This lag-dependent reversal suggests that if emotional distractors appear while target representations reside within an early visual buffer, having yet to be selected for consolidation, they impair target detection; however, once the window critical for attentional selection has passed, the impact of emotional distractors is observed through enhanced consolidation – and hence improved performance. Consistent with this interpretation, follow-up experiments revealed that emotional distractors impaired target processing when participants were required to maintain attentional selection criteria; in contrast, emotional distractors actually helped performance when the need for attentional selection was eliminated. Taken together, these results suggest that emotional distractors activate two processes, perhaps in parallel: one that disrupts attentional selection and another that enhances visual consolidation.

4:15 449 Saccadic planning controls the input to visual memory

Timothy Gersch[1] (tgersch@rci.rutgers.edu), Eileen Kowler[1], Brian Schnitzer[1], Barbara Dosher[2]; [1]Department of Psychology, Rutgers University, Piscataway, NJ, [2]Department of Cognitive Sciences, University of California at Irvine, Irvine, CA

Selective attention improves perception and memory, and designates the target of motor responses, including saccades. Dual-task studies have demonstrated superior perceptual performance at the saccadic goal, implying that a single attentional filter is used by saccades and perception (Gersch et al., 2004; VSS 2006). Does this same filter also determine the input to visual memory?

We examined visual memory during the performance of sequences of saccades. Observers made brisk sequences of oblique saccades across a 5x5 array of circles (diam 1°) following a path designated by a color cue. During a randomly-selected intersaccadic pause, an array of 25 letters (one in each circle) was presented. A post-cue in one of the central 9 circles designated the letter to be reported at the end of the trial.

Saccadic planning had dramatic effects. Performing the saccadic sequences impaired memory in that fewer letters were remembered during intersaccadic pauses (~2.1 letters) than during steady-fixation control trials (~3.4 letters). Memory for the target of the upcoming saccade was best (67% correct), exceeding even performance at fixation (43% correct). Performance at locations that were not saccadic targets was near chance levels. A pre-trial cue, disclosing the location of the letter to be reported, succeeded in broadening the attentional window, but did not abolish the effects of saccades. The pre-cue also led to more saccadic errors.

These results support a single attentional filter for both perceptual and motor tasks, and extend the domain of this filter to visual memory. The effects of this filter on memory were, if anything, more pronounced than the effects observed in perceptual tasks. To avoid an overly-narrow attentional field in natural tasks, and remember information off the path of saccades, it may be necessary to adopt a flexible saccadic strategy that sacrifices saccade frequency or accuracy, as needed.

Acknowledgement: Supported by NIH (EY15522)

4:30 450 Determining parietal involvement in visual working memory: Causal or Incidental?

Marian Berryhill[1,2] (berryhil@psych.upenn.edu), Ingrid Olson[1,2]; [1]Center for Cognitive Neuroscience, [2]University of Pennsylvania

Recent neuroimaging studies (Todd & Marois, 2004; Xu & Chun, 2006) report bilateral posterior parietal activity during visual working memory (VWM) tasks that is associated with capacity limitations. These findings are surprising when viewed through the lens of neuropsychology: damage to the parietal lobe is not usually associated with VWM deficits. The goal of the present study was to determine whether parietal activations reflect a functional role in VWM or whether observed fMRI activity reflects non-mnemonic aspects of the task. We tested patients with right parietal damage (as assessed through neuroimaging) and matched controls in several VWM tasks. Patients were tested at least 1-year post-insult and did not have neglect. Subjects were required to remember either four novel shapes, colors, tools, or locations over a 1 s delay. Two tasks were used: a sequential VWM task in which each item was presented centrally, and a simultaneous VWM task in which all items were presented at the same time and both item and spatial processing were critical. The patients demonstrate preserved VWM for the sequential task, and modest deficits in the simultaneous task that required some spatial memory. However, when asked to remember locations alone, the patients showed considerable impairment. The present data do not find strong support for the hypothesis that the parietal lobe is critical for VWM in general. We speculate that the association between the BOLD response and VWM capacity limitations in the parietal lobe reflects limitations in spatial attention and enumeration.

4:45 451 Are Visual Working Memory and Multiple Object Tracking Limited by A Common Attention Capacity?

Hang Zhang[1,2] (zhangh@psych.ac.cn), Yuming Xuan[1], Xiaolan Fu[1]; [1]State Key Laboratory of Brain and Cognitive Science, Institute of Psychology, Chinese Academy of Sciences, [2]Graduate School of the Chinese Academy of Sciences

About 4 objects can be kept in visual working memory (VWM) and about 4 objects can be visually tracked simultaneously in the Multiple Object Tracking (MOT) task. This resemblance was caught by Cowan (2001) as evidence for a common attention limit underlying both VWM and MOT. Consistent with Cowan's argument, fMRI studies showed that the activation of the posterior parietal cortex increases with the number of items in VWM or MOT. However, it should be noted that MOT is closely associated with location information whereas many VWM tasks demand a comparison of visual properties at the same location in sample and probe displays. So it might be the processing of spatial information that leads to the similarity between VWM and MOT. We tested this possibility in two experiments by examining the dual-task interference of MOT and VWM. In Experiment 1, we found that there was interference between VWM for color-location combination and MOT but no interference between VWM for color-shape combination and MOT. In Experiment 2, we further tested whether tracking more targets would lead to more impairment on location-relevant VWM and found that it depended on speed of objects in MOT. Only under low speed did more targets lead to more impairment. In summary, our results suggest that VWM and MOT might share some capacity-limited resource related to spatial processing, but not a common attention resource.

Acknowledgement: This research was supported in part by grants from 973 Program of Chinese Ministry of Science and Technology (2006CB303101) and the National Natural Science Foundation of China (60433030 & 30500157).

5:00 452 Visual Working Memory Represents a Fixed Number of Items Regardless of Complexity

Edward Awh[1] (awh@uoregon.edu), Brian Barton[1], Edward Vogel[1]; [1]University of Oregon

Luck and Vogel (1997) found that working memory capacity for objects defined by a single feature (e.g., color or orientation) was equivalent to capacity for multi-featured objects (e.g., colored lines of varying orientations). They concluded that capacity is determined by the number of objects, and not the number of features that are stored. By contrast, Alvarez and Cavanagh (2004) demonstrated that change detection performance declined monotonically as object complexity increased, suggesting that "informational load" also constrains the number of items that can be represented. We also found that capacity estimates dropped as complexity increased. However, these apparent capacity reductions were strongly correlated with increases in sample-test similarity (operationalized by RT in a one-item change detection task). This raised the possibility that change detection was limited by errors in comparing the sample and test rather than by a drop in the number of items that were maintained. In line with this, when comparison errors were minimized by reducing sample/test similarity, capacity estimates for even the most complex objects were equivalent to that of the simplest objects (r = .84). We conclude that visual working memory holds a fixed number of items, regardless of complexity. These slots have limited resolving power, however, such that high similarity between sample and test items will elicit errors during the comparison stage of the task. Thus, although complexity strongly determines change detection performance, it does so by influencing the probability of comparison errors rather than the number of items that are represented. When low similarity prevents comparison errors, capacity estimates for complex and simple objects are equivalent. Finally, a correlational analysis suggested a two-factor model of working memory ability, in which the number and resolution of representations in working memory correspond to distinct dimensions of memory ability.

5:15 453 The Binding of Objects to Locations in Visual Short-Term Memory

Andrew Hollingworth[1] (andrew-hollingworth@uiowa.edu), Ian P. Rasmussen[1]; [1]Department of Psychology, University of Iowa

According to the framework of Kahneman et al. (1992), the representation of an object's perceptual features (e.g., color, shape) is indexed to a spatial location, forming an object file. When the object moves, the spatial index is updated to the new location, and the object property information comes to be associated with the new location. In previous work, we demonstrated that object file updating depends on the visual short-term memory (VSTM) system studied extensively over the last decade. However, we found that object feature information in VSTM was bound not only to the updated location but also to the original location, and the latter binding was more robust than the former. In the present study, we hypothesized that binding to the original location depends on configural coding in VSTM. Participants saw an array of boxes that were filled briefly with a set of colors. The empty boxes moved to new locations and were simultaneously translated so that the boxes formed the same spatial configuration but in new absolute locations. The boxes were again filled with colors. All were the same, or one was changed; the task was change detection. The test colors appeared either in the appropriate updated positions, in the original positions within the configuration, or in positions corresponding to neither of these (no correspondence). The advantage for the original position condition over the updated condition was maintained, as was the advantage for the updated condition over the no correspondence condition. The configuration benefit remained even in the presence of large-scale, static scene structure. Thus, there appear to be two forms of object-position binding in VSTM, a mechanism that updates object property information with motion (the object file system) and a more robust binding mechanism that is not sensitive to motion and codes object position relative to array configuration.

Acknowledgement: This research was supported by NIH grants R01 EY017356 and R03 MH65456.

5:30 454 Priming of Pop-out: An automatic process that is governed by volition.

Jillian Fecteau[1,2] (j.fecteau@nin.knaw.nl); [1]The Netherlands Institute for Neuroscience, [2]University of Amsterdam

What you've seen before helps you see it again. This effect has been shown in visual search studies looking at the consequence of the previous trial: reaction times are shorter when the features defining a target and distractors are repeated. In this study, I explored whether this bias in attentional selection occurs automatically or whether it depends upon the current goals of observers. Participants performed a visual search task, in which a color and a shape singleton appeared in the search array. The observers were instructed which singleton was relevant at the beginning of every trial.

A previous trial analysis revealed that observers responded sooner when the task, the color of the target, or the shape of the target remained the same across trials. This pattern replicates the outcomes of previous investigations. Importantly, though, these benefits were contingent upon the current task the observers performed: Repeating the color of the previous target facilitated performance only when observers performed the color task and repeating the shape of the previous target facilitated performance only when observers performed the shape task. This pattern did not depend upon the task the observers performed on the previous trial: Everything was 'remembered', even though only task relevant repetitions benefited performance. This basic effect became exaggerated when re-analyzing the data on the basis of the previous singletons. Neither color nor shape singletons affected performance when they were irrelevant to the current task. However, when the singleton was relevant to the current task, it facilitated performance when it was the previous target and inhibited performance when it was the previous salient distractor. A two-tired system is required to explain these results: the salient features from the previous trial are remembered, but affect performance only when they are consistent with the observers current goals.

Acknowledgement: I thank Jolanda Roelofsen for her help with data collection. Funding for this study was provided by the Canadian Institutes of Heath Research and the Nederlandse Organisatie voor Wetenschappelijk Onderzoek.

Spatial Vision II

Sunday, May 13, 4:00 - 5:45 pm, Hyatt Ballroom North
Moderator: James Elder

4:00 455 Entasis: architectural illusion compensation, aesthetic preference or engineering necessity?

Peter Thompson[1] (p.thompson@psych.york.ac.uk), Georgia Papadopoulou[1], Eleni Vassilou[1]; [1]Department of Psychology, University of York, York, UK.

A typical characteristic of columns in Doric temples is entasis; a slight convexity in the body of the column. Often, particularly in guide-books, it is suggested that entasis compensates for an illusion of concavity in columns with parallel sides. Architectural experts generally agree: Entasis is the "swelling given to a column in the middle parts of the shaft for the purpose of correcting a disagreeable optical illusion, which is found to cause their outlines to seem concave instead of straight" - Penrose (1888). Nuttgens (1999) writes 'Most Greek buildings of this golden period use entasis, the device whereby columns are given a slight swelling ....to counteract a tendency of the eye to see them as curving inwards from either side...'

We investigated whether any such illusion exists in a series of experiments in which we vary the degree of entasis from a negative value (columns waisted in the middle) through parallel sides to positive values (columns bulging in the middle). Our experiments presented 7 stimuli; 3 convex, 3 concave and 1 with truly parallel columns in a constant stimuli paradigm. Each stimulus was presented 30 times (to 12+ subjects) in pseudo-random order and results plotted as a psychometric function from which the PSE where columns appear neither convex nor concave determined. Several experiments, with more or less realistic column stimuli, failed to find any evidence to support any illusion-compensation theory.

Secondly, we have explored the possibility that entasis was employed for purely aesthetic reasons. 5 computer-generated temples were judged for their aesthetic preference by 30 subjects. The temples differed in the application of entasis on the columns: 2 had negative entasis, 2 positive and one had parallel-sided columns. The results showed positive entasis as the least preferred aesthetically.

Finally, we shall present some evidence supporting an engineering role for entasis.

4:15 456 Adaptation can increase sensitivity to visual features

Mick Falconbridge[1] (michaelf@psych.ucla.edu), Ladan Shams[1], Stephen Engel[1]; [1]Department of Psychology, UCLA

In adults, prolonged exposure to simple visual features usually reduces sensitivity to the exposed feature. During development, however, long-term exposure to visual features increases or maintains sensitivity to the exposed features. Here, we show that prolonged exposure to a relatively simple novel feature can increase sensitivity in adult humans. Subjects viewed images that had been manipulated to introduce a second-order visual feature, a consistent correlation between particular local image elements. Wherever an image contained local energy at a specified orientation (135 degrees), phase (0), and spatial frequency (4 cycles/deg.), we added an equal amount of local energy with the same characteristics at a constant spatial offset (0.5 deg. down and to the left). These manipulations were performed on frames taken from a popular television show. Subjects passively viewed 42 minutes of the altered video (accompanied with original soundtrack). Prior to and following viewing, subjects performed a contrast matching task. This allowed us to measure the apparent contrast of a target grating patch with the same orientation and spatial frequency as in the second order feature. Subjects matched the patch presented alone, or in the presence of a flanking patch. The flanker had the same spatial offset as that used to create the second order feature, and its orientation either matched that of the target, thus precisely reproducing the configuration of the second order feature, or was orthogonal to it. Exposure to the altered videos reliably increased the apparent contrast of the target grating. The increase occurred only when the target/flanker configuration matched the second-order feature added to the video. Subjects that viewed an unaltered video showed no effects of exposure. Our results suggest that adaptation can increase sensitivity to novel low level visual features. The visual system may modify its encoding of features to reflect the statistics of the environment.

Acknowledgement: Supported by NIH EY11862

4:30 457 Learning of unconscious scene-target spatial associations involves the sharpening of a distributed network of visual areas

Maximilien Chaumon[1] (Maximilien.Chaumon@chups.jussieu.fr), Valérie Drouet[1], Denis Schwartz[2], Catherine Tallon-Baudry[1,2]; [1]Cognitive Neuroscience and Brain Imaging Laboratory, LENA, Université Pierre et Marie Curie-Paris6, CNRS UPR640, France, [2]MEG-EEG Center, Hôpital Pitié-Salpêtrière, Paris, France

Scene context is known to facilitate attentional deployment in visual search. How are scene-target associations learned in this task? We developped a modified version of the contextual cueing paradigm. In the predictive condition, each layout of distractors (scene) was always associated with the same target position. In the non predictive condition, each scene was associated with each possible target position on successive presentations. A regular scene-target association was present only in the predictive condition. The learning of this association is expressed behaviorally after just 5 presentations of each scene: reaction times become shorter in the predictive than in the non predictive condition. At the beginning of the experiment, when behavior is not yet influenced, the brain is forming a new representation of the scene-target association. Predictive – non predictive differences in the magnetoencephalographic (MEG) signal are seen in the occipito-parietal cortex at 115-175 ms, followed by a difference in the left ventral occipital cortex at 175-225 ms. Spanning these two time windows (100-400 ms), we found an increase of induced oscillatory gamma activity (30-48Hz) over parietal sites in the predictive condition. Scene-target associations are thus first detected in a distributed network of visual areas. Gamma oscillations could coordinate this network in a synchronous neural assembly. In contrast, at the end of the experiment, when scene-target associations influence behavior, the earliest difference in the MEG signal appears as soon as 100 ms in the calcarine region. A rapid extraction of the learned scene-target associations thus occurs locally, possibly in a feedforward manner. How the associations first detected in a distributed network are finally transferred to early visual cortex remains an open question. We suggest that gamma oscillations trigger the neural plasticity that sharpens the distributed representation in a more efficient network representing scene-target associations in early visual cortices.

4:45 458 The Impact of Prolonged Contrast Reduction on Visual Contrast Coding

MiYoung Kwon[1] (kwon0064@umn.edu), Fang Fang[1], Allen M.Y. Cheong[1], Gordon Legge[1], Sheng He[1]; [1]Psychology, University of Minnesota

How does prolonged reduction in retinal-image contrast affect visual-contrast coding? Rubin and Legge (Vision Research, 29, 79-91, 1989) proposed that vision through cataracts and some other ocular-media opacities can be modeled by a contrast-reducing "filter" in front of an otherwise normal visual system (contrast attenuation model). Recent evidence, however, indicates that some forms of long-term visual deprivation result in compensatory perceptual and neural changes in the adult visual pathway. The goal of our study is to investigate the impact of prolonged contrast reduction on contrast coding with both behavioral and neuronal measures. If long-term contrast reduction results in a form of neural compensation, we might expect to see improvement in behavioral contrast discrimination and an increase in the gain of neuronal contrast responses compared with the unadapted condition. In order to test this hypothesis, normally sighted participants adapted by viewing the world through contrast reducing goggles (approximately three fold reduction of image contrast) for four hours. During the adaptation period, participants went about their usual daily activities. Participants' contrast-discrimination functions (psychophysics) and neuronal contrast response functions (fMRI BOLD) were measured before and after adaptation. Data from two participants showed that after adaptation, there were significant decreases in contrast discrimination thresholds (improved contrast discrimination) and increased BOLD responses in the early visual cortical areas of the brain (V1 and V2) compared to unadapted values. There was also evidence that these changes in contrast coding were more pronounced for contrasts below about 30%, i.e., within the range of contrasts available during adaptation. These findings indicate that the early visual pathway adapts to prolonged exposure to a reduced-contrast world. The adaptation appears to be compensatory, such that the precision of contrast coding is improved for low retinal-image contrasts.

Acknowledgement: This research was supported by NIH grant R01 EY02934.

5:00 459 **Classification image analysis of oriented texture detection**

Charles C.-F. Or[1] (cfor@yorku.ca), James H. Elder[1]; [1]Centre for Vision Research, York University, Toronto, Ontario, Canada

Humans readily perceive the structure in oriented textures, e.g., Glass patterns. Here we seek to understand the computational factors that underlie their detection. In a series of experiments, random-dot patterns were displayed briefly (165 ms) within the central 14 deg of the visual field. Each stimulus consisted of 200 dipoles distributed over a discrete number of orientations. On noise-only trials, dipoles were uniformly distributed over all orientations. On signal-plus-noise trials, a portion of the 200 dipoles were oriented in a common direction, and the remaining were oriented randomly. Detection thresholds were estimated by varying the proportion of signal dipoles using the QUEST procedure in a Yes/No task with feedback. We derived an ideal observer for this task, and found that human efficiency for dipole texture detection is roughly 1%. We then considered a model observer that is ideal except for three types of inefficiency: 1) false matches between dipole dots (correspondence errors), 2) orientation uncertainty and bias, and 3) decline in sensitivity with eccentricity. By comparing detection performance for oriented textures based on dipole dots with performance for oriented line segments, we estimated that false matches reduce efficiency by a factor of approximately 3. Using a classification image technique in the orientation domain, we estimated observer bias and uncertainty in detecting elements at the signal orientation. Incorporating the estimated orientation uncertainty and bias into our model accounts for an additional factor of 5 reduction in efficiency. We used the same classification image technique to model the decrease in sensitivity with eccentricity, finding that this factor accounts for an additional factor of 6 reduction in efficiency. Our results suggested that the three factors: correspondence errors, orientation uncertainty, and decline in sensitivity with eccentricity, account for roughly 90% of the perceptual losses in the detection of oriented textures such as Glass patterns.

Acknowledgement: This work is supported by NSERC, CIHR and PREA.

5:15 460 **Measuring Visual Mechanism Sensitivity**

Charles Chubb[1] (cfchubb@uci.edu), Michael S. Landy[2]; [1]Cognitive Sciences Department & Institute for Mathematical Behavioral Sciences, UC Irvine, [2]Psychology Department & Center for Neural Science, New York University

Poirson and colleagues (JOSA A, 7, 783-789, 1990) presented a simple and compelling argument to show that one cannot determine the sensitivity of mechanisms that underlie discrimination performance if thresholds lie on an ellipsoid (and they almost always do, at least within measurement error). In brief, the ellipsoidal model assumes that stimuli p and q are n-dimensional (n=3 for color vision, but is typically far larger for spatial visual stimuli), and that discrimination performance is based on their difference d=p-q as processed by m mechanisms. If the mechanism sensitivities to each dimension are summarized in an mÞn matrix M, the ellipsoidal model predicts that performance is a function of |Md|=|RMd| for any orthonormal (e.g., rotation) matrix R. That is, any such rotation applied to the mechanisms results in an alternative model that makes the same predictions. On the other hand, Chubb, Landy & Econopouly (Vis Res, 44, 3223-3232, 2004) claimed to have isolated and measured the sensitivity of an individual texture-sensitive mechanism: the blackshot mechanism. How can this be? The method used by Chubb and colleagues requires one to use a high-dimensional space of stimuli and to find a relatively high-dimensional subspace of stimuli in which almost all dimensions of that subspace trade off linearly in controlling discrimination performance. If these conditions hold, one can be practically certain that a single mechanism determines discrimination performance within that subspace. And, by trading off stimulus power in that subspace with power in other directions, one can measure the complete sensitivity function of the isolated mechanism. Robustness of the method to small violations of its assumptions will be discussed.

5:30 461 **Feature Integration for Letter Identification is Just as Good in Peripheral as in Foveal Vision**

Susana Chung[1] (schung@optometry.uh.edu); [1]University of Houston College of Optometry

Evidence exists suggesting that our ability to integrate local features to form a coherent percept of a global pattern is degraded in peripheral vision. If this deficiency in feature integration generalizes to letter identification, then we would expect that more features are required for identifying letters in peripheral than in foveal vision. Because crowding has been attributed to an erroneous feature integration process, we would also expect that more features are required for identifying crowded letters than for single letters. To test our predictions, we used a set of 26 lowercase letters that were constructed of Gaussian patches, with each patch representing a "letter feature" and could be individually turned on or off. We measured the accuracy of identifying such letters when they were presented singly, or when flanked by two nearby letters, at the fovea and 10° lower field for three observers. The percentage of patches within the target and its flanking letters was varied from trial to trial, and ranged between 20 and 100%. Letter sizes were 1, 2 and 4x the acuity-threshold for a given condition. As expected, accuracy of letter identification increased with the percentage of patches present in the letters. The threshold number of patches that yielded 50% correct of letter identification decreased for larger letters. The drop was larger for identifying single than for crowded letters; consistent with the explanation that crowding is due to erroneous feature integration. However, contrary to our prediction, for any given nominal letter size, the threshold numbers of patches required to identify letters (single or crowded) were virtually identical at the fovea and 10° eccentricity. This finding suggests that as long as the difference in visual resolution is taken into account, feature integration for letter identification can be as good in the periphery as in the fovea.

Acknowledgement: Supported by NIH grant R01-EY12810.

Poster Session D

Sunday, May 13, 8:30 am - 1:00 pm, Municipal Auditorium

Rivalry and Bi-Stability II

Author Presents: 8:30 - 10:15 am

D1 462 **Stabilizing bistable visual patterns through interocular suppression, crowding, and inattention**

Sheng He[1] (sheng@umn.edu), Yi Jiang[1], Xiangchuan Chen[1]; [1]University of Minnesota

Alternating perception of bistable visual patterns can be slowed, and even halted, if the visual stimuli are presented intermittently and periodically removed from view. Here we demonstrate the similar stabilization effect of a number of different bistable visual patterns by interrupting the conscious experience of the bistable stimuli through interocular suppression, crowding, or removal of attention. Specifically, we found that: (1) Binocular rivalry: the perceptual switch of binocular rivalry could be dramatically slowed down by intermittently adding distractors around the rivalry stimulus and by intermittently engaging observers attention on a demanding task away from the rivalry stimulus. This observation is consistent with recent discoveries of attentional modulation of rivalry speeds. (2) Bistable rotating sphere: the perceived directional switch of a bistable rotating sphere defined by structure from motion patterns could be stabilized by intermittently rendering the bistable stimulus invisible through interocular suppression as well as through crowding. Inattention was also effective in stabilizing rotation. These observations imply that the neural stages of interocular suppression and crowding precede that of the structure from motion. (3) Bistable plaid: The perceptual alternation between two component gratings sliding across each other and a single coherently moving plaid could be stabilized with intermittent interocular suppression. Such an observation also suggests that interocular suppression disrupts information processing before the engagement of the neural mechanism responsible for component vs. pattern motion. Taken together, these observations indicate that interocular suppression, crowding, and the removal of attention are all nearly as effective as physical removal of bistable stimuli in perceptual stabilization. These observations also support the critical role of attention in facilitating perceptual alternations of bistable stimuli.

Acknowledgement: This research was supported by the James S. McDonnell foundation, the US National Institutes of Health Grant R01 EY015261-01, and the Eva O. Miller Fellowship from University of Minnesota.

D2 463 **Establishing stable interocular suppression through repeated presentation of very brief stimuli**

Xiangchuan Chen[1] (chenx248@umn.edu), Sheng He[1]; [1]Department of Psychology, University of Minnesota

When two different stimuli are dichoptically presented to the two eyes, observers experience alternating views of these two stimuli, so called binocular rivalry. It is well accepted that the competing stimuli need to be presented for longer than 100 ms to establish rivalry dominance. It is also shown that the rivalry switch can be stabilized if the two stimuli are presented intermittently. In this study, we investigated whether interocular inhibition could occur within the first 100 ms of stimulus presentation following repeated intermittent but very brief presentations of competing stimuli. Furthermore, we tested whether a stabilization effect could be established for very briefly presented stimuli. A vertical and a horizontal grating were dichoptically presented to the subjects' two eyes for 70 ms, every two seconds. Subjects perceived the mixture of the gratings during the initial variable number of trials. Gradually their percept was stabilized to one of the two gratings. The perceptual dominance of one stimulus was measured with a monocularly presented 20-ms flash probe. The two eyes showed dramatically different sensitivities to the probe after perceptual dominance was established. The inter-eye sensitivity difference was the highest when the probe was presented simultaneously with the gratings. Interestingly, such a sensitivity difference was still observed 50 ms after the removal of the stimuli, but dropped significantly after 150 ms. These results suggest that when presented with two competing stimuli, the suppressive interaction between the two eyes can accumulate across temporal gaps of stimulus presentation. Following many trials of very briefly presented competing stimuli, the interocular suppression is engaged immediately at the beginning of stimulus presentation. Our data also suggest that during these temporal gaps, the sensitivity difference between the two eyes decays relatively rapidly, yet the polarity, and possibly the strength, of interocular suppression is maintained across trials.

Acknowledgement: This research was supported by the James S. McDonnell foundation, the US National Institutes of Health Grant R01 EY015261-01.

D3 464 **Monocular Depth Ordering Affect Perceptual Filling-In and Motion Induced Blindness**

Li-Chuan Hsu[1] (lchsu@mail.cmu.edu.tw), Peter Kramer[2], Su-Ling Yeh[3]; [1]Medical College of the China Medical University, Taichung, Taiwan, [2]Department of General Psychology, University of Padova, Italy, [3]Department of Psychology, National Taiwan University, Taipei, Taiwan

Perceptual-Filling-In (PFI) and Motion-Induced-Blindness (MIB) are two phenomena of temporary blindness in which, after prolonged viewing, perceptually salient targets repeatedly disappear and reappear, amidst a field of distracters. We used monocular depth cues such as occlusion and those provided by the Water-Color Illusion and manipulated the eccentricity. Results show that the target disappears sooner and longer when it appears in back than when it appears in front. We argue that our earlier findings (Hsu, Yeh, & Kramer, 2004) that stereoscopically presented targets disappear longer when they have a negative rather than a positive or zero disparity reflect a more general effect of depth on PFI and MIB that is independent of how this depth is induced.

Acknowledgement: [Supported by the National Science Council of Taiwan, NSC 95-2413-H-039-002, 95-2752-H-002-007-PAE, and 95-2413-H-002-020]

D4 465 Representation of location during misbinding of color

Para Kang[1] (para@uchicago.edu), Steven Shevell[1]; [1]Visual Science Laboratories, University of Chicago

PURPOSE Perceptual misbinding of color during binocular rivalry reveals separate neural representations of color and form followed by a neural binding process (Hong & Shevell, Visual Neuroscience, 2006). During misbinding of color, the neural representation of color from a suppressed form is expressed within a region of the dominant form. The study here examined how color is misbound to a non-retinotopic location and considered how the neural representation of location relates to perceptual binding of color to form.

METHOD A 2 cpd square-wave vertical grating was presented to one eye and a tooth-shaped vertically oriented grating (top half of grating phase-shifted right by one-half cycle relative to bottom half) to the other eye for 90 seconds. A grating with luminance-contrast (e.g. a red/black grating) was presented to one eye, and an isoluminant grating (e.g. a green/white grating) to the other eye. The exclusive visibility time was measured for the percept of each eye's stimulus alone (dominance) and for a two-color vertical or tooth-shaped grating (e.g. a perceived red/green grating). The two different forms (vertical vs tooth-shaped) distinguished whether misbinding was perceived in the form with luminance contrast or the form at isoluminance.

RESULTS With luminance contrast of 75% or more, misbinding of color was perceived frequently within the isoluminant form but very rarely within the luminance-contrast form.

CONCLUSION The results indicate misbinding occurs within the form with a weak neural representation of location. Misbinding of a chromatic signal from the suppressed luminance-contrast form shows that location information provided by luminance-contrast edges does not inhibit binding the color to a non-retinotopic region within the dominant isoluminant form. Suppression of form may also suppress the neural representation of location but an open question is whether form and location are represented separately.

Acknowledgement: Supported by PHS grant EY-04802

D5 466 Misbinding of Color to Form in Afterimages

Rebecca St.Clair[1] (rstclair@uchicago.edu), Sang Wook Hong[2], Steven Shevell[1]; [1]Visual Science Laboratories, University of Chicago, [2]Department of Psychology, Vanderbilt University

PURPOSE: Retinal stimulation is required for afterimages but mechanisms beyond the retina are involved in afterimage formation. Recent evidence suggests that percepts (not merely visual stimuli) during adaptation can influence the afterimage (Gilroy & Blake, Current Biology, 2005). Binocular color rivalry was used here to investigate the relation between percepts during adaptation and the percepts of afterimages. This method provides constant retinal stimulation while the percept of the stimuli changes over time.

METHOD: Perceptual alternation was measured for two dichoptically presented, chromatically rivalrous gratings. The gratings were equiluminant so observers would experience perceptual misbinding of color to form during adaptation (Hong & Shevell, VSS 2005). In a control condition the gratings had luminance contrast, which eliminated perceptual color misbinding. Following the rivalrous adaptation, a uniform achromatic field was presented and the observer's percepts of the afterimage were reported using a computer's button pad.

RESULTS: Color misbinding in the afterimage was experienced following adaptation to the equiluminant gratings. The percept with misbound color was dominant during adaptation but was not the dominant afterimage. In the control condition, no misbinding was experienced during adaptation or in the afterimage.

DISCUSSION: The measurements showed that color misbinding was experienced in the afterimage only when rivalrous chromatic gratings during adaptation resulted in misbinding. Two possible explanations are that the afterimage with color misbinding results (1) directly from the misbound percept during adaptation or (2) from a neural process of color-form (mis)binding that follows monocular neural representations of an afterimage.

Acknowledgement: Supported by PHS grant EY-04802

D6 467 Temporal characteristics of priming effects on the perception of ambiguous patterns

Alexander Pastukhov[1] (alexander.pastukhov@nat.uni-magdeburg.de), Jochen Braun[1]; [1]Cognitive Biology, Otto-von-Guericke Universitaet, Magdeburg, Germany

When an ambiguous pattern is viewed once, it may be perceived in two equally compelling ways. When viewed repeatedly, its perception is biased by priming effects: (i) An unambiguous pattern negatively primes a subsequent ambiguous pattern, which is less often perceived in the same way. This "flash suppression" [1] may reflect habituation of the primed percept. (ii) An ambiguous pattern positively primes a subsequent ambiguous pattern, which is more often perceived in the same way [2]. The effect persists across blank periods and reveals a "perceptual memory".

We presented prime and probe patterns in succession, sometimes with an intervening blank period, to establish time constants for the rise (increase with prime duration) and fall (decrease with pause duration) of positive and negative priming effects in the perception of ambiguous patterns. Kinetic-depth-effect was used as stimulus. Nine observers participated, with mean dominance time <Tdom> ranging from 1.0 s to 15 s across observers. All time constants are given as multiples of the <Tdom> for each observer.

Negative priming rises and falls rapidly (observer average trise- = 0.3, tfall- = 0.52). Across observers, neither time-constant correlates significantly with <Tdom> (r=-0.3, p=0.42; r=0.04, p=0.92, respectively). Positive priming rises more slowly and decays extraordinarily slowly (observer average trise+ = 0.53, tfall+ = 25). Across observers, both time-constants correlate significantly with <Tdom> (r=0.42, p=0.02; r=0.84, p=0.02, respectively).

Of the two known priming effects in the perception of ambiguous patterns, only positive priming correlates with the time course of rivalry. We conclude that, contrary to current models, negative priming (habituation) may not provide the elusive cause of perceptual rivalry.

1. Wolfe, J. M. (1984). Reversing ocular dominance and suppression in a single flash. Vision Res 24(5), 471-8.

2. Leopold, D. A., M. Wilke, et al. (2002). Stable perception of visually ambiguous patterns. Nat Neurosci 5(6), 605-9.

D7 468 Further differences between positive and negative priming in the perception of ambiguous patterns

Jochen Braun[1] (Jochen.Braun@Nat.Uni-Magdeburg.DE), Alexander Pastukhov[1]; [1]Cognitive Biology, Otto-von-Guericke Universitaet, Magdeburg, Germany

In repeated viewing of ambiguous patterns, perception is biased by positive and negative priming effects. In a companion abstract, we report that positive priming lasts 20-30 times longer than negative priming. Here, we exploit this difference to disentangle positive and negative priming by a given pattern. To establish generality, we compare five kinds of patterns (kinetic-depth-effect or KDE, two instances of binocular rivalry, Necker cube, Anstis dots). Nine observers participated.

For all kinds of ambiguous patterns, an unambiguous version negatively primes the ambiguous pattern: the two are rarely perceived in the same way (Psurvival ò 0), if no pause intervenes. When a pause is introduced, negative priming is no longer evident (Psurvival ò 0.5). When a pause separates two ambiguous patterns, positive priming is found in all cases (Psurvival ò 1.0). Thus, only ambiguous patterns appear to leave a "perceptual memory" which may bias subsequent perceptions.

To further study this particularity of ambiguous patterns, we generated KDE patterns with varying degrees of 'bias' for one percept or another (quantified separately for each observer). The dominance fraction under continuous viewing served as a measure (50% for unbiased and 100% for completely biased). Next, we asked how a biased pattern ("prime") affects perception of a subsequent ambiguous pattern ("probe")? With no pause between probe and prime, negative priming (Psurvival ò 0) gradually gives way to positive priming (Psurvival ò 1.0) as prime bias decreases. When a pause between probe and prime allows negative priming decay, statistically identical positive priming (Psurvival > 0.5) obtains for prime bias 50% to 97%. No priming (Psurvival ò 0.5) occurs for 100% bias (unambiguous KDE).

We conclude that ambiguous patterns engage additional levels of processing where they leave a "perceptual memory". Unambiguous patterns do not engage these levels and leave no "memory".

D8 469 Noise vs. adaptation: which is responsible for perceptual switches?

Asya Shpiro[1] (avs203@nyu.edu), Ruben Moreno-Bote[1], John Rinzel[1,2], Nava Rubin[1]; [1]Center for Neural Science, New York University, [2]Courant Institute of Mathematical Sciences, New York University

Perceptual bi-stability occurs when the same physical stimulus gives rise to two distinct interpretations that switch in dominance irregularly. Adaptation, or fatigue processes are commonly believed to be the mechanism responsible for perceptual switches. However, noise is also known to be capable of producing alternations. The question arises, therefore, whether noise is merely a source of randomness in the switching behavior, or perhaps it plays a central role in causing alternations?

It is difficult to disentangle the effects of noise and adaptation in experiment alone, because we have no methods to control the magnitude of noise and/or adaptation independently. Mathematical models can provide insight into this question by allowing to vary these parameters at will. We performed numerical simulations in an idealized firing rate model where neuronal competition is implemented by reciprocally inhibitory populations (Shpiro et. al., J Neurophys 2007), and examined the effects of noise and adaptation parameters on the statistics of dominance durations by varying them independently.

We focus on three main measures: the mean dominance duration of a percept (typically of the order of a few seconds), the CV (the ratio between the standard deviation and the mean; typically about 0.5), and the shape of distribution of dominance durations (typically, fit by gamma or log-normal functions). We sought to find regions in the noise-adaptation parameter space where computed alternation statistics are similar to those observed experimentally. We classify the switching behavior as being noise-dominated if no alternations occur in the absence of noise, and adaptation-dominated if noise is not necessary to produce alternations. Our results indicate that in order to comply with the above constraints, noise has to be the primary mechanism behind perceptual switches, while the adaptation processes are responsible for the shape of the distributions dominance durations.

D9 470 Do eyes or stimuli dominate perception duringbinocular rivalry? The answer is clear!

Derek Arnold[1] (darnold@psy.uq.edu.au), Philip Grove[1], Thomas Wallis[1]; [1]School of Psychology, The University of Queensland

Showing different images to either eye can induce perceptual switching, with alternating disappearances of each image. This phenomenon, known as binocular rivalry, has been the focus of extensive contemporary interest as it permits an opportunity to explore the relationship between changes in awareness and brain activity in the absence of changes to sensory input. Different explanations exist: disappearances might be related to selections of a particular stimulus or to selections of information from a specific eye. We believe there is a third possibility – that disappearances during rivalry could be driven by a process which facilitates visibility near the point of fixation. As the fixation point is a property that belongs neither to a particular stimulus nor to a specific eye, indifference to both would be an essential characteristic for the process we envisage. We demonstrate this indifference using image blur to cue distance from fixation. We break the links between this cue and both eye of origin and stimulus type. We find that perceptual dominance can track a better focused image as it is swapped between the eyes and that perceptual switches can be driven by alternating the focus of images fixed in each eye. Our findings suggest that perceptual suppression, during binocular rivalry, is not an irrelevant curiosity. Instead, we argue that it is a product of a functional adaptation, prevalent in daily life, which facilitates visibility near the point of fixation.

Acknowledgement: This research was supported by a Discovery Project Grant and Australian Postdoctoral Fellowship awarded to DHA by the Australian Research Council.

URL: http://www2.psy.uq.edu.au/~darnold/

D10 471 Percept-dependent modulations of neuronal activity occur earlier for shape than for colour stimuli

Sandra Veser[1] (veser@uni-leipzig.de), Urte Roeber[1], Erich Schröger[1]; [1]Institute of Psychology I, University of Leipzig, Seeburstr.14-20, 04103 Leipzig, Germany

Binocular rivalry occurs when dissimilar images are presented to the two eyes. That is, at one time only a single image is perceived while the other is suppressed. Hierarchical models claim that binocular rivalry can occur at different levels within the visual process. In this study, we compared the time course of percept-dependent neural responses between a condition with stimuli of different colours and a condition with stimuli of different shapes. Equiluminant red/black or green/black radial frequency patterns of different shapes were presented dichoptically. Rivalling stimuli either differed in colour but had the same shape (report-perceived-colour task) or differed in shape but had the same colour (report-perceived-shape task). We measured event-related brain potentials (ERPs) following transitions from rivalling to non-rivalling stimulation. Depending on the prevailing percept reported by the observer, these transitions could concern the eye that was dominant (incompatible change) or suppressed (compatible change). Our results show that the first percept-dependent modulation of the ERP following shape rivalry occurs earlier (around 120 ms, P1-range) than the first percept-dependent modulation following colour rivalry (around 230 ms, N1-range). In both cases, incompatible changes elicited larger amplitudes than compatible changes. In conclusion, stimulus features determine the stage of percept-dependent processing of visual stimuli with shape-based processing being influenced earlier than colour-based processing.

D11 472 Distinct binocular interactions for pattern and color revealed by visibility modulation of rivalrous stimuli

Satoru Abe[1] (s-abe@graduate.chiba-u.jp), Eiji Kimura[2], Ken Goryo[3]; [1]Graduate School of Humanities and Social Sciences, Chiba University, [2]Department of Psychology, Faculty of Letters, Chiba University, [3]Faculty of Human Development and Education, Kyoto Women's University

[Purpose] Visibility of rivalrous flashes can be modulated by presenting a stimulus prior to the flashes (visibility modulation, VM). In the previous study (Kimura, Abe & Goryo, VSS2006), we investigated the VM using color flashes and found that the VM occurred in an eye-specific as well as stimulus-specific fashion depending upon temporal parameters of the stimuli. The present study extended the investigation to spatial patterns and examined the nature of binocular interactions for color and pattern stimuli. [Methods] The rivalrous test stimulus was composed of left-tilted (-45°) and right-tilted (+45°) gratings of 2 c/deg presented dichoptically. The preceding stimulus was either the left-tilted or right-tilted grating. The stimulus size was 2° and the contrast was 0.9. The temporal parameters such as the test duration and the ISI between the preceding and test stimuli were systematically varied. [Results and Discussion] We only found the stimulus-specific VM for spatial patterns; that is, the left-tilted preceding grating phenomenally suppressed the left-tilted test regardless of the eye to which it was presented, and thus the percept of the right-tilted grating was reported (or vice versa). This was true even under the temporal conditions where the eye-specific VM was observed for color flashes. These findings suggest that dominance and suppression of binocular inputs are determined in distinct fashions for color and pattern stimuli. This interpretation was supported by the additional observation of misbinding of color and pattern. When rivalrous chromatic gratings were presented dichoptically (e.g., a red/gray left-tilted grating to the left eye and a green/gray right-tilted grating to the right eye) following monocular presentation of one of the gratings, observers often reported the percept of a red/green stripe or an isochromatic red (or green) plaid. These percepts cannot be explained if the dominance and suppression for pattern and color are determined concomitantly.

Acknowledgement: Supported by JSPS grant

D12 473 Influence of emotional stimuli on the dynamics of binocular rivalry

Rachel Bannerman[1] (r.bannerman@abdn.ac.uk), Maarten Milders[1], Beatrice De Gelder[2], Arash Sahraie[1]; [1]Vision Research Laboratories, School of Psychology, University of Aberdeen, [2]Cognitive and Affective Neurosciences Laboratory, Tilburg University

A number of studies have demonstrated factors affecting perceptual dominance and suppression of stimuli during binocular rivalry. These include stimulus strength, context, complexity and attention affecting the dominance of visual percepts. Here we report whether emotional information has an impact upon the dynamics of binocular rivalry. In Experiment 1 we have shown that an emotional facial expression (fearful or happy) in the background of a rivalry display is not sufficient to promote the predominance of an associated foreground stimulus, while Experiment 2 revealed that when emotional and neutral faces are presented dichoptically, without being associated with other stimuli, expressive faces predominate. To rule out a response bias as an explanation for the results, Experiment 3 examined dominance periods of fearful and neutral faces presented as face-house composites and showed that fearful faces persisted longer than neutral faces. These results indicate that emotional meaning can modulate binocular rivalry.

D13 474 Onset rivalry: Brief presentation isolates an early independent phase of perceptual competition

Olivia Carter[1] (ocarter@wjh.harvard.edu), Patrick Cavanagh[1]; [1]Vision Sciences Lab, Harvard University

When the left and right eyes are simultaneously presented with different images, observers typically report exclusive awareness of only one image. Every few seconds the dominance alternates in a cycle of perceptual competition that continues indefinitely (binocular rivalry). Despite the apparent continuity in perceptual switching, we now demonstrate that the initial "onset" period is fundamentally different to all subsequent rivalry epochs. In a series of five psychophysical experiments, onset rivalry dominance reveals strong biases that reflect low-level, spatially localized factors that are stable over periods of weeks. If the presentation exceeds ~1sec at any location, however, the very different and much more balanced alternations of sustained binocular rivalry become apparent. These powerful onset biases are observed with brief intermittent presentations at a single location or with continual smooth motion of the targets. Periods of adaptation to one of the rivaling targets induced local switches in dominance to the non-adapted target. However, these effects were generally limited to the spatial site of adaptation and had less influence over each subsequent cycle of the target. We conclude that onset rivalry is independent of sustained rivalry and cannot be explained by local regions of monocular dominance or memory of past perceptual history. These findings suggest that brief presentation paradigms are inappropriate for their current use in studies of the mechanisms underlying sustained rivalry. However, brief presentations are ideal for investigating early stages of perceptual competition.

D14 475 Long-Lasting Connections: the Relationship between Motion-Induced Blindness and Binocular Rivalry Reconsidered

Dina Devyatko[1] (tsukit86@gmail.com); [1]Department of Psychology, Lomonosov Moscow State University (Moscow, Russia)

Motion-induced blindness (MIB) refers to perceptual disappearance in natural ('monocular') vision when salient stimuli superimposed on a moving mask fluctuate in awareness (Bonneh et al., 2001). MIB history is connected with binocular rivalry (BR) (Grindley, Townsend, 1965, 1967), which we believe is not accidental. Since 2001, MIB and BR similarities/distinctions have been discussed once and again. Carter and Pettigrew (2003) compared temporal dynamic of perceptual oscillations in BR and MIB and proposed a common timing mechanism for both phenomena.

We investigated interactions between MIB and BR under two conditions: the experimental (MIB stimulation presented through anaglyph glasses, with a mask viewed by one eye and target dots by the other eye) and the baseline (a 'regular' MIB demonstration). 10 subjects were asked to report immediately on disappearances/reappearances of any display elements.

If a common MIB/BR oscillator exists, we expected no significant differences in general characteristics and the amount of perceptual events in the 'regular' MIB and MIB under BR-conditions. If there are two relatively independent mechanisms, differences should be observed. Also, when a MIB demonstration is viewed under BR-conditions, mask disappearances could be due to the BR only. Simultaneous disappearances/reappearances of three dots could be caused by either BR or MIB. All other types of events would be MIB markers.

We compared the amount of different perceptual events under both conditions. As expected, mask disappeared under BR-conditions only. There were significantly more simultaneous disappearances/reappearances of three dots, disappearances of two dots and then one dot, and disappearances of one dot followed by two dots under BR-conditions. Under baseline condition, one dot disappeared significantly more often, as well as two dots simultaneously. Besides, we obtained evidence of 'adaptation' to regular MIB with no 'adaptation' under BR-conditions which can be considered as an indirect evidence of different nature of MIB and BR.

Time Perception and Temporal Processing

Author Presents: 8:30 - 10:15 am

D15 476 Contrast gain changes affect the perceived duration of visual stimuli.

Aurelio Bruno[1] (a.bruno@ucl.ac.uk), Alan Johnston[1]; [1]Department of Psychology, University College London

Increasing stimulus contrast can shorten the temporal impulse response in the M cells of the macaque monkey, but not in P cells (Kaplan & Benardete, 2001, Prog Brain Res, 134:17-34). The shortening of the temporal impulse response function has been proposed as a possible cause of perceived duration distortions (Johnston, Arnold & Nishida, 2006, Current Biology, 16(5):472-9). We investigated the influence of luminance contrast context on the apparent duration of a visual stimulus. Subjects were presented with two test intervals (one of them with different durations across trials) containing a drifting grating of 50% contrast embedded in a variable contrast sequence of oscillating motion and they indicated which one contained the longer stimulus. In the first condition, in the initial and the final intervals the grating contrast was set to 90%, while in the intervening interval it was set to 10%. In a second condition, the first and last interval contrast was 10%, while the intervening one was 90%. The orientation of the gratings in the test intervals was orthogonal to those in the background

intervals and we varied the temporal frequency of the stimuli in a range between 2 and 20 Hz. We found that the duration judgments obtained in the two conditions differ only when the stimuli oscillated at high-temporal frequencies. When the test interval was preceded by a high-contrast interval, we observed a shrinkage of its perceived duration, while when the preceding interval contrast was low, the test appeared to last longer. We also showed that the differences in the onset-offset perception of the stimuli in the two conditions cannot account for the observed effects. The specificity of this contrast effect on time perception to high-temporal frequencies and the greater sensitivity of magno cells to contrast adaptation suggest that the underlying mechanisms are in the magnocellular pathway.

D16 477 Perceived duration is shortened after motion direction changes

Joan Lopez-Moliner[1] (j.lopezmoliner@ub.edu), Daniel Linares[1]; [1]GRNC, Parc Cientific de Barcelona-Universitat de Barcelona

Recently it has been shown that the misbinding between color and motion also appears with a single change of motion direction. This finding, mainly observed for changes of direction of 180 degs, implies that motion direction takes longer to acknowledge than the concomitant change of color and is regarded as there being a role for motion opponency mechanisms in the core of color motion asynchrony illusions. So as to better understand the underpinnings of color-motion asynchronies we here test the hypothesis that the duration itself of an interval defined by a new motion direction is perceived shorter after a direction change of 180 degs in comparison to durations after changes of 90 degs. By using life-limited random dots we find that the perceived duration of a motion interval is shortened (about 60 ms) when its direction follows a change of 180 degs. This result turns out to be independent of motion coherence after comparing two motion coherence conditions (50% and 100%).

Acknowledgement: This work has been funded by grant TIN2004-04363-C03-02 from the Spanish Ministry of Education and Science

D17 478 Temporal masking within and between chromatic and achromatic axes

David Alais[1] (alaisd@physiol.usyd.edu.au), John Cass[2], Branka Spehar[3], Colin Clifford[1]; [1]School of Psychology, University of Sydney, [2]Institute of Ophthalmology, University College London, [3]School of Psychology, University of New South Wales

Previous temporal masking studies using iso-oriented, luminance-defined (LD) target and masking stimuli have estimated that there exist two sets of temporal channels: one low pass and one or two higher bandpass channels (Anderson & Burr, 1985; Hess & Snowden, 1992). Recent data indicate that low-pass masking only occurs between iso-oriented stimuli, while the higher bandpass masking is iso-tropic (Cass & Alais, 2006). To investigate whether this implies a functional distinction between precortical and cortical levels of temporal processing, we conducted analogous temporal masking experiments with iso-oriented chromatic gratings (1 cpd). We did this both within LD and chromatic axes (L-M & S-(L+M)), as well as between these axes. Although chromatically-defined modulation transfer functions are distinctly low-pass, we found temporal masking functions within-chromatic channels that were qualitatively similar to those found with achromatic stimuli: one lowpass channel and a higher bandpass channel. This result challenges current models, which assume that chromatic channels are entirely low-pass, and resolves an apparent contradiction between these models and data from speed discrimination experiments with chromatically-defined stimuli (Cropper, 1994; Metha & Mullen, 2000). Interestingly, conditions testing masking between chromatic axes (S-(L+M) vs. L-M) also revealed both lowpass and higher bandpass channels, suggesting that in the context of chromatic stimuli, both temporal channels are probably cortically mediated. We also confirmed previously reported asymmetries whereby L-M stimuli robustly masked LD targets, but not vice versa.

D18 479 Moving Objects are Perceived Later

Pascal Mamassian[1] (pascal.mamassian@univ-paris5.fr), Andrei Gorea[1], Alan Johnston[2]; [1]CNRS & Université Paris 5, France, [2]University College London, UK

Moving objects can generate various spatial illusions, such as the effect reported by DeValois and DeValois (1991) where the location of a stationary moving Gabor is misperceived in its direction of motion. One essential component of these illusions is some error in the time at which the moving object is perceived. We present here a method to measure the perceptual delay between moving and stationary objects. Observers were presented with Gabor patches that were modulated by a Gaussian window in both space and time. Two such Gabors were presented in succession and the observer had to estimate the time interval between them (in the order of 1 sec). The observer then had to press a key after a delay that was equal to the previously defined interval. One of the Gabors was stationary whereas the other was moving (drifting carrier at 5 deg/sec). We found that time intervals where the moving Gabor was presented first were systematically estimated to be shorter by about 80 msec compared to trials in which the static Gabor was presented first. In other words, moving Gabors were perceived to occur about 40 msec later than stationary ones. These results could appear counter-intuitive in face of physiological data showing that moving displays are processed faster than stationary ones. We discuss potential models that could account for this delay in perceived motion.

Acknowledgement: Chaire of Excellence from the French Ministry of Research

D19 480 Effect of stimulus brightness on LRP latency and RT

Agnieszka Nowik[1] (akiwon@gmail.com), Piotr Jaúkowski[2]; [1]Poznan University of Medical Sciences, Department of Biophysics, Poland, [2]University of Finance and Management, Department of Cognitive Psychology, Warszawa, Poland

Van der Molen and Keuss (1979, 1981) reported U-shaped relationship between reaction time (RT) and loudness in difficult tasks requiring choice responses. This effect was recently replicated by Jaúkowski and WŠodarczyk (2006) for visual stimuli. In the current study, we used ERP to investigate the locus of this paradoxical elongation of RTs for extremely bright stimuli. The visual stimuli were a black capital letter in the centre presented against a white square. The luminance of the square was manipulated. We tested participants whose task was to make either a simple responses or choice responses according to letter identity. Results: The RT-luminance relationship was monotonic for simple responses and U-shaped for choice responses, with RTs up to 50 ms longer for the brightest as compared to moderately intense stimuli. Notably, LRP-R was independent of stimulus intensity for both tasks. However, S-LRP latency changed with brightness similarly to RTs. That is, it decreased gradually with intensity for the simple task and it showed elongation with very bright intensities for the choice task. These results support Van der Molen and Keuss' proposal that it is the response selection stage that is affected by very strong stimuli. Conclusions: our study clearly indicates that response selection is influenced by intensity changes, resulting in a U-shaped relationship between RT and intensity when the task needs choice.

D20 481 Peri-Saccadic Temporal Uncertainty

Girish Kumar[1] (gkumar@uh.edu), Scott Stevenson[1]; [1]College of Optometry, University of Houston, Houston

Purpose: To quantify the ability of humans to localize the timing of events relative to the execution of a saccadic eye movement.

Methods: Three subjects participated in this study. Their task was to make a judgment of when a vertical grating, shifted phase by 90 degrees relative in time to a 10 degree vertical movement. The vertical movement was achieved by three methods – vertical saccades, simulated saccades and simulated saccades that were triggered by the subject with a key press. All simulated saccades were produced by moving a mirror mounted onto a galvo-motor. In all three procedures subjects had three response options – "before", "during" or "after" the real/simulated saccade. To quantify the uncertainty in making these judgments, the spread of the time difference

Sunday Posters

between the phase shift and the real/simulated saccade for "during" responses as well as the slope of the psychometric function of proportion of "after" responses were calculated.

Results: All subjects made errors in judging the temporal relationship between stimulus shift and image motion, with the largest errors occurring for the triggered task and the smallest errors in the simulated task. The average standard deviations of "during" judgments were 59.65, 28.26 and 83.81 msecs for the saccadic task, simulated saccade task and the triggered task, respectively. The mean standard deviations for discriminating "before" vs. "after" were 176.98, 128.79, and 219.76 msecs, respectively, for the three tasks.

Conclusions: Previous work has showed that subjects spatially mislocalize targets that are presented around the time of a saccade. A possible confound is that subjects misjudged when their eyes moved, relative to the target presentation. Our study shows that do make relative temporal judgment errors around the execution of a saccade, and this may largely be due to task demands of having to make a movement while making the judgment.

D21 482 Modulation of feature fusion by visual masking

Johannes Rüter[1] (johannes.ruter@epfl.ch), Frank Scharnowski[1], Michael Herzog[1]; [1]Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland

Feature integration is one of the fundamental steps in vision. To examine temporal aspects of feature fusion, we displayed two verniers with opposite offset direction in rapid succession at the same location. Only one fused vernier is perceived with its offset being a combination of the two verniers. We balanced the duration of the two verniers at a performance level of 50% for each observer individually. To probe the time course of feature fusion, we masked the two verniers by a light mask at several SOAs. Mask presentation before the onset of the verniers causes the second vernier to dominate the fused vernier, whereas the first vernier dominates when the mask is presented after the onset of the second vernier. Hence, we can manipulate the contribution of each vernier offset to the perceived, fused vernier. Surprisingly, the mask we used does not mask a single vernier when presented alone. Thus, the modulation of dominance by the mask must be caused by an interaction with the process of integration.

D22 483 Subjective area size influences time perception

Fuminori Ono[1] (fuminori@med.juntendo.ac.jp), Jun-ichiro Kawahara[2]; [1]Juntendo University, [2]National Institute of Advanced Industrial Science and Technology

The perceived duration of events is affected by non-temporal attributes of stimuli, such as the number of components, size, or complexity. Presenting an observer with more stimuli tends to result in an overestimated duration. Although previous studies have suggested that time perception is influenced by the physical attributes of stimuli, it is not known whether time perception is influenced by differences in the subjective appearance of physically identical stimuli. Specifically, we examined whether the subjective area size of the critical object in an Ebbinghaus illusion influences its time perception. We measured the perception of time spent looking at visual objects whose perceived area size was altered by the Ebbinghaus illusion, in which a central circle surrounded by large inducers appears to be smaller than a central circle of the same size surrounded by small inducers. In the experimental trial, one of two types of surrounding circle (the subjectively large or small conditions) was randomly displayed for 1500 ms. The central circle appeared for either 150 or 350 ms. The participants estimated the duration of the central circle. The results showed that the perceived duration of the subjectively large condition was longer than that of the subjectively small condition, although the actual area size remained invariant. This suggests that later visual processing systems influence time perception, because the Ebbinghaus illusion is a prototype for size contrast illusions that affect cognitive judgment by introducing bias into the processing of information at a higher level of visual processing (Coren & Enns, 1993). In summary, these results are the first to show the effect of a size contrast illusion (the Ebbinghaus illusion) on processing the temporal characteristics of a stimulus. This indicates that the time perception of visual events is influenced by higher-level representation of visual processing.

D23 484 Subjective time expansion through cross-modal integration

Kuan-Ming Chen[1] (d92227003@ntu.edu.tw), Hao-Hsiang You[1], Su-Ling Yeh[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

Dynamic or attended visual stimuli are known to lengthen their perceived duration. What if a sound is added to the visual onset? Two contrasting predictions can be made based on the integration hypothesis and the distraction hypothesis respectively. If the sound is integrated into the visual onset and forms an integrated event, it is predicted that adding a sound should increase the perceived duration of this event. However, if the sound works to direct one's attention away from the visual stimulus, its perceived duration should be decreased instead. We adopted an oddball paradigm similar to that in Tse, Intriligator, Rivest, and Cavanagh (2004) to test these two hypotheses. An oddball was inserted into a sequence of visual standards, and the perceived duration of the oddball was measured with the method of constant stimuli. The points of subjective equality were computed separately for the oddballs with or without a tone. Results show clearly a subjective time expansion for the oddballs with the tone, compared to when the tone is absent, thus supporting the integration hypothesis. We conclude that the added sound is integrated into the visual onset and they become an integrated event which has a lengthened perceived duration than a uni-modal stimulus.

Acknowledgement: [Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020]

D24 485 Flash visibility degradation compresses apparentbrief inter-flash intervals as does saccadic eye movement.

Masahiko Terao[1,2,3] (masahiko_terao@mac.com), Junji Watanabe[3,4], Akihiro Yagi[1], Shin'ya Nishida[3]; [1]Department of Psychology, Kwansei Gakuin University, [2]Japan Society for the Promotion of Science, [3]NTT Communication Science Laboratories, NTT Corporation, Atsugi, Kanagawa, Japan, [4]PRESTO Japan Science & Technology Agency

The duration perception of visual events is considered to rely on a variety of mechanisms depending on the time scale. For brief durations, sensory mechanisms are likely to play critical roles. For instance, adaptation to higher or lower temporal frequencies can change the apparent duration of ~500 ms dynamic stimuli (Johnston et al, 2006, Curr Biol, 16, 472-479). For even shorter durations, Morrone et al. (2005, Nat. Neurosci, 8, 950-954) found that the interval defined by two colored flash bars (~100ms) was perceptually compressed by about one half when the flashes were presented immediately before a saccade. Here we show the occurrence of a similar illusory compression of perceived time without saccades. Using a display similar to Morrone et al., we presented two red flash stimuli sequentially on an equiluminannt green background, one on the top and the other on the bottom of the display, with an interval of 100 ms. The red flashes were presented under steady fixation, but with dynamic random luminance modulation of the stimulus areas (within ±25%, 120Hz update), which was introduced to mask transient visual responses to the flash stimuli. The apparent duration of these intervals were compared with an interval defined by a subsequent flash pair presented without the luminance noise. The results indicate that the apparent flash interval is reduced when it is presented with luminance noise, in a similar way to flashes presented before a saccade. We also found a similar compression effect in static displays when the flash visibility was degraded by reducing the chromatic contrast of the target flash bars relative to the background. This compression was not observed for a longer interval (500 ms). These findings indicate that visual neural encoding of brief intervals of the order of 100 ms is strongly affected by the visibility of stimuli.

Acknowledgement: MTis supported by Japan Society for the Promotion of Science.

D25 486 **A cortical locus for post adaptation facilitation in spatio-temporal vision**

Peter Bex[1] (p.bex@ucl.ac.uk), Keith Langley[2], John Cass[3]; [1]The Schepens Eye Research Institute, [2]Department of Psychology, University College London, [3]Institute of Ophthalmology, University College London

We used a dichoptic adapting and test paradigm to examine the functional organisation of adaptation processes in spatio-temporal vision. Observers were simultaneously adapted to two horizontal and two vertical flickering 1-d blue noise patterns arranged around a fixation point and presented to either the left or right eye (at random locations across runs) with a Wheatstone stereoscope. Adaptation periods were cycled with test intervals containing one vertical and one horizontal flickering noise pattern, whose locations (4AFC) were identified by observers. This arrangement produced 8 randomly interleaved combinations of vertical or horizontal adapt and test patterns, presented monoptically or dichopitcally. Threshold elevation was greatest when adapt and test patterns were of the same orientation and monoptic, with high temporal frequency (TF) adapting patterns producing greatest threshold elevation. Orthogonal effects of adaptation were approximately the same in magnitude under monoptic and dichoptic adapt-test pairings and in some cases produced cross-orientation facilitation – ie detection thresholds that were lower following adaptation to an orthogonal flickering pattern than with no adaptation. Our results are generally inconsistent with simple contrast gain control models involving two TF channels where the adaptability and sensitivity of the visual system are predicted to correlate, but consistent with the predictions made by an optimized two-temporal channel signal encoding and decoding strategy in which there also exists the possibility for whitening at high spatial and temporal frequencies. The observation that this shift is at least as great for dichopitc presentations suggests that the shift in TF tuning originates in cortex and may impinge on pre-cortical areas via feedback.

Acknowledgement: Supported by the Wellcome Trust and by the EPSRC

D26 487 **Contrast masking using VEP state triggered kernel estimation (STKE)**

Justin Ales[1] (ales@berkeley.edu), Thom Carney[1], Stanley Klein[1]; [1]University of California, Berkeley

White noise stimuli have been very useful in studying nonlinear system properties. The white noise method assumes that the system studied is stationary, that is, the responses do not change during the course of the experiment. However we are interested in studying system dynamics during state transitions between response regimes. Specifically, how does the system impulse response change at different time delays after a sudden contrast change? The sudden contrast change violates the stationarity assumption and would have been impossible to analyze with previous white noise methods. The system dynamics were analyzed by implementing a novel state triggered kernel estimation (STKE) method that allowed us to trigger the kernel estimation to a change in the stimulus (Menz, Menz & Sutter IOVS 2004;45:E-Abstract 4228).

A standard 30 Hz pattern reversing m-sequence stimulus was presented to one eye, while the stimulus in the other eye alternated at 0.5 Hz between a mean luminance field and a high contrast pattern. The experiment was also performed with the m-sequence and the slowly alternating pattern both presented binocularly. The STKE method was used to show how the presentation of a contrast mask dynamically changes the system response kernels.

Both dichoptic and binocular high contrast mask conditions rapidly (~64 ms) reduced the VEP. The suppression was sustained over the 1 sec presentation. However, when the mask was presented dichoptically there was an early component that was not masked as much as the binocular presentation. While in the binocular presentation a late component appears that was not present in the response during the unmasked interval.

The STKE method is easily extendable to other system state transitions such as changes of attention, figure/ground, or color, thereby extending the power of nonlinear systems analysis to stimulus changes that were previously unmeasurable.

D27 488 **Perception correlates with feedback but not with feedforward activity in human visual cortex**

Johannes J. Fahrenfort[1] (j.j.fahrenfort@uva.nl), H. Steven Scholte[1], Victor A. F. Lamme[1,2]; [1]Department of Psychology, University of Amsterdam, [2]Netherlands Institute for Neuroscience

Although many experiments have shown that awareness covaries with activity in early visual cortex, the exact spatiotemporal profile of this correlation is still unclear. In this experiment we use EEG to correlate the entire spatiotemporal profile of neural processing in visual cortex with perception. This makes it possible to distinguish between those stages of visual processing that correlate with human perception and those that do not. Subjects had to detect a texture defined square which was degraded by a subsequent pattern mask. We correlated subjects' ability to detect the figure with the corresponding EEG signal through time and space. The results show that extra-striate activity in the 100-160 ms range does not correlate with perception, while more posterior (plausibly striate) activity in the same time frame and beyond correlates strongly with perception. This is consistent with the notion of an unconscious feedforward sweep and feedback processing being necessary for visual awareness. Furthermore, several subsequent stages show an alternating pattern of such bilateral extra-striate (180-230 ms) and more posterior (240-260 ms) activity, all of which correlate with perception. This suggests that multiple reentrant loops are engaged in visual perception.

D28 489 **A Synchrony-Based Sparse Code in Cat Visual Cortex Signals Complex Contours in Natural Images**

Melanie Bernard[1] (melanie.r.bernard@vanderbilt.edu), Zhiyi Zhou[1], A.B. Bonds[1,2]; [1]Department of Biomedical Engineering, Vanderbilt University, [2]Department of Electrical Engineering and Computer Science, Vanderbilt University

The mechanisms by which salient stimulus features are represented in neuronal responses remain unresolved. We have previously shown that synchrony between cell pairs can represent co-circular contours, suggesting that synchrony within larger assemblies may be involved in encoding more complex contours. To investigate the role of synchrony as a contour-encoding mechanism in natural vision, we measured the synchronous responses of large neural assemblies to a sequence of 3024 natural images. Using a 10x10 microelectrode array, we recorded from 75 complex cells in the primary visual cortex of two paralyzed and anesthetized cats. We randomly identified 4500 neural assemblies, ranging in size from 2 to 10 cells with 500 assemblies per size group. Using a novel measure to quantify synchrony within assemblies of arbitrary size, we found that the receptive fields of cells within an assembly tend to be aligned on a complex contour in the image with the highest synchronized response. Furthermore, spline and receptive field analyses reveal that each complex contour is relatively conserved across images with highly synchronized responses. In contrast, contours are not conserved in the images generating the highest average firing rate across an assembly. We also measured the synchrony and average firing rate response distributions for each assembly over the set of images and used six different selectivity metrics to compute population and lifetime sparseness values. All metrics indicate that synchrony response distributions were sparser than firing rate response distributions and sparseness increased with assembly size. We propose that higher-order features found in natural images (e.g. complex contours) are responsible for the high selectivity of synchrony compared to average firing rate because adequate descriptions of high-order spatial correlations require the coordinated response of multiple cells. This process is cumulative, in that more complex structures require larger neural assemblies for accurate description.

Acknowledgement: Supported by NIH EY014680-3, USARL W91INF-05-2-0019

Sunday Posters

D29 490 **Temporal and Frequency Analysis of Synchronized Neural Responses in Cat Visual Cortex**

Zhiyi Zhou[1] (zhiyi.zhou@vanderbilt.edu), Melanie R. Bernard[1], A.B. Bonds[1,2]; [1]Department of Biomedical Engineering, Vanderbilt University, [2]Department of Electrical Engineering and Computer Science, Vanderbilt University

Synchronized neural responses, which often are accompanied by oscillations in the gamma frequency band, exist extensively in visual cortex and are proposed as supporting perceptual mechanisms. Neural synchrony and oscillation are normally studied with cross-correlation analysis and coherence analysis respectively. We studied responses from cat visual cortex to explore the relationship between synchrony and coherency. With a Cyberkinetics 10x10 microelectrode array, we recorded 66 complex cells from areas 17 and 18 in two paralyzed and anesthetized cats. Drifting sinewave gratings (SF = 0.5 cycle/½, TF = 2Hz, Contrast = 50%) were used as visual stimuli. We identified 694 pairs that showed significant synchrony using the JPSTH representation of correlation. We also studied frequency dependence in these synchronized pairs with multi-taper coherence analysis (Chronux 1.0) and found that 98.4% data samples showed coherence values higher than the 95% confidence interval at certain frequency band(s). Linear regression analysis reveals strong correlation between neural synchrony and the corresponding coherence (R2 = 0.63), which validates the normalization implemented in the JPSTH. To test dependence of synchrony/coherence on fine response structure, we randomly jittered the neural spike trains over different time ranges (±5ms, ±10ms, ±20ms) to deconstruct the timing accuracy. The strength of synchrony and coherence systematically decreased with increase of jitter range. We defined the average coherence with spike trains jittered ±20ms as the "baseline" coherence (independent of fine structure), and derived modulation functions. The coherence of the unjittered spike trains in the gamma frequency band showed the greatest losses after spike trains were jittered. We believe that the fine temporal structures in spike trains are important in maintaining the temporal and frequency dependence between neurons. Our results suggest that cross-correlation analysis and coherence analysis are internally related, though these two methods study neural connectivity from different perspectives.

Acknowledgement: [Supported by NIH EY014680-3, USARL W91INF-05-2-0019]

D30 491 **A Velocity Association Field for Visual Synchrony**

Aaron Clarke[1] (Aaron.Clarke@ndsu.edu), Stéphane Rainville[1]; [1]Center for Visual Neuroscience, NDSU

PURPOSE: Perceptual grouping is highly sensitive to temporal synchrony between oscillating Gabor elements, yet the nature of mechanisms mediating synchrony perception remains unknown. Here we explore two competing hypotheses: Synchrony perception between two Gabor elements is either A) limited by the intersections-of-constraints (IOCs) that characterizes single MT cells, or B) defined by a velocity association field similar to the static association field inferred by edge grouping studies.

METHODS: Observers discriminated the synchrony of two spatially adjacent Gabors oscillating at 5 Hz in a temporal 2AFC task. Spatial phase varied sinusoidally with time as $\phi(t) = A \bullet \cos(?t + ?)$. The A term controls the oscillation amplitude, ? the oscillation frequency, and ? determines synchrony. We varied the Gabors' relative oscillation amplitudes, orientations, spatial frequencies, and spatial separation in a manner that either satisfied or violated a particular MT cell's IOC.

RESULTS: Synchrony discrimination thresholds for varying relative oscillation amplitude Gabor pairs follows a log-Gaussian tuning function, peaking at mid-range amplitudes. While orientation differences between Gabors reduced performance, satisfying or violating a single MT cell's IOC by varying oscillation amplitude had no effect. Spatial-frequency differences between Gabors reduced performance if an MT cell's IOC was satisfied, whereas performance remained high if the cell's IOC was violated but preserved spatial scale invariance. Spatial separation between Gabors had little effect.

CONCLUSIONS: Barlow suggested that, due to their finite temporal-integration window, neurons can act as coincidence (i.e. synchrony) detectors. MT cells therefore constitute potential candidates for synchronous motion oscillation processing. However, our data reveal that stimuli constructed to allow single MT cells to perform the relevant discrimination are ineffective or deleterious to performance. Our results suggest instead that synchrony perception is mediated by a spatial association field that groups synchronous signals as a function of their joint oscillation amplitudes, orientations, spatial frequencies, and separation.

Motion Integration

Author Presents: 10:30 am - 12:15 pm

D31 492 **Response properties of MT neurons in amblyopic macaques**

Yasmine El-Shamayleh[1] (yasmine@cns.nyu.edu), Adam Kohn[1], J. Anthony Movshon[1], Lynne Kiorpes[1]; [1]Center for Neural Science, New York University

Cells in area MT/V5 are selective for motion direction, speed, and some correctly signal the motion of complex patterns. We have studied the responses of these neurons in monkeys with known deficits in motion perception. We recorded 198 neurons from 3 amblyopic macaques (2 strabismics, 1 anisometrope) whose behavioral sensitivity to coherent motion in random dot displays was reduced at fine spatial offsets and long temporal offsets when tested in the amblyopic eye (Kiorpes et al, 2006, Vis. Neurosci.).

We studied neurons driven by both eyes in both hemispheres. Many neurons could be activated through either eye, but we found a clear shift in eye dominance away from the amblyopic eyes. We measured selectivity for grating direction, spatial and temporal frequency, and for pattern motion using plaids. We also measured selectivity for dot direction, speed, displacement, temporal offset, and sensitivity to motion coherence. We found no differences between the selectivity of neurons driven by the fellow and amblyopic eyes. We used a pooling method to analyze neuronal coherence sensitivity, and found no difference in any animal between pools of neurons driven by the two eyes. For both eyes, behavioral sensitivity to coherent motion was much better than neuronal sensitivity at long temporal offsets, suggesting that areas other than MT – perhaps downstream of MT – are responsible for integrating coherent motion information over time.

We conclude that changes in the properties of MT neurons are not responsible for the behavioral motion deficits of these amblyopic subjects. Our results suggest that the effects of amblyopia on motion processing occur in areas downstream of MT.

D32 493 **Second-order optic flow processing in amblyopia.**

Craig Aaen Stockdale[1] (craig.aaenstockdale@mail.mcgill.ca), Robert F. Hess[1], Timothy Ledgeway[2]; [1]McGill Vision Research, McGill University, Montreal, Canada, [2]School of Psychology, University of Nottingham, Nottingham, UK

Purpose: Humans with amblyopia show deficits for global motion discrimination that cannot be accounted for by low-level visibility or contrast sensitivity deficits. The processing of translational global motion is deficient in amblyopia [Simmers, A.J., Ledgeway, T., Hess, R.F., & McGraw, P.V. (2003) Vision Res, 43 (6), 729-738] as is the processing of optic flow defined by global motion [Simmers, A.J., Ledgeway, T., Mansouri, B., Hutchinson, C.V., & Hess, R.F. (2006) Vision Res, 46 (16), 2571-2580]. These findings suggest that extra-striate function (i.e., MT and MST) is impaired in amblyopia. Furthermore, deficits in processing of translational motion are more pronounced for second-order stimuli. Here, we asked whether this pattern holds for optic flow stimuli defined by second-order motion and whether deficits are correlated across motion class.

Sunday Posters

Methods: We used random dot kinematograms in which the dots were areas of increased luminance or contrast of the background noise. Global motion of the dots within the stimulus area was translational, radial or rotational. Coherence thresholds for direction discrimination were obtained across a range of modulation depths.

Results: Our results suggest that motion processing deficits, unrelated to the low-level contrast deficit, occur in our amblyopic group as a whole for translation, rotation, and radial components of optic flow and that these deficits are more pronounced for second-order stimuli. In addition, these first- and second-order deficits are found to correlate.

Conclusions: Extra-striate deficits to global motion and optic flow processing affect the second-order pathway to a greater extent than the first-order. The correlation between first- and second-order deficits is consistent with form-cue invariance in MST.

Acknowledgement: This research is funded by the Natural Sciences and Engineering Research Council of Canada (RGPIN 46528-06 awarded to RFH) and the Canadian Institutes of Health Research (MT 108-18 awarded to RFH).

D33 494 Global Motion: effects of spatial scale and eccentricity

Robert Hess[1] (robert.hess@mcgill.ca), Craig Aaen-Stockdale[1]; [1]McGill Vision Research, Dept. Ophthalmology, McGill University, Canada

Purpose. Much is known about global motion processing, the ability to extract the global motion attributes from a collection of noisy local motion signals. Less is known about its dependence on spatial scale and eccentricity because it has been general practice to use large fields of spatially broadband stimuli. Here we first look at the effects of spatial scale and, equipped with this knowledge, explore the dependence on eccentricity. Methods Our stimulus comprised an array of spatially bandpass elements in which some of the elements (signal) move in a coherent direction while the other elements (noise) move in a random direction. We vary the contrast of the individual elements and measure, using a standard 2AFC task, the signal/noise threshold (coherence) for motion direction.Results The detectability of the elements is strongly spatial scale dependent as is the influence of eccentricity, however coherence thresholds are, to a large extent, independent of both spatial scale and eccentricity. Conclusion The effects of spatial scale and eccentricity being strongly contrast dependent reflect the low-level dependencies of local motion processing. At the level where global integration occurs such factors exert only small effects.

Acknowledgement: CIHR #108-18 and NSERC grant #0GP0046528 to RFH

D34 495 The role of path continuity in motion integrationacross space and time

Mehdi Aghdaee[1] (aghdaee@fas.harvard.edu), Patrick Cavanagh[1]; [1]Harvard Vision Lab

In this study we examine the integration of motion signals from random dots moving within a circular patch (3.3° in diameter) that was presented for 5120 ms and moved along either a smooth or discontinuous trajectory. The dots within the patch moved either toward or away from the central fixation point and the patch itself moved along a circular path 6.1° from fixation at 70.3 deg/sec in one condition or jumped to random locations around the 6.1° radius circle each 160 msec in the other. The two paths (smooth vs. random) and the two directions of dot motion (inward or outward) were randomly interleaved during each block and the dot motions were presented at several different coherence levels. Subjects' task was to report the direction of the dot motion (inward versus outward). When the circular patch moved smoothly, the coherence threshold was 24% (for 75% correct). However, when the region jumped randomly, the coherence threshold was dramatically higher, 51%, even though the motion was present for the same duration in both cases. Motion integration across discontiguous locations appears to be less efficient than integration along a continuous path.

D35 496 Neural mechanisms underlying motion opponency in hMT+

Javier Garcia[1] (jogarcia@uci.edu), John Pyles[1], Emily Grossman[1]; [1]University of California, Irvine

Background. Previous psychophysical and physiological research has shown the direction of visual motion to be perceptually cancelled in displays with locally balanced opposing motion signals (Qian et al.,1994). The perceptual consequences of these specialized circumstances are thought to be a result of exploiting the center-surround antagonistic relationship of directionally-selective inputs in motion-selective brain area MT. Motion antagonism, which in unbalanced conditions signals transparency, has been associated with "local" neurons in MT (Born & Tootell,1992), is dependent on stimulus contrast (Pack et al.,2005), implicated in perception of object motion (Tadin et al.,2003), and may underlie direction discrimination learning (Lu et al.,2004). The following experiments investigate the interaction of stimulus size and contrast in displays with locally unbalanced and balanced motion. A second set of experiments measures the BOLD response in V1 and hMT+ as a function of these same parameters. Method. Limited lifetime random dot cinematograms were constructed with dot-pairs that parametrically vary in spatial proximity between the paired dots. Subjects make a 2AFC angle discrimination on each 133msec trial (clockwise or counter-clockwise relative to an unseen reference angle). Angular thresholds were collected as a function of contrast and stimulus aperture size. In a blocked fMRI experiment, BOLD responses to the paired random dot cinematograms were collected as a function of proximity of the dot-pairs, stimulus aperture size, and contrast. Results. Angular deviation thresholds increase (i.e. poorer performance) as dot-pair proximity decreases. Angular deviation thresholds improve for larger stimuli and higher contrasts. BOLD responses from hMT+ also vary as a function of dot proximity and contrast. Conclusions. Our results evidence locally antagonistic neural computations underlie direction discrimination, and reflect local summation of directionally-selective inputs (perhaps through "local" neurons in hMT+) which mediate perception of transparent motion with motion opponent paired-dot displays.

D36 497 Motion capture is motion integration

Alex Huk[1] (huk@mail.utexas.edu), Jeremy Freeman[2], Frank Durgin[2]; [1]Neurobiology & Center for Perceptual Systems, The University of Texas at Austin, [2]Department of Psychology, Swarthmore College

The phenomenon of "motion capture" has been described as a suppression of the motion of high spatial-frequency (SF) elements in favor of the motion of low SF components, allowing larger forms to capture their smaller features when they move (e.g., Ramachandran, 1990). However, recent evidence suggests that motion capture might not reflect active suppression of high SF signals, but instead is simply an instance of weighted combination of high and low SF signals (Durgin, Freeman, Huk, VSS 2005). Here we show that increasing the contrast (and thus the motion energy) of high SF components allows them to "capture" the low SF components, thus arguing against the need for the specialized motion capture mechanism originally posited. We utilized displays in which we independently manipulated the contrast and speeds of two superimposed motion components, consisting of randomly scattered 2D Gaussian elements of two different sizes (low-SF and high-SF). Participants were instructed to judge the speed of either the high-SF or low-SF elements relative to a standard speed (2.5 deg/sec). The irrelevant (unjudged) elements moved either 75%, 100%, or 125% of the standard speed. The contrast of the low-SF elements was always 20%; the contrast of the high-SF elements was either 20% or 80%. We measured the actual speed of the relevant elements necessary to perceptually match the standard speed (for each irrelevant element speed). When nominal contrasts were equal, the low-SF elements exerted larger effects on the perceived speed of the high-SF elements than vice versa. But when the high-SF elements were higher in contrast the relative weights reversed. A generic model of weighted motion integration accounts for both traditional motion capture as well as for the reversed capture of low SF components by high SF elements.

D37 498 Motion integration across space for non-rigid objects

Camilla McG Magnussen[1] (cma4@gcal.ac.uk), Harry Orbach[1], Gunter Loffler[1]; [1]Department of Vision Sciences, Glasgow Caledonian University, UK

INTRO

Features play a fundamental role in motion perception because, unlike contour segments, their signal is unambiguous for rigid objecs. But what happens when two features signal different motions?

METHODS

Three invisible circular apertures (1.6° diameter) were separated by 1.2°. The outer two contained line terminators, the centre a featureless contour. The orientation of the line was vertical, and the motion of the central segment horizontal. In the first condition, the direction of one of the terminators was horizontal and that of the second terminator differed from this by 0°, ±10°, ±25°, ±45°. In a second condition, the direction of one terminator was fixed at either + or -45° to horizontal, while the other varied within ±45°. Different configurations are consistent with a physically shrinking, expanding or rigidly translating line. The perceived direction of motion of the centre segment was measured.

RESULTS

Vector averaging (VA) of the two terminators' velocities provides a reasonable overall fit to our data, but there are a few notable exceptions. When one of the terminators is moving in the same direction as the central segment, perception is biased away from VA, towards the second terminator's direction, if its motion is very different (45°) from that of the line segment. In contrast, if this terminator's motion is close to that of the line segment, perception is in the opposite direction: towards the motion of the central segment. When both terminators move in opposite directions from horizontal, their VA has to differ from the central segment's motion by more than ±10° before an effect is seen.

CONCLUSIONS

Our results suggest that the visual system typically implements a vector averaging solution for non-rigidly translating objects, but, depending on stimulus configuration, tends towards the motion of a featureless line segment or towards the motion of one of the features.

Acknowledgement: This research is supported in part by EPSRC Grant No. GR/S59239/01.

D38 884 Visual motion area MT+ carries precise information about object position.

Nicole Spotswood[1] (nmspotswood@gmail.com), David Bressler[1], David Whitney[1]; [1]Center for Mind and Brain, Department of Psychology, University of California, Davis

Single unit primate and human neuroimaging studies have reported that visual motion area MT+ displays selectivity for motion direction and coherence, and has receptive fields that are spatially localized. Despite this, previous results indicate that MT+ is only coarsely retinotopic. In an fMRI experiment we tested the precision of position coding in human area MT+ using a novel technique. For each of seven subjects, we defined an MT+ region of interest (ROI) by contrasting moving visual stimuli with a fixation baseline in a general linear model. Within these ROIs we cross-correlated activity patterns produced by flickering Gabors (i.e. Gabors with no direction of motion) in five slightly different positions, within a two degree window. When the Gabors were closely positioned, the patterns of activation in the MT+ ROIs were highly correlated. As the distance between the Gabors increased, the patterns of MT+ responses were able to reliably detect shifts in Gabor position of less than two degrees, at ten degrees eccentricity. The results suggest that MT+ carries precise topographic information about object position and may therefore play an important role in coding the position of moving objects.

D39 500 Transcranial magnetic stimulation (TMS) disrupts processing of translational, radial and rotational global motion within distinct epochs

Laura Stevens[1] (lwxlks1@psychology.nottingham.ac.uk), Paul McGraw[1], Timothy Ledgeway[1]; [1]Visual Neuroscience Group, School of Psychology, University of Nottingham, UK

Recently, TMS has been used to investigate the timing of the contribution of visual areas to motion perception, but with widely conflicting results. For example TMS of human visual area V5/MT substantially disrupts global motion judgements. Taken together, previous reports suggest a very broad temporal window (~ ±200 ms relative to stimulus onset) over which TMS impairs performance on global motion tasks. To resolve this issue we employed standard psychophysical techniques, in conjunction with TMS, to investigate the disruption profile for random-dot-kinematograms depicting either translational, radial or rotational global motion. We measured the influence of TMS over a broad temporal range (±200 ms), sampled at 13 ms intervals, to reveal the fine temporal structure of the disruption profile. Prior to applying TMS we established baseline thresholds for the three types of global motion: specifically the stimulus coherence level was manipulated by constraining a fixed proportion of the dots ("signal" dots) to move coherently along either a translational, radial or rotational (circular) trajectory and the remainder ("noise" dots) to move in random directions. Four observers judged the global direction (either up vs. down, expansion vs. contraction or clockwise vs. anticlockwise, respectively) and the coherence level producing 75% correct performance was taken as the threshold. Adopting each observer's individual coherence level at threshold we then examined how single-pulse TMS (2T) delivered to V5/MT modulated the percentage of correct judgments. Results showed that TMS produced a peak performance deficit of ~15%. More importantly the disruption profile revealed two distinct epochs (separated by 60 to 80 ms) during which global direction judgments were reliably disrupted, although there were individual differences regarding the onset of the time windows of disruption. The bimodal nature of the disruption profiles, is consistent with feed-forward and feed-back pathways between visual areas mediating global motion processing.

Acknowledgement: PM and TL are supported by the Wellcome Trust and BBSRC, respectively.

D40 501 Effects of Reference Stimuli on Motion Sensitivity

Yu-Chin Chai[1] (sunnia.chai@gmail.com), Bart Farell[1]; [1]Institute for Sensory Research, Syracuse University

The presence of a reference stimulus can alter spatial judgments of a target stimulus. Moreover, the similarity of reference and target stimuli can affect the precision of these judgments. For example, a spatial frequency difference between reference and target can scale stereoacuity by the frequency ratio (Farell, VSS 2003). Motion and stereo are similar in that they take input as a single stimulus at two different locations, spatiotemporal and retinal, respectively. We ask here whether motion sensitivity, like stereoacuity, shows a dependence on the relative spatial frequencies of reference and target stimuli. We measured thresholds for discriminating the phase of one cycle of displacement (first leftward then rightward vs. first rightward then leftward) of sinusoidal gratings. The target was annular (a radial Gabor) and the reference was a foveally centered Gabor patch. Motion thresholds measured the amplitude of the instantaneous to-and-fro phase shift of the surrounding sinusoidal carrier that allowed 84% correct left-right vs. right-left discriminations. The central Gabor reference was stationary. We varied spatial frequencies of target and reference stimuli independently and also varied reference orientation. Target and reference contrasts were constant multiple of contrast detection thresholds. Motion thresholds varied with the relative spatial frequencies and orientations of the target and reference gratings. For a given target frequency, threshold was highest when the reference frequency was at its lowest value. Threshold decreased as the reference frequency increased and was smallest when reference and target frequencies matched. Orientation differences raised thresholds; the increase was proportional to the reference

Sunday Posters

period in the direction of the target's motion. These effects were generally smaller for motion than for stereo, with some qualitative differences as well. The data are consistent with an analysis of motion, including relative motion, that takes place within frequency and orientation channels.

Acknowledgement: NIH Grant EY 012286

D41 502 What determines the perceived direction of global motion in displays composed of asymmetric distributions of local motions?

Timothy Ledgeway[1] (txl@psychology.nottingham.ac.uk), Ben Webb[1], Paul McGraw[1]; [1]Visual Neuroscience Group, School of Psychology, University of Nottingham, UK

Psychophysical studies frequently characterize human global motion perception in terms of the statistical properties of stimuli (e.g. vector average, mode or median of local directions). Conversely physiological research has investigated the computational principles (e.g. vector average, winner-take-all or maximum likelihood) by which cortical decision networks could read from the neural representation in the middle temporal area to guide the perceived direction of global motion. To reconcile these stimulus-based and mechanism-based approaches, we compared the ability of statistical measures of stimulus central tendency and algorithms based on the trial-by-trial responses of directionally-tuned mechanisms to predict perceived global direction. In a series of experiments, using the method of constant stimuli, human observers discriminated the global directions of two sequentially presented random-dot-kinematograms (RDKs). Each RDK (diameter 12 deg) contained 226 dots, drifting at 5 deg/s for 0.53 s. The dots of the standard RDK all moved in the same direction, randomly assigned on each trial. The direction of each dot of the comparison RDK was chosen independently from a skewed (asymmetric) probability distribution (either Gaussian or rectangular) with distinct measures of central tendency. The perceived global direction of the comparison RDK was derived from the point of subjective equality of the resulting psychometric functions. Results showed that none of the statistical measures of image direction central tendency was a consistently accurate predictor of perceived global motion direction. However regardless of the local composition of motion directions both maximum likelihood and winner-take-all (but not vector average) models, applied to the activity of a population of physiologically-plausible motion mechanisms, produced global motion estimates commensurate with the psychophysical data. This suggests that mechanism-based, read-out algorithms offer a more accurate and robust guide to human motion perception than any stimulus-based, statistical estimate of central tendency.

Acknowledgement: TL, BW and PM are supported by the BBSRC, Leverhulme Trust and Wellcome Trust, respectively

D42 503 On the contribution of form and motion cues in the perception of transparency

Andrew Meso[1] (a.i.meso@rhul.ac.uk), Johannes Zanker[1]; [1]Brain and Behaviour group, Psychology, Royal Holloway University of London

Transparency is the perceptual separation of a region of visual field into two or more depth layers based on available visual cues. Interpreting motion and form (luminance and shape) cues is crucial for biological systems to make sense of the complex visual environments which they inhabit. Form and motion induced transparency have predominantly been investigated as separate phenomena. We combine them, using transparently moving stimuli in which form cues can be manipulated. We designed a 2 interval 2AFC task in which the perceived strength of transparently moving test stimuli is measured by repeated, randomly interleaved comparisons with reference stimuli which form a measurement scale. One such scale was made up of a pair of moving luminance gratings in which the number of odd Fourier harmonics used to make the gratings forms a measure of perceived transparency strength. Speed difference, contrast and spatial frequency are kept constant in the reference. Paired luminance gratings moving in the same direction at different speeds can be perceived as transparent, but to a lesser degree than gratings moving in opposite directions. Hence, modulation by form cues becomes measurable under this 'same direction' condition. Using a computational model of global motion based on correlation motion detectors, we predict component separability in these test stimuli from the distribution of their pooled local motion signals, while varying spatial frequency and amplitude parameters of one of the paired gratings. Results from presenting the same stimuli to participants using the 2AFC task deviate from predictions based only on motion cues. Lowering amplitude of one grating in the test pair unexpectedly increases transparency strength. Increasing spatial frequency differences between the grating pairs also unexpectedly decreases transparency strength. We discuss these results in the context of a general transparency percept, which integrates all available cues that reveal differences between the two components.

Acknowledgement: Funded by a UK-EPSRC & HolViz Ltd CASE studentship

D43 504 The spatial tuning of visual motion contour detection in humans

Szonya Durant[1] (szonya.durant@rhul.ac.uk), Johannes Zanker[1]; [1]Department of Psychology, Royal Holloway University of London

Investigation of the spatial properties of filters in the human visual systems that process luminance contours has made extensive use of the optimal balance between spatial frequency content and spatial localization offered by 2D Gabor patches. We investigate whether these properties can be useful for probing the detection of contours defined in the motion domain. Motion defined contours are ecologically important cues to object boundaries in a three-dimensional world, and also can help to disambiguate camouflage. We designed motion-defined Gabor stimuli which consist of limited lifetime moving random dots. The velocity of the dots for any given position is defined by the 2D Gabor function, and dots can either be moving parallel or orthogonal to the motion defined contours. The Gabor patterns are embedded in motion noise dots with speeds drawn randomly from the speeds in the Gabor area. In a contour detection task participants were asked to judge whether the motion defined Gabor pattern is oriented horizontally or vertically. We find that observers become very proficient at performing this task, with as little as 12 dots providing enough information for 90% accuracy. We measured performance over different values of spatial extent of the Gabor function and found that the number of correct responses increases and saturates with size. We then chose the average point at 90% of peak performance, using a fitted function and used this fixed spatial extent to measure the number of correct responses at various spatial frequencies. We find that the number of correct responses decreases with higher frequencies, with optimal detection being at 0.1 cycles/degree, the lowest spatial frequency tested. These results suggest that putative human motion contour detectors may be most sensitive to single isolated edges. We also consider these results experimentally in the context of vernier acuity for motion contour localization mechanisms.

Acknowledgement: Supported by the Engineering and Physical Sciences Research Council

D44 505 The role of color vision in translation and radial global motion processing

Magda L. Michna[1] (magda.michna@mcgill.ca), Kathy T. Mullen[1]; [1]McGill Vision Research, Department of Ophthalmology, McGill University, Montreal, Quebec, Canada

Purpose: We address the issue of whether color vision can support both radial and translational global motion. Previous studies have argued that translational chromatic global motion is significantly impaired, however, these have not addressed the role of both contrast and coherence level in global motion discrimination, and/or have not used stimulus parameters appropriate for chromatic spatio-temporal contrast sensitivity. In addition, the chromatic contribution to radial motion has not been investigated.

Method: We analysed translational and radial global motion processing for random dot kinetograms (RDKs) calibrated for the selective activation of the L/M cone-opponent (red-green), S-cone-opponent (blue-yellow) or achromatic systems. Each RDK consisted of 50 Gaussian 'dots' (Û =

Sunday Posters

0.25deg.) presented using a limited lifetime paradigm in a circular window (12° diameter). 'Dot' speed was 5.4°/sec., and stimulus duration was 240msec. RDKs were presented in a Gaussian temporal window (Û=0.125sec). We measured direction discrimination thresholds (% coherence) using a method of constant stimuli over a wide range of stimulus contrasts scaled in multiples of detection threshold.

Results: We find that, for both chromatic and achromatic RDKs, coherence thresholds for discriminating global motion decrease as contrast increases. At higher contrasts, coherence thresholds for isoluminant red-green and S-cone isolating chromatic RDKs are similar to those for achromatic stimuli for both radial and translational motion, indicating that the chromatic system can perform as well in global motion processing as the luminance system.

Conclusion: We conclude that global motion processing is available to both red-green and blue-yellow color vision for both translational and radial motion stimuli.

Acknowledgement: Supported by Canadian NSERC Grant RGPIN 183625-05

D45 506 Visual tracking of ambiguous moving objects: A recursive Bayesian model

Anna Montagnini[1] (Anna.Montagnini@incm.cnrs-mrs.fr), Pascal Mamassian[2], Laurent Perrinet[1], Guillaume Masson[1]; [1]Institut de Neurosciences Cognitives de la Mediterranée , CNRS-Université d'Aix-Marseille, [2]Laboratoire de Psychologie de la Perception, CNRS-Université de Paris 5

Perceptual and oculomotor data demonstrate that, when the visual information about an object's motion differs on the local (edge-related) and global levels, the local 1D motion cues dominate initially, whereas 2D information takes progressively over and leads to the final correct representation of global motion. Previous models have explained the initial errors (deviations from the global motion) in terms of best perceptual guess in the Bayesian sense. These models accounted for the intrinsic sensory noise of the image and general expectancies for object velocities. Here we propose a recursive extension of the Bayesian model, with the purpose of encompassing the whole dynamical evolution of motion processing, from the 1D cues to the correct global motion. Our model is motivated and constrained by smooth pursuit oculomotor data. Eye movements were recorded in 3 participants using the scleral search coil technique. Participants were asked to track either a single line (vertical or oblique) or a Gaussian blob moving horizontally. In our model, oculomotor data obtained with non ambiguous stimuli (e.g. with coherent local and global information, such as a Gaussian blob or a vertical line moving horizontally) are combined to constrain the initial likelihood and prior functions for the general, ambiguous case (e.g. a tilted line moving horizontally). The prior knowledge is then recursively updated by using the previous posterior probability as the current prior. The idea is that the recursive injection of posterior distribution boosts the spread of information about the object's shape, favoring the integration of 1D and 2D cues. In addition, a simple model of the sensory-oculomotor loop is taken into account, including transmission delays and the evolution of the retinal motion during pursuit. Preliminary results show substantial agreement between the model prediction and the oculomotor data.

Acknowledgement: AM was founded by an EU Marie Curie fellowship

D46 507 Grouping by visual synchrony – Separate motion and flicker pathways

Stéphane Rainville[1] (Stephane.Rainville@ndsu.edu); [1]Center for Visual Neuroscience, North Dakota State University

PURPOSE: Human vision is extremely skilled in combining synchronous features of the retinal image – features that change contrast (or 'flicker') simultaneously tend to form coherent perceptual groups, as do moving features that change direction simultaneously. A key issue is whether the visual system is sensitive to the synchrony of higher-order events (e.g. direction changes) because such events are usually accompanied by confounding lower-order artefacts (i.e. contrast changes). METHODS: Here I present a novel technique by which changes in contrast can be made directional or nondirectional purely through manipulation of their local spatiotemporal phase spectrum. Observers discriminated the synchrony of counterphasing Gabors pairs oscillating at 3.1 Hz in a 2AFC task. The level of directionality in each Gabor was manipulated by varying the spatial phase of a superimposed static Gabor mask. RESULTS: Human observers, while exquisitely sensitive to synchrony among directional changes or among nondirectional changes, are surprisingly blind to synchrony between directional and nondirectional changes, despite the fact that both types of events have identical local and global spatiotemporal spectra. CONCLUSION: This failure of the visual system to encode synchrony between directional and nondirectional events provides compelling evidence that distinct motion and flicker pathways mediate perceptual grouping by synchrony. Results imply that perceptual grouping mechanisms capitalize on the synchrony of higher-order events. These findings challenge existing notions on grouping-by-synchrony and strongly motivate computational research on the nature of synchrony in dynamic natural scenes as well as physiological and behavioural research on their perceptual-grouping correlates.

Acknowledgement: NIH/NCRR COBRE grant P20 RR020151 to the Center for Visual Neuroscience at North Dakota State University.

D47 508 Direction Encoding in Infants is Sensitive to Occlusion Cues

Vanitha Sampath[1] (vansampath@yahoo.com), Gene Stoner[2], Karen Dobkins[1]; [1]UCSD Department of Psychology, [2]Salk Institute for Biological Sciences

Purpose: Previous studies indicate that by two months of age, infants integrate one- (1D) and two-dimensional (2D) motion signals (Dobkins, Lewis & Fine, 2006). Here, we investigated whether infants are sensitive to depth-ordering (occlusion) cues that determine whether 2D features are seen as intrinsic or extrinsic to moving 1D features. Methods: Modeled after the barber-diamond (BD) stimulus of Duncan, Albright & Stoner (2000), our BD stimulus consisted of vertically moving gratings (0.8 cpd, 8 Hz) presented within 83 diamond-shaped apertures (3 x 3 deg), evenly spaced across the display. Two occluding white bars (3.0 by 0.4 deg) abutted each BD on opposite sides. The two other sides were framed by a black background. We predicted that 2D terminators abutting the occluders would appear as extrinsic to the moving gratings, while 2D terminators along the two (unoccluded) sides would appear as intrinsic. Using a directional (left vs. right) eye movement (DEM) technique, we asked whether infants distinguished between the motion of intrinsic and extrinsic terminators, which moved up/right (45 deg) and up/left (135 deg), respectively (or vice versa). Performance (where 50% = chance) from the BD condition was compared to that from an Equivalent Direction (ED) condition, which consisted of diamond-shaped apertures containing unambiguous grating motion at 45 or 135 deg. For each infant, a BD index (BDI) was calculated as: (DEM performance on the BD condition–50%)/(DEM performance on the ED condition–50%). BDI values greater than 0 indicate a BD effect. Results: For 13 four-month-olds tested thus far, performance in the BD condition was significantly above chance (50%) ($p<0.001$) and the mean BDI was 0.48 ($p=0.001$). Conclusions: By four months of age, visual motion mechanisms are sensitive to depth-ordering (occlusion) cues. We are currently tracking the development of this phenomenon in infants of different ages.

D48 509 Age related differences in the perception of global motion: local motion and stimulus size effects

Jeffrey D. Bower[1] (Jeffrey.Bower@email.ucr.edu), George J. Andersen[1]; [1]University of California, Riverside

The present study examined age related differences in the perception of global coherent motion when considering available local motion information and stimulus size. The stimuli consisted of random dot cinematograms (RDCs) in which the path of each dot was sampled from a Gaussian distribution of directions with a standard deviation of 36 degrees. 8 younger (mean age 20.9) and 8 older (mean age 78.6) participants were asked to discriminate the coherent direction of motion from two sequentially presented RDCs. Two hypotheses were examined: 1) that older

observers are less efficient at incorporating local motion information into a perception of global motion, and 2) that older observers have a decreased ability to spatially integrate motion information. Hypothesis 1 was examined by using 6 or 24 dots in the motion display and three different types of dot motion; continuous, limited lifetime, or random walk. These three motion types can be quantified as containing varying amounts of sampling information based on the number of local motion vectors and amount of angular information presented. To test hypothesis 2 we used RDCs that had circular viewing areas of 1.5, 3, or 6 degrees visual angle in diameter. The results show that younger observers have lower thresholds relative to older participants when 24 dots were present. This result indicates that older observers may not be able to incorporate local motion information into global coherent motion as efficiently as younger observers. This effect was more pronounced when the display size was reduced to 1.5 degrees visual angle. An ideal observer model will be discussed that is used to compare sampling efficiencies in both age groups.

Acknowledgement: Research supported by NIH AG13419-06

Perception and Action II

Author Presents: 8:30 - 10:15 am

D49 510 Anticipatory vs. reactive Response Times: a new method to compare perceptual and motor latencies

Pedro Cardoso-Leite[1] (pdrcardoso@gmail.com), Andrei Gorea[1], Pascal Mamassian[1]; [1]Laboratoire Psychologie de la Perception

One of the most frequent assessments of the relationship between perceptual and motor processing consists in comparing their latencies as derived from Temporal Order Judgments (TOJ) and simple Response Times (RT), respectively. Most of these studies have yielded significant differences between these latencies and concluded in favor of at least a partial perceptual-motor dissociation. The comparison of these latencies remains debatable as the two tasks make use of dual (TOJ) and single (RT) stimulations, possibly entailing cognitive and sensory confounds. As an example of the latter, the rapid sequential stimulation in TOJ may yield the transient fading of the lower saliency stimulus and/or apparent motion. To avoid such hitches, we've replaced the TOJ with an anticipatory RT (ART) task based on the rationale that, like TOJ, ART mirrors the time needed by the internal response to reach a decision threshold and decreases with stimulus saliency. In randomly interleaved blocks of 50 trials (repeated twice), 7 Observers pressed a key either in synchrony with the third of a sequence of three equal contrast (not offset) stimuli appearing at a constant pace of 500 ms (ART), or in response to the onset of the last stimulus presented at a random interval (RT). Each block was also specified by one of four contrasts ranging between .1 and .8. Linear regressions on the ART-RT means and on their variances yield slopes below 1 (.85 and .3, respectively) supporting the notion that perceptual and motor decisions operate on the same internal signal but are based on distinct criteria with the perceptual criterion below the motor one. Relatively to RT, ART yield a significantly smaller variance than TOJ. This higher reliability together with it being more tractable and less time consuming than TOJ favor ART over TOJ as a better task for the assessment of perceptual latencies.

Acknowledgement: ANR Neurosciences 2006

D50 511 The Perceptual-Motor dissociation tested negatively with a standard 2AFC task

Andrei Gorea[1] (Andrei.Gorea@univ-paris5.fr), Pedro Cardoso-Leite[1]; [1]Laboratoire de Psychologie de la Perception, René Descartes University & CNRS, Paris, France

It has been repeatedly asserted that motor responses can be triggered without 'conscious' perception. Scrutinizing such studies always reveals methodological and/or logical drawbacks. We re-examine the issue with a standard 2AFC detection task combined with a speeded simple or choice Response Time task (sRT & cRT). Observers were presented with two high contrast ('mask') annuli (S2) displayed at ±6° and ±2° along the horizontal and vertical meridians and with one Gaussian target blob (S1) set at its detection threshold (81% correct) and preceding the annuli by 50 ms. S1 was displayed either within (masked condition, M) or 4° below or above one of the two annuli (non-masked condition, nM). Observers had first to react to the S1+S2 complex by pressing one (sRT), or one of two, left/right button(s) contingent on S1 location (cRT) and then to specify/confirm this location (perceptual 2AFC). cRT were 26 ms longer than sRT and yielded close to chance performance. Both sRT and cRT were shorter (1) for correct than for incorrect perceptual responses (22 and 14 ms for nM & M conditions; with sRT[incorrect responses] = sRT in the absence of S1) and (2) for M than for nM conditions (3 and 12 ms for correct & incorrect perceptual responses). Observation (1) supports the notion that motor responses do not 'profit' from non-detected targets, disproving the perceptual-motor dissociation. Together with observation (2), it sustains a sensorimotor race model positing that the two processes operate on the same internal response but are based on distinct decision variables, one fixed (motor threshold) and the other context-dependent (perceptual criterion) and well above the former in the M relatively to the nM case. The chance performance obtained with cRT requires that perceptual decisions be taken once the internal response reaches its asymptotic level, well after it exceeds the motor threshold.

URL: http://andrei.gorea.free.fr/

D51 512 Action, but not Perception, Relies on Continuous Presentation of External Objects

San-Yuan Lin[1] (d94227106@ntu.edu.tw), Chia-Chien Wu[1], Yi-jia Su[1], Su-Ling Yeh[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

We examined whether the two visual systems ("what" and "how"; Milner & Goodale, 1995) share common object representations by using the double-rectangle cueing paradigm of Egly, Driver, and Rafal (1994). The reliance of the action/perception system on external object presentation was examined, especially the tolerance of disruption of the presentation of objects in view. One of the two oblong objects (a shaver and a remote controller) was cued, followed by a red ant (the target) shown on one end of the two objects. In the action task, participants were asked to lift their finger from the spacebar to grasp the red ant on the screen as soon as possible once they saw it. Reaction times for finger lifting and grasping were measured. In the perception task, participants were asked to press the spacebar as soon as when they detected the ant. Three critical manipulations about the objects were that they were either continuously present in view, disappeared after being cued then reappeared at the target display, or disappeared throughout the trial after being cued. Results indicate robust same-object effects (i.e., shorter reaction times for targets appeared on the cued object compared to the uncued object) for continuously presented objects, and no such effect is observed when the objects disappear from view after being cued. However, the same-object effect observed in the disappear-then-reappear condition occurs only for the perception task but not for the action task. The action system thus seems to rely on continuous object presentation whereas the perception system can tolerate the disruption of object presentation, as long as the object appears with the target. These results suggest different object representations for action and perception during the attentional cueing task used.

Acknowledgement: Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020

D52 513 Visually mismatched feedback within a head-mounted display affects a perceptual-motor but not a cognitive real world egocentric distance response

Betty J. Mohler[1,3] (bmohler@cs.utah.edu), Sarah H. Creem-Regehr[2], William B. Thompson[1]; [1]School of Computing, University of Utah, [2]Department of Psychology, University of Utah, [3]Max Planck Institute for Biological Cybernetics

We describe an experiment in which mismatches between actual walking speed and visual indicators of the speed of self-motion within a head-mounted display (HMD) alter a perceptual-motor but not a cognitive indi-

Sunday Posters

cation of egocentric distance perception in the real world. We conducted a within-subject design experiment (pre- and post-test) that had four between subject conditions: 2 HMD feedback conditions (visually faster, visually slower) x 2 response measures in the real world (blind walking to previously viewed targets, verbal reports). While pre-tests revealed accurate real world direct blind walking performance, visually faster and slower post-tests showed an 11% undershoot and 17% overshoot, respectively. Verbal reports in the real world were approximately 81% of the actual distance both before and after HMD feedback. We previously found that verbal reports and blind walking in an HMD, which without feedback are both compressed, became near accurate after matched continuous visual feedback was given within the HMD. The same experience within the HMD had little or no effect on either real world blind walking or real-world verbal reports of distance (Mohler et al. 2006 APGV). The result from this previous experiment that both perceptual-motor and cognitive responses within the HMD were affected by feedback that was predominately perceptual-motor in nature suggests to us one of three explanations: (1) a common cognitive rule is applied across responses, (2) perceptual-motor and cognitive responses are adapted using different mechanisms producing similar changes, or (3) adaptation produces a general change in the perception of space. The current results showing a differential effect on two response measures in the real world, one perceptual-motor and the other cognitive, argues against an explanation exclusively involving changes in space perception and supports an account in which cognitive effects, perhaps combined with perceptual-motor adaptation, play a role.

Acknowledgement: This work was supported by NSF grant 0121084.

D53 514 Children combine visual cues for perception and action unevenly in working memory

Marko Nardini[1] (marko.nardini@psy.ox.ac.uk), Oliver Braddick[1], Janette Atkinson[2], Taski Ahmed[1], Eleanor Swain[2]; [1]Dept Experimental Psychology, Oxford University, [2]Dept Psychology, University College London

If visual information for perception and action is processed by distinct pathways, how is it subsequently combined? In disorientation studies, Hermer & Spelke (Nature 1994) found an intriguing failure by disoriented children to search combining wall colours with cues about room layout. In the present studies we hypothesised that this result is not specific to disorientation, but represents a more general difficulty combining “ventral” and “dorsal” visual information in early childhood. 18-24 month olds seated at a table saw toys hidden in boxes distinguished by different colours (e.g. red, blue) and retrieval actions (e.g. push, pull). After a short delay, children had to discriminate between boxes to find the toy, based either on (i) action alone, (ii) colour alone, or on (iii) the conjunction of the two. Colour was poorly remembered on its own, but moreover when colour and action had to be combined, action information was retained but colour information was lost. At 30-36 months, although colours and actions were equally well remembered on their own, colour but not action information was lost in conjunction judgements. Studies in progress indicate that monochromatic textures are likewise lost in conjunction judgements with actions at 30-36 months, but faces are not. Adults remembering conjunctions of subtly different actions and colours do not seem to show the selective disregard of colour, either when tested like children with a free response time, or when pushed to make speeded responses. These results show that there are systematic biases in how “dorsal” and “ventral” visual cues held in children’s working memory are matched to visual cues in the test phase; however this pattern differs for different “ventral” cues. One hypothesis is that which information children use or disregard is determined by uneven speeds of processing for different visual cues.

Acknowledgement: Supported by Economic and Social Research Council grant RES-000-23-1474

D54 515 Visual and visuomotor crowding

Paul F. Bulakowski[1,2] (pbulakowski@ucdavis.edu), Robert B. Post[1], Michael D.K. Nguyen[3], David Whitney[1,2]; [1]Department of Psychology, [2]The Center for Mind and Brain, [3]Department of Computer Science, University of California, Davis

Although crowding is a well-established perceptual phenomenon, the degree to which it impacts action, such as reaching and grasping, is unclear. The current study sought to characterize visual and visuomotor crowding across a range of target/flanker separations and visual eccentricities. Using a 3AFC perceptual paradigm, subjects judged the orientation of a central bar presented within a radial display of 6 non-overlapping flankers. Utilizing the same stimuli, subjects’ visuomotor responses were recorded as the approach angle of a pincer grasp directed toward the target bar. Visuomotor accuracy was operationalized as the correspondence between the orientation of the target bar and the angle between the index finger and thumb. As the separation between the target and distracters decreased, performance on both perceptual and visuomotor tasks declined at comparable rates. This crowding effect occurred more strongly at larger eccentricities and followed the half-eccentricity rule (e.g. Bouma, 1970; Pelli et al, 2004), which states that multiple objects separated by less than half their visual eccentricity crowd each other. These results extend crowding into the visuomotor domain, and suggest an overlapping mechanism between perceptual and visuomotor systems. Interestingly, however, the influence of the average flanker orientation differed across visual and visuomotor trials. Specifically, in very crowded trials, perceptual judgments of the target orientation more highly correlated with the mean ensemble orientation (e.g. Parkes et al, 2001). This finding suggests that visuomotor coordination of a grasp may not utilize ensemble information in the same way that it drives perceptual judgments in crowded scenes.

D55 516 Visually Directed Action: Learning to Compensate for Perceptual Errors

John Foley[1] (foley@psych.ucsb.edu); [1]Department of Psychology, University of California, Santa Barbara

Perceived distance tends to be less than physical distance. The error increases with distance and is greater when distance cues are limited and in virtual environments. How then do people perform visually directed actions, such as throwing and blind walking, accurately? This study examined the effect of error feedback on performance in these tasks in virtual environments. There were two cue conditions: lighted room and dark room, and 7 target distances. The experiment had four stages designed to analyze the effects of error feedback training: 1) Measure throwing and blind walking to perceived positions of visual targets without feedback. 2) Provide visual error feedback to train accurate performance in one of the tasks. 3) Measure transfer of learning to the other task. 4) Measure throwing and walking to the perceived positions of the targets. The 4 stages required 16 half hour sessions. Results: All eight subjects initially threw and walked systematically short of the targets, shorter in the dark condition. All subjects improved substantially with feedback training and their average responses became close to accurate. Throw training produced substantial transfer to walking. Walk training produced less transfer to throwing. There were large stage 4 differences. Two throw trained subjects showed no change from stage 1 to stage 4. Two walk trained subjects showed no change in throw responses. In the other cases response distance increased from stage 1 to stage 4 in all four conditions. An analysis based on a simple model leads to the following conclusions. Both types of training change the transform between perceived distance and cognitive distance. Walk training has the additional effect of changing the motor transform between the walking response and distance. Perceptual changes cannot be ruled out for the subjects who showed stage 4 changes in all four conditions.

D56 517 Subjective Control and Motor Behavior in a Goal-Driven Visuomotor Task

John Dewey[1] (john.a.dewey@vanderbilt.edu), Adriane Seiffert[1]; [1]Vanderbilt University

The perception of control is the experience of being causally responsible for events we observe between our bodies and the environment. Here, we investigated the question of how subjective control during visuomotor tasks is modulated by factors other than objective control. We measured how motor behavior and perceived control were influenced by success rate and the spatial location of attention in a simple video game. In Experiment 1, participants used a joystick to move an object on the screen towards a goal. The participants' objective control was varied across conditions by adding pseudo-random noise to the object's movements. Additionally, on some trials an autopilot of varying strength moved the object towards the goal. After each trial, participants rated their control on a scale from 1 to 9. Even though engaging the autopilot reduced the correlation between the joystick and the object's motions, subjective control ratings were higher when the autopilot was strong. In Experiment 2, participants performed a similar task while attending to an RSVP stream of letters slightly in front of the goal. The letters could lie directly along the straight path to the goal or at various angles to either side. On half the trials, an autopilot influenced the object's movement either towards the goal, or to positions 45 degrees clockwise or counterclockwise from the goal. Results showed the object's average path was biased in the direction of the attended location—participants tended to move the object towards where they were looking. This was true regardless of the degree of control, but was modulated by the autopilot direction. This provides empirical support for the folk wisdom that it is best not to look directly at an obstacle when driving or riding a bike, but rather to attend to the path that avoids the obstacle.

Acknowledgement: NIH EY014984
URL: http://www.psy.vanderbilt.edu/faculty/seiffert/

D57 518 Attentional versus intentional biases in hand movements: Hand specific coupling and bimanual reaching

Gavin Buckingham[1] (g.buckingham@abdn.ac.uk), David P. Carey[1]; [1]Department of Psychology, College of Life Sciences and Medicine, University of Aberdeen

While the left and right hands no doubt share a degree of spatial and temporal coupling during rhythmic tasks (e.g. Kelso et al. 1985), research into the temporal linkage of the hands in reaching movements is scant. Kelso et al. (1979) reported that both hands move in near perfect synchrony during such tasks, while contrasting reports of independent error correction in each limb suggest no such entrainment (Boessenkool et al. 1999). Asymmetries in the performance of each hand during unimanual reaching tasks have been documented, including an advantage for the left hand in reaction time (an earlier process such as attention or visuo-spatial localisation) and a right hand advantage for accuracy and movement duration possibly mediated by preferential online monitoring (an intentional process, i.e. Peters 1981). In addition, studies of unimanual reaching have noted a clear discrepancy in performance when reaching across the body midline (i.e. Carey et al., 1996). There is however a distinct lack of research into how the dominant hand performs, in relation to the non-dominant hand when making bimanual reaches, especially to different sides of space. To examine any attentional and intentional asymmetries across the hands, participants made bimanual reaches to 2 equidistant targets in right, left, or central space. Upon landing, a further unimanual movement, to a target appearing near the peak velocity of the first (bimanual) movement. No difference in (the unimanual) reaction time was found. In a further study, unimanual reaches to targets across the workspace were compared with identical movements in a bimanual context (i.e. the measured movement accompanied by a concurrent reach of the other hand). These data will demonstrate which arm is yoked to the other, as bimanual movements into ipsilateral space for the coupled arm would be slowed by the other arm, reaching into its contralateral workspace.

Acknowledgement: 6th Century Studentship from University of Aberdeen

D58 519 Action observation leads to motor learning. An rTMS study.

Liana Brown[1] (lbrown38@uwo.ca), Elizabeth Wilson[1], Paul Gribble[1,2]; [1]Department of Psychology, University of Western Ontario, [2]Department of Physiology and Pharmacology, University of Western Ontario

Research participants (Ps) who watch a movie of another person learning to reach in a viscous, rotational force field know better how to compensate for the force field than Ps who did not see the movie. Does information derived from watching another person act directly engage learning mechanisms in the motor system (motor cortex)? If so, motor-learning-by-observing should be degraded by the application of repetitive transcranial magnetic stimulation (rTMS) to the motor cortex after observation. We applied 15 minutes of 1-Hz rTMS to the contralateral motor cortex after subjects watched a movie of another person learning a clockwise (CWFF) or counter-clockwise force field (CCWFF). After observation, all subjects were tested in a clockwise force field (CWFF). Subjects who received rTMS to M1 after watching the CWFF movie performed worse in subsequent CWFF training than controls who did not receive rTMS. In contrast, subjects who received rTMS to M1 after watching the CCWFF movie performed better in subsequent CWFF training than controls who did not receive rTMS. These results replicate earlier findings of motor learning by observing, and in addition show that both the facilitating and interfering effect of observing CWFF and CCWFF learning, respectively, can be attenuated by applying rTMS to M1. Thus, we provide direct evidence that visual information acquired simply by observing another person perform a new motor skill is translated into motor parameters used to update an internal model of that skill.

Acknowledgement: Canadian Institutes for Health Research

D59 520 Factors that decline a manual dexterity on persons with mental retardation: an analysis of tasks, motions, and eye movements in the time course.

Kohei Oka[1,2] (oka@hus.osaka-u.ac.jp), Toshiaki Miura[1]; [1]Graduate School of Human Sciences, Osaka University. Department of Applied Cognitive Psychology., [2]Research Fellow of the Japan Society of the Promotion of Science.

We investigated what factors cause the decline of a manual dexterity of person(s) with mental retardation (PMR), by analyzing tasks, hand and body motions, and eye movements. We adopted an enclosing task in real work environment. The task was to put two candies (17mm x 17mm x 13mm) into a soft thin plastic bag (with 60mm width and 100mm depth) and fold over so as to close the plastic bag. Most PMR showed difficulty to perform the task with accuracy and speed.

In this study, one PMR (28 years old, male, right-handed, TIQ=35, VIQ=48, PIQ=35) and one person without mental retardation (27 years old, male, right-handed) participated. Participants were instructed to perform as accurately and fast as possible. After sufficient practices, participants performed twenty trials.

We classified actions into subtasks and analyzed the order and duration of actions and fixation points, by using video and eye-mark recorder. Moreover, we analyzed hand and body motion by using a motion capture system.

The result showed that there were four factors that would decline manual dexterity and time performance of PMR. 1) Most of saccades to a target of PMR were delayed at the start of reaching. Meanwhile, the saccades of the control participant were always initiated before the reaching started. 2) The trunk of the body of PMR was more unstable, and shoulders, elbows, and hands of PMR moved more widely than the control participant. 3) The PMR did not perform two subtasks at the same time. 4) The PMR repeated some subtasks. Factor 1 and 2 seem to decline the manual dexterity of PMR. Factor 3 and 4 seem to take the PMR more time to perform.

We will discuss the possibility of overcoming the problems of manual dexterity and performance speed.

Acknowledgement: We thank Support Network AMICA and March for cooperation. This study was supported by grants from the Japan Society for the Promotion of Science (188708) and the Grants-in-Aid for Scientific Research (17653087).

D60 521 Does perceived effort influence verbal reports of distance?

Adam J. Woods[1] (ajwoods@gwu.edu), John Philbeck[1]; [1]Department of Psychology, George Washington University

Proffitt et al (2003) reported that increases in perceived effort (by wearing a heavy backpack) result in overestimation of egocentric distance. If true, this has important implications for theories of visual space perception.

Here, we attempted to verify this finding, first by replicating the methods closely and then by using a well-established rating scale to directly evaluate whether wearing a backpack indeed influences perceived anticipated effort.

Participants verbally estimated egocentric target distances while either wearing a backpack weighted 1/5 to 1/6 of their total body weight (n=12, 6 females) or without wearing a backpack (n=12, 6 females). Targets were randomly presented in one of six directions on the ground to prevent the use of landmarks as distance cues. Participants were given two blocks of six practice trials and two blocks of six test trials. Using similar methods, other participants rated how much effort would be required to walk to various targets, using the Borg CR-10 perceived effort scale (backpack: n=11, 6 females; no backpack: n=12, 6 females). Test distances for both studies ranged from 4 to 14 m.

We found no effect of backpack on verbal estimates of egocentric distance (F=.05, p=.82). On average, participants underestimated target distance by 9.3 percent. Direct judgments of perceived walking effort also showed no effect of backpack (F=2.1, p=.16).

Our results contrast sharply with those of Proffitt et al (2003). We followed the previously-reported methodology closely, so our results suggest that the effect is sensitive to as-yet undetermined methodological factors. One possible interpretation is that effects of perceived effort on distance perception do occur, but that they occur under a more limited set of circumstances than has previously been supposed. Another possibility is that some factor other than changes in perceived distance influences the calibration of verbal reports when observers don a heavy backpack.

Acknowledgement: Research supported by NSF Graduate Research Fellowship (Woods) and NIH R01 NS052137 (Philbeck)

D61 522 Does perceived effort influence verbal reports of shape?

John Philbeck[1] (philbeck@gwu.edu), Adam J. Woods[1]; [1]Department of Psychology, George Washington University

Witt et al. (2004) reported that perceived effort (manipulated by throwing a heavy vs. light ball) influences perceived egocentric distance. If distance perception errors result in a perceptually-slanted ground plane, changes in perceived distance should alter the perceptual slant of the ground surface, but not the perceived aspect ratio of shapes lying on the ground. However, if ball-throwing changes perceived distance only for the immediate location of the throwing target, one might expect effort-related changes in aspect ratio judgments.

Two groups of participants threw to a target (4, 6, or 8m distant) using a heavy ball (0.91kg, n=23) or a light ball (0.32kg, n=22). After the third throw, participants viewed an L-shape lying flat on the ground at the same distance as the target and gave a verbal estimate of its depth-to-width aspect ratio. Physical aspect ratios ranged from 0.75 to 2.25. The size of the frontal leg of the L-shape was 0.6m. In a separate study (n=24), we closely replicated Witt et al.'s methodology to confirm the effect of ball throwing on verbal reports of distance.

Aspect ratios were systematically underestimated, but the ball-condition comparison did not reach significance (F=2.5, p=0.11). Women gave smaller ratios than men (F=4.7, p=.03), perhaps due to sex-related eye-height differences. Importantly, there was no effect of ball throwing on verbal reports of egocentric distance (F=3.1, p=0.082), although there was a trend for the heavy-ball group to give somewhat SMALLER distance estimates.

Despite following their methodology closely, we could not replicate Witt et al.'s effect of ball throwing on verbal distance estimates. The robustness of this effect may rely crucially on methodological features that remain unknown. This leaves the possible effect of effort on perceived shape unclear, but emphasizes the need to more fully characterize the relation between effort and perceived egocentric distance.

Acknowledgement: Research supported by NIH R01 NS052137 (Philbeck) and NSF Graduate Research Fellowship (Woods)

D62 523 Handedness Effects Body Schema

Linkenauger Sally[1] (sal3g@virginia.edu), Witt Jessica[2], Bakdash Jonathon[1], Proffitt Dennis[1]; [1]Department of Psychology, University of Virginia, [2]Department of Psychology, University of Western Ontario

Previous research has shown that body schema has its roots in the ability to act or experience in action. In the present set of experiments, the effect of handedness on body schema was investigated. In one experiment, participants estimated the length and of their left and right arms. Right-handed participants perceived their right arms to be longer and their left arms to be shorter than their actual lengths; whereas, left-handed participants perceived both arms accurately. In the second experiment, we observed the same pattern when participants estimated the distance that they could reach with each arm. Right-handed participants overestimated their reachability with their right arm more than they overestimated their reachability with their left arm. Left-handed people overestimated their reach with the left arm the same amount as they overestimated their reach with their right arm. These results support the notion that left-handed people have a symmetrical body schema, and right-handed people have an asymmetrical body schema. These differences in body schema lead to differences in anticipated actions.

D63 524 Hemispheric Differences in the Perception of Hills

Jonathan Zadra[1] (zadra@virginia.edu), Dennis Proffitt[1]; [1]Department of Psychology, University of Virginia

Previous research has demonstrated a distinction between conscious perception and visually guided action in people's responses to hills. Verbal reports (reflecting conscious perception) of the slant of a hill are greatly overestimated, while motoric responses (visually guided action) are far more accurate. Similarly, in the Ebbinghaus Illusion (also known as the Titchener circles illusion), conscious verbal reports of the size of the inner circles indicate that people perceive the circles to be different sizes, however recorded motoric responses to the circles indicate accurate visually guided actions, as the grip aperture is not affected by the illusion (Aglioti, S., DeSouza, J.F., & Goodale, M.A., 1995). Recently, Gonzalez, Ganel, and Goodale (2006) reported that this distinction is not true when participants grasp with their left hand; the left hand is affected by the illusion, indicating that there may be a left hemisphere specialization for visual control of action.

The possibility of a hemispheric specialization for slant perception and visually guided action on slants was investigated in the current study. Participants viewed various slants in a virtual environment. Visual information was restricted to either the left or right visual hemifield on a given trial, and motoric responses were recorded with both the left and right hand. Preliminary results indicate that the response hand is not a significant predictor of motoric slant estimates, however verbal responses are overestimated to a greater extent when the hill is presented to the right visual hemifield than to the left.

URL: http://faculty.virginia.edu/perlab/

D64 525 Exploring the boundaries of unconscious processing: Response inhibition can be triggered by masked stop-signals

Simon van Gaal[1] (s.vangaal@uva.nl), K. Richard Ridderinkhof[1,2], Wery P. M. van den Wildenberg[1], Victor A. F. Lamme[1,3]; [1]Department of Psychology, University of Amsterdam, [2]Department of Psychology, Leiden University, [3]Netherlands Institute for Neuroscience

Many perceptual and motor processes can occur in the absence of consciousness, as evidenced by recent subliminal priming studies. However, which cognitive processes can be triggered by unconscious information, and which cannot? It has been suggested that cognitive control processes, associated with prefrontal cortices, can only operate on consciously perceived stimuli. To put this claim to a direct test, we used a masked stop-signal paradigm to study response inhibition. Participants responded as fast and accurately as possible to go-signals, but tried to inhibit their responses when an occasional stop-signal was presented after the go-signal. By varying the SOA between stop-signals and masks, behavioral measures on unconscious and conscious stop trials could be compared with behavioral measures on trials containing no stop-signal (go trials). After sufficient practice, participants inhibited more responses to go-signals in unconscious stop trials, than in perceptually comparable go trials. Additionally, unconscious stop-signals significantly slowed down the speed of responses. The latter effect was only present for good inhibitors, i.e. participants with a short duration of the inhibitory process. In this study, we show that response inhibition can be triggered unconsciously, but that it depends heavily on S-R automation and task performance. These results increase the traditional range of cognitive processes known to operate outside awareness and allow inferences about the depth of processing of unconscious stimuli in the human brain.

D65 526 Tracing sequential waves of rapid visuomotoractivation in lateralized readiness potentials

Thomas Schmidt[1] (thomas.schmidt@psychol.uni-giessen.de), Nuria Vath[2]; [1]University of Giessen, Germany, [2]University of Göttingen, Germany

Feedforward activation processes are widely regarded as crucial for the automatic initiation of motor responses, whereas recurrent processes are often regarded as crucial for visual awareness. Here, we used a set of behavioral criteria to evaluate whether rapid processing in the visuomotor system proceeds as would be expected of a feedforward system that works independent of visual awareness. We measured lateralized readiness potentials (LRPs) for keypress responses to color targets ("masks") preceded by masked color primes mapped onto the same or opposite response, and traced the time-course of motor activation as a function of different prime and mask characteristics. LRP time-courses showed that initial motor activation occurred in prime direction and was time-locked to prime onset. Response activation was then captured on-line by the mask signal, with motor activation now time-locked to the mask and proceeding in mask direction. Crucially, the time-course of early activation by the prime was independent of all mask characteristics. This invariance in early priming effects contrasted with large differences in visual awareness for the prime produced by different masks. Results suggest that primed responses to color stimuli are controlled by feedforward waves of activation sequentially elicited by prime and mask signals travelling rapidly enough to escape the recurrent processes leading to backward masking.

D66 527 Effect of spatial integration of visual motion on the quick manual response and related brain activity

Hiroaki Gomi[1,2] (gomi@idea.brl.ntt.co.jp), Kaoru Amano[1,3], Toshitaka Kimura[1]; [1]NTT Communication Science Labs., Nippon Telegraph and Telephone Corporation, Japan, [2]Shimojo Implicit Brain Function Project, JST-ERATO, Japan, [3]The University of Tokyo, Japan

Surrounding visual motion during arm reaching induces an ultra short latency manual response in the direction of visual motion. Such short latency manual response (named MFR) is almost proportional to the stimulus log-speed up to the stimulus temporal frequency around 15 Hz (Gomi et al. 2006). However, effect of the spatial integration of visual motion on the MFR is not well understood. In this study, we investigated the influence of change in stimulus size to the MFR. In the experiment, vertical sinusoidal grating pattern (85x70, or 46x36 deg) with 50% image contrast was shown on the screen. Experimental protocol was almost the same to that in our previous study. The MFR amplitude was quantified by the difference, between the rightward and leftward visual motion conditions, in the hand acceleration averaged over a brief period after the visual motion onset. The four kinds of visual stimuli were randomized within each experimental block. The MFR amplitudes for 0.02cpd with 80deg/s were significantly smaller than for the 0.125cpd with the same stimulus speed for all subjects in each stimulus size. For the small size stimuli, MFR was not greater for 0.02cpd 500deg/s than for 0.125cpd 80deg/s and 0.05cpd 200deg/s, in spite of higher speed stimulus. For the large size stimuli, however, MFR was greater for 0.02cpd 500deg/s than for the other stimuli in some subjects. These results suggest that the MFR amplitude cannot be represented only by stimulus speed in the very low spatial frequency range, and that the spatial integration characteristics varied by the stimulus spatiotemporal frequency is different in individual subjects. This subject dependent MFR modulation was highly correlated to the modulation of magnetoencephalography responses observed in the similar kind of experiment, which were evoked with a short latency (~60ms) after the visual motion onset, suggesting a MFR related brain activity.

D67 528 Optimal Weighting of Speed and Accuracy in a Sequential Decision-Making Task

Kyler Eastman[1] (Kyler_Eastman@yahoo.com), Brian Stankiewicz[1], Alex Huk[2]; [1]Psychology Department, University of Texas, Austin, [2]Neurobiology Department, University of Texas, Austin

Many sequential sampling models suggest decisions rely on the accumulation of evidence over time until reaching a particular threshold. These models can often account for variations of speed and accuracy in perceptual tasks by manipulation of this threshold. It has been hypothesized that the threshold maximizes an implicit reward function incorporates both the speed and accuracy of the response (Gold & Shadlen, 2003). This approach has produced a family of models that can describe a variety of behaviors in two-alternative forced choice (TAFC) tasks (Bogacz, et al., 2006).

We present a model of optimal sequential perceptual decision-making in a task that modifies the traditional TAFC by adding a supplementary option of acquiring additional information/sample at a cost (e.g., time). In the task, the observer receives a sample from two overlapping distributions. The observer can either use their estimation using this sample (and previous samples) to declare which distribution is the sampled distribution, or they can choose to receive another sample. A reward structure specifies the costs for correct and incorrect answers along with the cost for receiving an additional sample. Thus, the task is to weigh the current evidence against the benefit of acquiring an additional sample. The model adapts the drift-diffusion model (Ratcliff & Rouder, 1998) (Palmer, Huk, & Shadlen, 2005) for sequential decisions using a partially observable Markov decision process. The model provides a framework for evaluating the actual cost structures used by humans in a perceptual judgment task along with understanding the decision maker's sensitivity to these different reward structures. In addition to discussing these issues, the model provides a mechanism for evaluating the effects of imperfect integration (memory limitations), variable signal strengths, and variations in the reward structure for human and optimal behavior.

Acknowledgement: Project supported by NIH EY016089, AFOSR FA9550 AFOSR MURI FA09550-05-1-0321

D68 529 Grasping the function of tools: fMRI suggests that the ventral but not the dorsal stream codes the functional significance of familiar objects

Kenneth Valyear[1] (kvalyear@uwo.ca), Jody Culham[1,2]; [1]Neuroscience Program, University of Western Ontario, London, ON Canada, [2]Department of Psychology, University of Western Ontario, London, ON Canada

When grasping-to-use a familiar tool we often make use of stored information about the functional identity of the tool in order to guide our actions. At present, exactly which brain areas play an important role in representing this information is poorly understood. For example, is information regarding the functional significance of familiar objects stored within those areas mediating object-directed actions or does this information stem from other areas of the brain? During functional magnetic resonance imaging (fMRI), participants viewed short movies depicting different types of grasping actions made towards familiar tools. In one condition, the tool was grasped appropriately such that its function could be performed without further postural adjustments (e.g. a fork was grasped by the handle with the tines facing away from the actor). In the other condition, the tool was grasped inappropriately such that its function could not be performed without further postural adjustments (e.g. a fork was grasped by the handle with the tines facing toward the actor). We hypothesized that the viewing of functionally appropriate grasping actions would resonate more strongly with those areas involved in the processing of object function. Our results showed significantly stronger activity for the viewing of functionally appropriate as compared with inappropriate grasping actions within several brain areas previously implicated in higher-level object perception. In contrast, areas implicated in the control of object-directed actions did not distinguish between the two conditions. These findings suggest that information about the functional significance of objects is stored within areas specialized for object perception and not within areas specialized for object-directed action. Thus, object utilization based on stored knowledge of object function must involve a complex interplay between systems specialized for object perception and those specialized for the control of actions.

D69 530 Motor facilitation under binocular rivalry: the effect of suppressed motor affordances.

Jorge Almeida[1,2] (jalmeida@wjh.harvard.edu), Bradford Mahon[1,3], Alfonso Caramazza[1,3]; [1]Cognitive Neuropsychology Laboratory, Harvard University, Cambridge, [2]Harvard University Vision Sciences Laboratory, Cambridge, [3]Center for Mind/Brain Sciences, Università degli Studi di Trento, Polo di Rovereto, Italy

We investigated the extent to which motor relevant information is available from images of objects that are suppressed through binocular rivalry. The dorsal object processing stream has been shown to be activated by visible tools, as well as by tools that are suppressed through binocular rivalry (Fang and He, 2005, NN, 10, 1380-1385). Evidence also suggests that visuomotor processes sub-served by the dorsal stream are automatically activated when participants are presented with manipulable objects (e.g., Culham, et al., 2003, EBR, 153(2), 180-189). Motor facilitation has been observed when manipulable objects are presented in such a way that the handles of the objects afford a reaching/grasping action (Tucker and Ellis, 1998, JEP:HPP, 24(3), 830-846) – participants are faster to respond to auditory stimuli with the hand toward which the objects' handles are directed.

In our study, right-handed participants viewed pictures of manipulable objects with their handles directed towards participant's left or right hand. These pictures could either be visible or suppressed. Participants' overt task was to respond, using their left or right hand, to the pitch of an auditory tone presented after the image of the manipulable object was displayed (e.g., low tones/left hand; high tones/right hand). D-prime measures confirmed that participants were unaware of the contents of the suppressed images.

We obtained a motor facilitation effect for both visible and suppressed tools – participants were faster to respond to tones with the hand toward which the handle of the object was oriented. These data suggest that motor relevant information is processed even when it is suppressed. In addition, our effect was present only for right-hand responses. This is in line with recent data that suggests that right-hand, but not left-hand, visually-guided actions are refractory to visual illusions (Gonzalez, Ganel, and Goodale, 2005,VSS Abstracts, 97).

Acknowledgement: We wish to thank Brandi Newell for her help collecting data. The research reported here was supported by NIH Grant DC04542 to AC. JA was supported by a FundaÁ„o Calouste Gulbenkian. BZM was supported by a NSF Graduate Research Fellowship.

Attention: Selection, Enhancement, and Orienting

Author Presents: 10:30 am – 12:15 pm

D70 531 Attending to peripheral cues distorts objects, but attending to central cues does not

Sara Stevens[1] (sara.stevens@utoronto.ca), Jay Pratt[1]; [1]Department of Psychology, University of Toronto

Much is known about the temporal consequences of allocating attention in the visual field; targets are detected faster at cued locations. The spatial consequences, however, are much less understood. One such spatial consequence is the attentional repulsion effect (ARE), where a brief peripheral cue appears to shift the location of a Vernier stimulus in the opposite direction to where the peripheral cue was located. It has been suggested that the ARE interacts with dorsal stream processing, although it is not known whether object information carried by the ventral stream is also affected. The present study investigates if the ARE influences the shape perception of objects. The first experiment used peripheral cues and showed that a diamond shaped object presented at fixation appeared skewed in the direction opposite the cue. To examine if the ARE for objects is limited to exogenous peripheral cues, two additional experiments were conducted with central gaze and arrow cues, respectively. These central cues, that generate reflexive shifts of attention, were not found to generate AREs. Overall, the present study illustrates that the ARE influences ventral stream shape perception when peripheral reflexive cues are used, but not for central reflexive cues. The ARE could be due to receptive field shrinking, where the peripheral cues capture attention, which in turn sharpens the spatial tuning of the receptive fields in that area. The consequence of this is that receptive fields opposite the cue become spread out and objects therefore appear distorted.

D71 532 Probing the missing link between sources and targets of attentional control: a concurrent TMS/fMRI study of visuospatial selection

Klaartje Heinen[1] (kheinen@gmail.com), Christian Ruff[1], Sven Bestmann[2], Felix Blankenburg[1], Jon Driver[1], Bertram Schenkluhn[1], Otto Bjoertomt[1], Vincent Walsh[1], Chris Chambers[1]; [1]Institute of Cognitive Neuroscience ,University College London, [2]Functional Imaging Laboratory,University College London

Converging evidence from neuroimaging, neuropsychological, and TMS studies suggests that selective spatial attention is controlled by a cortical network including the posterior parietal cortex (angular gyrus, intra-parietal sulcus) and prefrontal cortex (frontal eye field, inferior frontal gyrus). At the same time, neuroimaging studies have established that activity in human striate and extrastriate visual cortex (V1-V5) is modulated by the spatial distribution of visual, auditory and somatosensory attention. Crucially, however, there is little direct evidence connecting sources of attentional control in frontoparietal cortex with sensory gating in visual cortex. Here we probed this missing link by establishing simultaneously the effects of Angular Gyrus (AG) stimulation on spatial orienting behaviour (TMS) and the corresponding BOLD response to behaviourally relevant stimuli in visual cortex (fMRI). Human participants undertook a covert-orienting task in a concurrent TMS/fMRI environment. On each trial, a coloured letter target flanked by distractors was preceded by a peripheral and behaviourally irrelevant spatial cue. To disrupt spatial reorienting of attention between the cue and target (required only on invalid trials), a rapid train of TMS was delivered to the right AG synchronously with target onset. At the same time, the target-related BOLD response was measured in areas V1-V5. Of particular interest was the relationship between the TMS-induced deficit of spatial attention and corresponding changes in the retinotopic representation of behaviourally relevant targets. Results provide new insights into the causal link between attentional control processes in the parietal cortex and sensory selection at various levels of the human visual system.

Acknowledgement: This research was supported by the Biotechnology and Biological Sciences Research Council (BBSRC, UK), through a David Phillips fellowship held by C.D. Chambers.

D72 533 Top-down attentional modulation of visual neglect in cancellation tasks

Margarita Sarri[1] (m.sarri@ucl.ac.uk), Jon Driver[1]; [1]Institute of Cognitive Neuroscience & Department of Psychology, University College London

Visual neglect following stroke does not invariably affect a fixed portion of space, but instead can be modulated by stimulation and task demands, including apparent attentional factors. Different versions of clinical cancellation tasks can reveal different degrees of neglect in the same patient, possibly due to variations in the attentional demands, although different versions typically vary in both top-down and bottom-up ways. Here we describe three cancellation experiments in which we manipulated solely 'top-down' attentional factors in different versions of a cancellation task, while always keeping visual displays identical across conditions. Our results show overall that top-down attentional demands can have a major impact on neglect performance in cancellation, with increasing demands on visual attention adversely affecting exploration towards the contralesional side. Specifically, we show that the level of difficulty for the required target discrimination (on the same stimulus displays) can dramatically modulate neglect performance. Further, that increasing discrimination difficulty for every item in the display can increase the number of contralesional omissions, even when no target selection process is required; but neglect can be more severe when attention has to be selectively directed to specific target among non-targets. We also investigate the possible effects of shifting attention from a more 'global' to a more 'local' level of discrimination, showing that while this may have some effect it is not a necessary condition for neglect to be exacerbated by discrimination difficulty.

D73 534 Faster, more intense! TheRelation between Attention-induced Event-Related Potential Amplitudes, andSpeed of Responding

Durk Talsma[1] (d.talsma@psy.vu.nl), Manon Mulckhuyse[1], Jan Theeuwes[1]; [1]Cognitive Psychology Dept. Vrije Universiteit, Amsterdam

Recent studies have provided evidence for a neurobiological model of attention, in which a fronto-parietal network of brain areas is responsible for orienting, shifting, and maintaining the focus of attention. These control areas are hypothesized to send biasing signals to perceptual brain areas, which have the effect that the sensitivity of perceptual areas responding to the attended (i.e. relevant) stimulus features are increased, whereas the sensitivity of perceptual areas responsive to irrelevant stimulus features are attenuated. Such a model would predict a direct relation between the strength of attentional orienting and; a) an enhancement of sensory responses in visual cortex to attended stimuli, and b) a decrease in response time. Here we examined this prediction by relating the amplitude attention-shift related ERP components to reaction-times. This was done using Posner's symbolic cueing paradigm. A cue predicted the location of an imperative stimulus (50% valid, 33% non-informative, and 16% invalid) to which participants were required to make a speeded two-choice response. Validly cued trials were sorted according to reaction time. ERPs differed systematically as a function of response time. All validly cued trials showed a shift-related positivity in the cue-target interval, but this effect was attenuated on the slowest trials, indicating a reduction of attentional effectiveness. Imperative stimuli elicited P1 and N1 components, of which the N1 varied as a function of reaction time. Faster responses corresponded with a larger N1 amplitude, suggesting a direct correspondence between the efficiency of stimulus processing and the sensitivity of visual cortex.

D74 535 The Locus of Processing Interference Produced by Salient Visual Distractors

Edward F. Ester[1] (eester@uoregon.edu), Edward Awh[1]; [1]Department of Psychology, University of Oregon

Numerous studies have shown that response latencies to visual targets are slowed by the presence of an irrelevant singleton. Some have suggested that these items impair target processing by biasing pre-attentive stages of processing. However, modulations in response latency may also be driven by disruptions that occur during post-perceptual stages of processing such as response selection. Nonetheless, if an irrelevant singleton biases pre-attentive processing, it should also disrupt the accuracy of target discrimination in a data-limited task. Recently, using a go/no-go version of a traditional additional singleton task, Theeuwes and colleagues have shown that the presence of an irrelevant singleton within a visual display produces a significant reduction in accuracy, consistent with the notion that pre-attentive processing was impaired. However, the observed d' cost in this study might also be explained by a reduction in observers' response thresholds on singleton-present trials. If the presence of the irrelevant singleton increased the likelihood of a "go" response, then false alarm rates would increase even though target discriminability was unaffected. In the present experiments, we sought to provide an additional test of the claim that irrelevant singletons disrupt in pre-attentive processing. First, we replicated the typical response latency cost that has been reported in the additional singleton paradigm. We then modified this task by using brief displays (<80 ms.) and backward masks. Observers made unspeeded responses to a target item defined by a specific attribute. Because of the nature of this task, it is unlikely that any performance would be influenced by disruptions in post-perceptual processing. Under these conditions, we find that a salient distractor item produced no cost in target discriminability, suggesting that singleton items do not disrupt pre-attentive processing, but instead influence later, post-perceptual stages.

D75 536 Features or space: Which dominates attentional selection?

Ilia Korjoukov[1] (i.korjoukov@nin.knaw.nl), Pieter Roelfsema[1,2], Jillian Fecteau[1,3]; [1]Netherlands Institute for Neuroscience, [2]Vrije University Amsterdam, [3]University of Amsterdam

Attention can be directed to two sources of information: to features or to space. In this study, we explored how priming affects these two types of attention. Observers performed a visual search task, in which they indicated whether a pre-specified target was a vowel or a consonant. Four letters served as potential targets. Unbeknownst to the participants, two letters were primed: one appeared in the same color 75% of the time and one appeared at the same location 75% of the time. We assumed that color priming would have a greater influence on feature-based attention and location priming would have a greater influence on space-based attention.

We found that color and location priming shared many features: both forms of priming sped up reaction times to a similar degree and started in a comparable number of trials. Important differences were observed as well. Location priming facilitated all targets appearing at the primed location, whereas color priming was specific to its primed letter. In a second experiment, we tested whether color and location priming are independent by adding a third condition, in which the target appeared in the same color and at the same location 75% of the time. We found that the combination of color and location priming was additive – the advantage of 'both' equaled the sum of each one. Therefore, feature-based and space-based attention possess different characteristics. Location priming may facilitate processing at an earlier stage, which benefits all targets. By contrast, color priming acts at a later stage where shape and color are integrated. Additional experiments show the mechanisms of this color priming – the situations in which it does and does not generalize.

Acknowledgement: The authors thank Jolanda Roelofsen for her help with data collection. Funding for this study was provided by the Canadian Institutes of Heath Research and the Nederlandse Organisatie voor Wetenschappelijk Onderzoek.

D76 537 Equisalience This !

Frédéric Poirier[1] (jamfpo@yahoo.com), Frédéric Gosselin[1], Martin Arguin[1]; [1]CERNEC, Université de Montréal

Introduction. Visual saliency plays an important role in early vision, guiding both attention shifts and eye movements. Visual saliency thus forms a central role in many models of early visual processing (e.g. Itti, 2006, VisCog; Zhaoping & Snowden, 2006, VisCog; Wolfe & Horowitz, 2004, NatRevNeurosci). Using a novel psychophysical method to measure saliency, we derive perceptual fields of contextual modulation.

Methods. The stimulus is a grid of right- or left-oblique red or green lines on a black background. Line luminance varies continuously over the image, which participants (N=9) adjust locally towards equisalience using a mouse. Assuming that systematic deviations from equiluminance are indicative of compensation for saliency, local luminance setting correlates negatively with local saliency.

Results. Perceptually salient image regions are more heterogeneous in color and orientation, indicative of short-range iso-feature inhibition. Perceptual fields of context modulation are obtained by correlating image properties with local saliency. Specifically, certain combinations of features correlated with local saliency, the strength of which was dependent on the distance between items containing these features. Using this analysis, we show that: (1) color center-surround fields for different-color are stronger but operate over shorter ranges than for same-color, (2) parallel orientations are inhibited, but less so if continuous, and (3) orthogonal orientations are more salient when end-stopping another line rather than being end-stopped. On average, these perceptive fields predict luminance and account for 60% of the variance in the data.

Discussion. These new results can be compared to predictions from current models of visual salience. Moreover, this new method is sensitive within the normal functioning range, where most current research methods produce ceiling effects and flat reaction time functions. Here, we used a simple stimulus to validate the method, but the method can be generalized to any stimulus (e.g. reading, visual textures, natural images).

D77 538 Spatial and temporal range for nonretinotopic integration of color and motion.

Wei-Lun Chou[1] (f90227011@ntu.edu.tw), Patrick Cavanagh[2,3]; [1]Department of Psychology, National Taiwan University, [2]Department of Psychology, Harvard University, [3]Department of Psychology, University of Paris 5

We used targets in apparent motion to study the spatio-temporal integration of color and motion features. In our display, 10 stimulus patches of colored dots were arrayed in a circle around fixation. The color of the dots in each patch alternated rapidly between red and green and the dots within each patch were also moving and they changed their direction from inward to outward (although the patch itself did not move) in synchrony with the color changes. Participants reported the color or the motion of the patch that was surrounded by a ring. In the stationary attention condition, the ring was flashed on and off at a fixed location, surrounding the target color or motion on every other frame. In the moving attention condition, the ring jumped from one location to the adjacent one on each frame. Because adjacent locations alternated in counterphase, the moving ring surrounded the same target color or motion on each frame and generated the percept of a single target in apparent motion, jumping from location to location around the array. Performance for reporting the individual feature (motion or color) was greatly enhanced in the moving attention case and performance also accumulated across locations, suggesting nonretinotopic integration. To determine the spatial and temporal range over which the integration occurred, we introduced gaps in the stimulus array by deleting every second location. Now the moving ring encircled the target feature only at each second location and the intervening locations were blank. Despite the spatial and temporal gaps that this introduced, there was little loss in performance when reporting color. However, there was a significant loss in performance for reporting the motion. These results suggest that the spatial and temporal ranges for integrating color and motion are different.

Acknowledgement: Wei-Lun Chou is supported by Graduate Students Study Abroad Program of the National Science Council, R.O.C. (Taiwan).

D78 539 Category expectation facilitates discrimination of complex objects

Amrita Puri[1] (ampuri@ucdavis.edu), David Whitney[2,3], Charan Ranganath[1,3]; [1]Center for Neuroscience, University of California, Davis, [2]Center for Mind and Brain, University of California, Davis, [3]Department of Psychology, University of California, Davis

It is well established that attentional cueing can facilitate processing of low-level visual attributes. However, it is unclear whether expectation at the category level can also result in facilitated processing. Here, we addressed this question by examining the effects of category-level cues on performance on a visual discrimination task. Stimuli were generated by morphing two "parent" images in varying degrees. One set consisted of morphs between two faces and another consisted of morphs between two places. On each trial, a valid (60% of trials) or invalid (20% of trials) category-level cue ("FACE", "PLACE"), or a neutral (20% of trials) cue ("XXXXX") was presented, followed by presentation of a morphed stimulus. Participants were required to decide which of the parent images was closer to the morph. Discriminability was higher after valid cues than after invalid cues, indicating that perception was enhanced when subjects were expecting the correct category. This effect could not be attributed to "unexpectedness" of targets in the invalid condition, because performance on valid trials was also improved relative to neutral trials. Additionally, analyses of RT data revealed that responses were faster after valid cues than after invalid cues. These results are consistent with the possibility that category-level expectation can enhance discrimination of complex visual stimuli.

D79 540 Faces Show No Prior Entry Effects

Greg West[1] (greg.west@utoronto.ca), Jay Pratt[1]; [1]Department of Psychology, University of Toronto

Visual prior entry effects, as measured by temporal order judgments (TOJs), are a sensitive measure of attentional capture. In the present study, we investigated if face stimuli tend to capture attention more effectively than non-face stimuli. To do so, we used a novel TOJ paradigm in which participants were presented with pairs of stimuli on either side of fixation cross arriving at different SOAs (12ms – 132ms) without any preceding cue. The task was to simply indicate which stimulus item had the first onset. If faces do show enhanced prior entry compared to non-face stimuli, then greater accuracy for face stimuli should be observed at short SOAs. First, we compared an innocuous abstract object against a neutral schematic face and, somewhat surprisingly, found the abstract object had a greater prior entry effect at SOAs of 12 and 24 ms. To further investigate this finding, a second experiment contrasted a schematic neutral face and a schematic mad face as earlier research indicates that attention is biased towards emotional faces compared to non-emotional faces. Here no significant difference at any SOA was found, with performance remaining at chance for shorter SOA. A third experiment that masked both stimulus items 100 ms after the second stimulus onset once again contrasted a mad face with an inverted neutral face, again revealing no prior entry effects for the mad face stimulus. A final experiment varied the spatial location of the stimulus onsets confirming the abstract object's ability to show visual prior entry over the face stimulus. These findings suggest that attention is not reflexively biased towards the detection of faces.

D80 541 What's in a name? Species of Redundancy in Visual Target Detection

Boaz Ben-David[1] (boaz.ben.david@utoronto.ca); [1]University of Toronto at Mississauga, Centre for Research on Biological Communication Systems

In a series of seven experiments this study examined the effect of similarity -- among targets, among distractors, and across targets and distractors -- on visual target detection in the redundant target design (RTD). A pair of stimuli can be same in (at least) three ways: physically (AA), nominally (Aa) or semantically (AE). The issue of similarity of the pertinent stimuli has drawn considerable attention in studies of same-different judgment (SDJ) and visual search, but has been neglected in studies of RTD. In particular, nominal sameness has not been addressed within RTD. The mission of this work was to redress this situation.

Target-distractor similarity: Performance deteriorated to a comparable extent when the distractor went by the name of the target, or when it resembled the physical appearance of the target. Observers likely processed the nominal attributes of the stimuli, although it was gratuitous to the task at hand. Target-target similarity: Detection of double-targets was faster when the two targets in the display were identical than when they were physically distinct. Distractor-distractor similarity: Rejection of distractor pairs was fastest when the stimuli were physical replicas, again, demonstrating superiority for physical sameness.

The analysis was augmented by the mathematical tools offered by Systems Factorial Technology. Two rival modes of processing, serial and parallel, accounted for selected portions of the data. I adapted for the RTD a hybrid model with two processors -- a fast parallel processor, and a slower serial processor -- that has been suggested in studies of visual search and SDJ.

Collectively, the results show that similarity, notably common names, must be taken into consideration in studies of RTD. Performance is fastest with physical sameness. However, nominal sameness, hitherto unexamined in RTD, affected performance to a great extent. People activate the names of the stimuli and these names affect their detection.

Acknowledgement: This research is supported in part by a strategic training grant – communication and social interaction in healthy aging, and a group grant on sensory and cognitive aging, both funded by CIHR.

D81 542 Priming effects reveal distinct attentional mechanism

Kimberly Halvorson[1] (kimberly-halvorson@uiowa.edu), Eliot Hazeltine[1], William Prinzmetal[2]; [1]Psychology Department, University of Iowa, [2]Psychology Department, University of California, Berkeley

Spatial cues can direct attention toward a particular location in the visual field. Prinzmetal, Park, and McCool (2005) proposed that two distinct types of attention are engaged by these spatial cues. Voluntary attention is engaged when the cues are predictive of the target's location and serves to facilitate the perceptual representation of the object (evidenced by increased accuracy of the response following a valid cue), as well as indicate the location of the target (evidenced by a faster response following a valid cue). Involuntary attention is engaged whether the cues are predictive or not and serves to select an object for a response, which is reflected in faster response times, but does not increase the accuracy of the perceptual representation. The goal of the present study was to test the dissociation between these two types of attention within the response time domain. Participants made speeded responses indicating the direction of an arrow that appeared in either the spatially cued (valid) or uncued (invalid) location. Separate groups of participants performed the task with predictive cues, to invoke voluntary attention, or nonpredictive cues, to invoke only involuntary attention. A small priming arrow appeared prior to the onset of the target arrow for 50 ms. The reaction time effect of this prime provided an index of perceptual enhancement. Faster response times were recorded for valid trails, but a larger priming effect was observed only when the prime appeared in the cued location and when voluntary attention was invoked, consistent with the proposal that voluntary and involuntary attention play distinct computational roles.

D82 543 On the relationship between flanker interference and localized attentional interference

Jason S. McCarley[1] (mccarley@uiuc.edu), Jeffrey R. W. Mounts[2]; [1]University of Illinois at Urbana-Champaign, [2]SUNY-Geneseo

Background: Studies of flanker interference (FI) have suggested that spatial attention operates as a spotlight or gradient within the visual field, selecting stimuli within the attended region (e.g., Eriksen & Hoffman, 1973). In contrast, recent data suggest that it is difficult to divide attention between multiple objects that are near one another in the visual field, an effect that has been called localized attentional interference (LAI) and has been attributed to competition between visual objects for the control of neural resources (e.g., McCarley, et al, 2004; Mounts & Gavett, 2004). The present experiments examined the relationship between FI and LAI. Method: Observers made speeded identity judgments of a colored target letter embedded in an array of gray filler letters. A response-compatible or -incompatible flanker letter of a nontarget color appeared at varying distances from the target. RTs for target judgments were analyzed as a function of target-flanker separation and compatibility. Results and conclusions: Data gave evidence of LAI together with spatially graded FI, with mean RTs and flanker compatibility effects both decreasing as target-flanker separation increased. A second experiment found that both forms of interference were reduced when the target location was spatially cued prior to imperative display onset, confirming that both effects were attentional. Results suggest a model in which distance from the focus of spatial attention modulates the relative strength of stimulus objects competing for visual representation.

D83 544 Attention does not influence critical spacing

Miranda Scolari[1] (mscolari@uoregon.edu), Andrew Kohnen[2], Brian Barton[1], Edward Awh[1]; [1]Department of Psychology, University of Oregon, [2]Department of Sociology, University of California, Berkeley

Crowding refers to the phenomenon in which nearby distractors impede target discrimination, possibly because of the excessive integration of target and distractor representations. Crowding is reduced as target-distractor distance increases, and is eliminated entirely at a distance that is labeled the critical spacing point. To determine which factors influence critical spacing, we examined three factors that are known to facilitate target identification in crowded displays: spatial attention, distractor preview, and target popout.

Previous evidence suggests that spatial attention can facilitate target processing by biasing the competitive interactions between targets and distractors in favor of the relevant stimuli (e.g., Desimone & Duncan, 1995). If this is the case, then critical spacing might also be reduced because of reductions in the strength of distractor representations. We manipulated attention by presenting peripheral cues that elicited stimulus-driven shifts of attention either towards or away from the target location. As demonstrated in previous studies, spatial cueing led to robust improvements on target discrimination. Despite these benefits, however, attention did not reduce critical spacing.

Distractor preview was examined by manipulating whether the crowding distractors were presented prior to or simultaneous with the target. Popout was examined by manipulating whether there was a salient color difference between the target and distractors. Again we found robust benefits of preview and popout in crowded displays. Furthermore, both preview and popout caused large reductions in critical spacing, perhaps by reducing the integration of target and distractor representations via Gestalt grouping cues. This hypothesis may also explain why spatial attention did not influence critical spacing, given that the bottom-up grouping cues between targets and distractors remained constant across the valid and invalid spatial cues. In this case, stimulus-driven shifts of attention may have enhanced target processing without directly influencing the tendency to group targets and distractors.

Acknowledgement: This research was supported by National Institute of Mental Health Grant R01 MH64119, awarded to Edward Awh. We are grateful to Gordan Logan, Denis Pelli, and two anonymous reviewers for their helpful comments and discussion. Thanks also to Adam White for assistance with data collection.

D84 545 Viewpoint Invariant Object Features Attract Overt Visual Attention

Jeremiah D. Still[1] (jeremiah@iastate.edu), Veronica J. Dark[1], Derrick J. Parkhurst[1]; [1]The Department of Psychology and The Human Computer Interaction Program, Iowa State University

Previous research suggests that salient image features attract overt shifts of attention when participants freely view complex artificial and natural scenes (Parkhurst, Law & Niebur, Vision Research, 2002). This evidence is consistent with the influence of a bottom-up stimulus-driven mechanism of attentional guidance. Attention to salient image features is a plausible default information selection strategy, especially in the absence of a well-defined task.

Given that object recognition is necessary for most natural visual tasks, a plausible alternative default strategy is to preferentially select information likely to be important for object recognition. Object recognition depends in part on the presence of visual features that remain invariant across viewpoints (Biederman, Psychological Review, 1987). Thus, it is possible that viewpoint invariant features of objects will attract visual attention.

To examine this possibility, the eye movements made by 12 participants freely viewing images of objects were recorded. Within each image, the Scale Invariant Feature Transform (SIFT) algorithm was used to identify highly invariant features (Lowe, International Conference on Computer Vision, 1999) and the Saliency model was used to identifiy salient features (Itti, Koch & Niebur, IEEE Transactions on Pattern Analysis and Machine Intelligence, 1998). Because the predictions of the two models can be highly correlated, we selected images of 100 different objects from the Amsterdam Library of Object Images (Geusebroek, Burghouts & Smeulders, International Journal of Computer Vision, 2005) that maximally decorrelated the predictions.

Both models performed significantly better than chance. The SIFT model performed signifcantly better than the Saliency model. These results suggest viewpoint invariant features of objects attract attention as reflected in eye movements. They also support the hypothesis that the default attentional selection strategy is biased to select visual features likely to be important for object recognition.

D85 546 Endogenous orienting of attention is impervious to masked priming

Jay Todd[1] (jay.todd@vanderbilt.edu), René Marois[1]; [1]Vanderbilt Vision Research Center, Department of Psychology, Vanderbilt University

The hallmark of endogenous attention is that it is under voluntary control. However, it is well known that stimuli that are not consciously perceived can nevertheless prime perceptual, motor, and even semantic processing, suggesting that such primes can deeply affect information processing. Can subliminal primes therefore also influence endogenous control of attention? To address this issue, we devised a dual-task experiment in which a masked priming task (Vorberg et al., 2003) was embedded within an endogenous Posner cuing task. At trial onset, the prime, a non-predictive arrow pointing left or right, was briefly presented at fixation. Following a variable interval a larger arrow, serving as both an endogenous cue (80% validity) and a metacontrast mask for the prime, pointed to one of two peripheral locations where a subsequent target stimulus could appear after a variable delay. Subjects made a speeded manual response to target presentation and an unspeeded response to the prime identity (left vs right arrow). Subjects showed typical cue validity effects, with quicker target detection at cued relative to uncued locations. Prime validity effects (the prime's ability to orient attention independent of cue orientation) and prime-cue congruency effects (the influence of prime orientation on the cue in the orienting task) were only present when subjects were aware of the prime. In a second experiment, the two tasks were performed in separate sessions. Similar results to the first experiment were obtained when the prime identity task was performed before the orienting task, but no prime validity or congruency effects were detected with the reversed task order even when the prime was consciously accessible, suggesting that the prime only affects the cuing of attention when it has acquired task relevance. Taken together, these results indicate that only primes that reach awareness can control endogenous orienting of attention.

Acknowledgement: Supported by a National Institute of Mental Health grant to R.M.

D86 547 Time-words guide spatial attention

Ulrich Weger[1] (ulrich.weger@utoronto.ca), Jay Pratt[1]; [1]Department of Psychology, University of Toronto

Visuo-spatial cuing effects have been obtained with various types of cues such as arrows, eye-gaze or sudden onsets. Here we test whether the spatial associations of temporal cues also cause a visual orienting response. The representation of time often implies a spatial association, and for people from many Western societies this association goes such that temporally earlier events are associated with left-side space while temporally later events are associated with right-side space. In our study we tested whether this association also causes a visual orienting response. A time word (e.g. “yesterday”, “tomorrow”) appeared in the middle of the screen, followed by a target in either the left- or right-side periphery. Word cues did indeed facilitate target detection, such that left-side targets were responded to faster after word-cues referring to the past while right-side targets were responded to faster after word-cues referring to the future. The results indicate that there is indeed an association between the representation of time and space and that this association can influence the orientation of visuo-spatial attention.

D87 548 Spatial limits of shifting attention as revealed through the attentional walk task

Elisabeth Hein[1] (egh2@psu.edu), Cathleen M Moore[1]; [1]Department of Psychology, Pennsylvania State University

The attentional walk task provides a method of revealing spatial limitations of attentional control. In this task, observers are asked to move their attention from one item to another in response to a series of tones within an array of items. At the end of the tone series, observers report some attribute of the item (e.g., the color) on which the attentional walk ended. As the density of the arrays increase, performance decreases. The density at which the attentional walk fails can be taken as a measure of attentional resolution. We explored characteristics of attentional resolution as measured in a series of experiments that used different versions of the walk task. In one experiment, we explored how quickly observers could shift attention within an array of items. In another experiment, we explored how long observers could sustain attention on a single item within an array. In a third experiment, we explored whether observers could limit their attentional walks to a subset of items defined by color. Together the results suggest that performance in the attentional walk task is limited by the ability to control shifts of attention between closely spaced stimuli, rather by the extent of spatial selection.

Acknowledgement: This research was supported by NIH grant MH67793.

D88 549 Feature Binding and Spatial Awareness

Lynn Robertson[1,2] (lynnrob@socrates.berkeley.edu), Thomas VanVleet[1,2]; [1]Veterans Affairs Northen Calif Health Care System, Martinez, [2]University of California, Berkeley

Feature integration theory proposes that searching for a feature v. conjunction of two or more features is qualitatively different. Spatial attention is theoretically needed to bind features together, whereas basic features can be processed without spatial attention. Neuropsychological studies of patients with spatial deficits (unilateral visual neglect, Balint’s syndrome) have supported this distinction. Features can be detected without intact spatial maps, while conjunctions are either missed entirely or conjoined inaccurately (produce illusory conjunctions). However, it is unclear whether features are conjoined implicitly below the level of awareness, making accurately bound conjunctions inaccessible to awareness, or remain separate and are conjoined at the time of awareness. The present study was designed to address this question. We tested 3 patients with unilateral visual neglect after right MCA stroke and presented feature or conjunction shape/color displays in a circular array around fixation. We used a psychophysical staircase procedure and dual threshold measures to first estimate stimulus presentation times (TPT) that produced approximately 25% detection and 75% detection for both features and conjunctions in the defective field. In this way search was equated at two levels of difficulty for each type of display. This was immediately followed by a priming procedure showing the same feature or conjunction primes at the two estimated TPTs. Participants were asked to discriminate a single target that appeared in the center of the screen where stimuli were clearly perceived. Significant priming effects in reaction time to the probe were present for both types of primes and for both TPTs. More importantly, performance was independent of explicit detection rates in the feature prime condition but mirrored detection rates in the conjunction prime condition. These findings support a fundamental role for spatial awareness in conjunction search but not feature search and are not consistent with implicit color/shape binding.

Poster Session E

Sunday, May 13, 2:00 - 6:30 pm, Municipal Auditorium

Color and Surface Perception

Author Presents: 4:00 - 5:45 pm

E1 550 **The appearance of glossy, bumpy surfaces**

Yun-Xian Ho[1] (yunxian.ho@nyu.edu), Michael S. Landy[1,2], Laurence T. Maloney[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University

We investigated how two surface properties—gloss and bumpiness—interact in judgments of the perceived gloss and the perceived bumpiness of 3D textures. An ideal observer for gloss would ignore changes in bumpiness and an ideal observer for bumpiness would ignore changes in gloss. We used a conjoint measurement design to determine how much each property influences the judgment of the other. Methods: Stimuli were 3D textures composed of 400 overlapping ellipsoids. Ellipsoid heights were drawn from a uniform distribution whose range determined surface bumpiness. Each surface had one of five levels of bumpiness and one of five levels of gloss (i.e., five sets of parameters of the Ward reflectance model used to create the images). We rendered stereo images of the 25 possible surfaces under a rectangular light source at a fixed location relative to the surface. Six observers viewed the 325 possible pairings of surfaces and judged which surface of each pair was bumpier; six observers viewed the same pairs but judged which of each was glossier. We fit an additive conjoint measurement model to each observer's choice data using a maximum-likelihood criterion. Results: Increasing surface gloss made surfaces appear bumpier. Gloss increased perceived bumpiness by about 0.14 (ranging from -0.11 to 0.16 across observers) of our range of bumpiness. Increasing surface bumpiness also led to an increase in perceived surface gloss. Bumpiness increased perceived gloss by about 0.27 (ranging from 0.03 to 0.68 across observers) of our range of gloss. In both conditions, four out of six observers showed a significant effect of one cue on judgments of the other cue. While the visual system clearly attenuated the effect of each cue in judging the other, there is still significant interaction.

Acknowledgement: Grants EY16165 and EY08266 from the National Institutes of Health

E2 551 **Specular reflectance and the perception of metallic surfaces**

Isamu Motoyoshi[1,2] (motoyosi@apollo3.brl.ntt.co.jp), Takafumi Nishizawa[2], Keiji Uchikawa[2]; [1]NTT Communication Science Laboratories, NTT, [2]Department of Information Processing, Tokyo Institute of Technology

In daily life, we encounter a variety of objects made of metals including gold, silver, and aluminium, and easily distinguish them from non-metallic stuff. For example, we perceive gold as clearly different from glossy yellow, or silver from glossy gray. In physics, the metallic surface is typically defined as having an extremely strong specular reflectance relative to the diffuse reflectance. Here, we examined if and how human judgement of metallicity depends on this parameter under variable illuminations. Using an HDR display (BrightSide DR37P; 0.1 - 3500 cd/m2), we presented a list of seven computer-generated bumpy objects with variable specular/diffuse reflectance ratios simulated under variable scenes and levels of image-based illumination, and asked the observers to classify them into metallic and non-metallic ones. When the illumination level was low, the observers often judged mirrored objects as non-metallic, depending on the scene of illumination; e.g., a mirrored surface illuminated by few ramps in a church looked glossy, but hardly looked metallic. When the illumination level was comparably high with the real world (Lmax > 2000 cd/m2), on the other hand, the classification depended on the specular/diffuse ratio regardless of the scene (except a snow field). The judgement data, as well as the physical specularity, for objects under a fixed illumination was characterized by changes in the standard deviation, but not skewness, of the image luminance histogram. For most scenes, the effect of illumination level appeared to be related to the image mean luminance as an anchor. These results suggest a possibility that the perception of metallic surfaces is determined by simple image statistics, but in a different way from the perception of mere glossiness that mainly depends on skewness (Motoyoshi, Nishida & Adelson, 2005, JOV, 5, 569a).

E3 552 **Coding Contrast as Brightness to Convert Colour Images to Greyscale**

Marina Bloj[1] (m.bloj@brad.ac.uk), David Connah[2], Graham Finlayson[2]; [1]Bradford Optometry Colour and Lighting Lab, School of Life Sciences, University of Bradford, Bradford, UK, [2]School of Computing Sciences, University of East Anglia, Norwich, UK

In terms of human and machine vision it is often assumed that greyscale is simply the weighted sum of three colour responses. Thinking of greyscale (or luminance) in this way occasionally causes practical problems: details in pictures or graphics can be lost in greyscale reproductions if two different colours share the same weighted response. An alternative way to envisage the greyscale is as brightness encoding, whereby rather than using the luminance value at each pixel, the greyscale image represents the colour-contrast of the colour image as luminance-contrast. Socolinsky and Wolff (Socolinsky & Wolff 2002, IEEE Trans. Im. Proc. 11(8):923-931) have proposed an algorithm that achieves this goal. The algorithm consists of two stages: computing a gradient field using DiZenzo's structure tensor

(DiZenzo 1986, Comp.Vis., Graph, and Im. Proc. 33(1):116 – 125), and then reintegrating the gradient field to produce a greyscale image whose local luminance-contrast reflects the colour-contrast of the original image. This approach has two problems: firstly, there is no guarantee that it is possible to preserve colour contrasts perfectly in a greyscale reproduction; secondly, the range of greyscale values required to maintain colour-contrasts may exceed the range displayable on a given display device. In this work we mitigate the second problem using a tone reproduction curve, which maps the grey-level histogram of the reintegrated image towards that of the luminance image. We will show images and numerical measures that will demonstrate the advantages of this new method and discuss the future implications for both image processing (e.g. digital photocopying) and displaying accurate greyscale reproductions of colour images.

Acknowledgement: This work is supported by joint EPSRC grants number EP/E012248/1 and EP/E12159/1.
URL: http://www2.cmp.uea.ac.uk/Research/compvis/c2gart/

E4 553 Abstract withdrawn

E5 554 Isolusions: Evidence for strong geometric-optical illusions under isoluminance

Thorsten Hansen[1] (Thorsten.Hansen@psychol.uni-giessen.de), Kai Hamburger[1], Karl Gegenfurtner[1]; [1]Department of Psychology, University of Giessen

It has long been known that color and luminance are processed together by the same parvo retinal ganglion cells (De Valois & De Valois, 1988). Recently it has been shown that in the primary visual cortex cells respond to oriented chromatic contrast (Johnson et al., Nature Neurosci. 4, 2001), and that the vast majority of color-selective neurons in V1 and V2 are also selective for orientation (Friedman et al., J. Physiol., 548, 2003). On the contrary, a largely segregated processing of unoriented chromatic contrast and oriented luminance contrast has been hypothesized. This idea was bolstered by observations that geometrical-optical illusions vanish under isoluminance (Livingstone & Hubel, J. Neurosci. 7, 1987). Here we examine the strength of various geometric-optical illusions under isoluminance (Delboeuf, Ebbinghaus, Hering, Judd, Mueller-Lyer, Poggendorff, Ponzo, Vertical, Zoellner.) Subjects interactively manipulated computer-generated line drawings to counteract the illusion. In all cases, illusions presented under isoluminance (both for colors drawn from the cardinal L-M or S-(L+M) directions) were as high as the luminance versions (both for high and low contrast). In two control experiments we tested whether subjective deviations from the nominal isoluminance or chromatic aberrations may have caused the observed strong illusions under isoluminance. Again, no significant differences between the illusions under luminance or isoluminance occurred. Our findings show that geometric-optical illusions under isoluminance are as strong as when presented in luminance, supporting the joint processing of oriented color and luminance contrast in early visual areas. Furthermore, the results show that our conscious percept is deceived similarly for both isoluminance and luminance conditions, suggesting that the joint processing for chromatic and luminance defined contours extends well beyond early visual areas.

Acknowledgement: Supported by the German Science Foundation (grants Ge 879/5 and 885/1).

E6 555 Plasmid illusion : symmetrical composition for equiluminance condition

Seiichiro Naito[1] (snaito@keyaki.cc.u-tokai.ac.jp), Naoko Kato[1]; [1]Human and Information Science,Tokai University, Hiratsuka, Japan

A new illusion figure named Plasmid illusion (PI) is created. The advantage of PI is that the figure elements are arranged in symmetrical positions with respect to the center point so that they easily yield the equiluminance condition if a subject fixates at the center. We obtained clear reduction of the magnitude of illusion at equiluminance condition. The illusion was diminished to 20%. In general, some classical illusions lose the illusory effects at equiluminance condition and others do not. One of the typical examples for the latter would be Gravity lens illusion (GLI). We failed to find the equiluminance condition for GLI to reduce the illusory effect, even though we tried not only red-green colors but also light-blue-gray-yellow color combinations. The illusion persisted with the effect perfectly. One of the reasons for the no-reduction would be the difference of the equiluminace condition over different eccentricities. By preliminary measurements, we also found that the difference of the equiluminance condition between the fovea and some peripheral areas at around 10 degrees was more than 20%. The difference is far above the magno sensitivity. Therefore we draw a red ring on a gray background and put 4 white tiny test segments on the ring at symmetrical positions. Then we add 4 pieces of green inducing ring segments on the flank of the 4 test segments in opposite directions so that a pair has inward inducing ring segments and the other pair has outward segments. The test pair with inward segments looks closer and the other looks far. The PI is a variant of GLI. The inducing figures of GLI are arranged at highly distorted quadrilateral, while the inducing segments of PI are fit into the ring. The luminance of green is changed. The appearance of PI is similar to plasmids in biology.

E7 556 Evidence for common mechanisms subserving chromatic assimilation and Munker-White effect

Yung-Chun Lin[1] (mentist@gmail.com), Chien-Chung Chen[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

The brightness or color appearance of a uniform gray region can be affected by a patterned surround. Munker-White effect and chromatic assimilation from patterned surround (e.g., Monnier & Shevell, 2004, Vision Research, 44, 849-56) are two examples. Here we compared the spatial configuration effect on these two chromatic context effects. We used an asymmetric matching task in which an observer was asked to match the appearance of a comparison patch along a predesignated color direction to a reference patch. The reference patch was either a ring superimposed on a bull eye surround (concentric square wave) for chromatic assimilation or a bar superimposed on a horizontal grating surround for Munker-White effect. The square wave surround (3.3 c/deg) was modulated along either isochromatic or one of the two isoluminant (M-L and S-cone modulation) directions. The contrast of surround for each color direction varied from near threshold to 4 times threshold of the surround modulated at that color direction. The comparison patch was either a ring or a bar on a uniform background. The uniform background was gray (CIE-xy =(0.33, 0.33)) with luminance 15 cd/m^2. The reference and the comparison patches were also gray with luminance 20 cd/m^2. The phase of the surround was either 0 or 180 deg relative to the stimuli center.

Compared with the uniform surround, the patterned surround shifted the perceived brightness or color of the reference patch. The amount of shift, when measured at the same color direction and contrast, was similar for both the bull eye and the grating surround. The amount of shift was a linear function of the surround contrast on log-log coordinates. Our result demonstrates a great similarity between the context effects produced by bull eye and grating surrounds. This implies that common mechanisms may underlie chromatic assimilation and Munker-White effect.

Acknowledgement: Supported by NSC 95-2413-H-002-001

E8 557 Very-long-term chromatic adaption from short-term adapting stimulation

Suzanne Belmore[1] (sbelmore@midway.uchicago.edu), Steven Shevell[1]; [1]Visual Science Laboratories, University of Chicago

PURPOSE: A new technique for establishing very-long-term (VLT) chromatic adaptation (over days and weeks) was assessed and compared to the classical approach. Shifts in equilibrium yellow were measured following VLT adaptation to either long-wavelength room illumination for several hours per day (classical paradigm) or to a long-wavelength CRT pattern for 1 hour per day. The aim was to test whether the briefer CRT pattern produced VLT chromatic adaptation comparable to that invoked by longer-lasting illumination.

METHODS: (a) Both means of adaptation used a long-wave reddish-appearing light. In the classical condition, the subject spent 4 hours/day in a windowless room in which overhead light passed through a filter that allowed only 5% transmittance of wavelengths below 540nm (Judd x = 0.408, y = 0.420). In the new method, the subject viewed a moving grating composed of only the R phosphor of a CRT monitor (Judd x = 0.598, y = 0.345) for 1 hour per day. [We thank Dr. J. Neitz of the Medical College of Wisconsin, who suggested this approach to us.] (b) Measurements to assess color perception were performed either 22 hours (CRT) or 19 hours (room illumination) after the most recent adapting period. The subject set an admixture of 540nm-plus-660nm light to appear equilibrium yellow at 4 luminance levels between 3 and 100 trolands.

RESULTS: Both methods of chromatic adaptation produced VLT shifts in the chromaticity of equilibrium yellow as well as similar shifts back toward baseline during the 2-week post-adaptation recovery period.

CONCLUSION: Viewing a chromatic grating for 1 hour/day produces very-long-term chromatic adaptation. The CRT adapting stimulus has the following advantages over room illumination: the VLT adapting stimulation can be (1) retinotopically localized, (2) dichoptic (unequal in the two eyes) and (3) precisely controlled with respect to chromaticity and cone stimulation.

E9 558 Color constancy in 3D scenes: contrasting illumination-estimation and heuristic models

Laurence T. Maloney[1,2] (ltm1@nyu.edu), Katja Doerschner[3], David H. Brainard[4]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University, [3]Department of Psychology, University of Minnesota, [4]Department of Psychology, University of Pennsylvania

Purpose: The illumination of a surface patch can change with the location or orientation of the patch. Recent work indicates that observers partially discount the illumination in judging the color and lightness of matte surfaces. Whether this constancy is most usefully understood in the context of illumination-estimation models or as resulting from the action of a set of heuristics is a matter of current dialog. Here we test whether a coplanar ratio heuristic (see Gilchrist 1977) can parsimoniously account for performance. The test is whether the judged color of a surface depends strongly on the chromatic properties of light reflected from other scene surfaces that are coplanar with it.

Methods: Stimuli were computer-rendered stereo scenes, illuminated by a yellow punctate source and a blue ambient source. Embedded in each scene were two intersecting arrays of coplanar patches, one oriented at 45° azimuth and the other at -45°. One array (B) contained bluish surfaces while the other (Y) contained yellowish surfaces. A test patch near the center of the scene was presented at 45°, 0° or -45° azimuth. Observers adjusted the test patch until it appeared achromatic.

We manipulated the simulated reflectance of scene surfaces to dissociate the effects of coplanar surfaces from those of the scene illumination. In our initial experiments, the manipulation was a spatial reversal of the embedded B and Y arrays. We studied the effect of this manipulation for both sparse and rich scenes.

Results: The B-Y reversal of the coplanar arrays had no discernable effect on the achromatic settings. This result casts doubt on the general utility of the coplanar ratio principle. Further experiments will attempt to characterize the stimulus domain where this heuristic applies, and compare this to the domain where illumination-estimation models are effective.

Acknowledgement: NIH R01 EY08266 R01 EY015261 R01 EY10016 P30 EY001583

E10 559 Relational Color Constancy in the Absence of Ratio Constancy: 3D Scenes with Spatially Inhomogeneous Illumination

Holly E. Gerhard[1] (holly.gerhard@nyu.edu), Laurence T. Maloney[1,2], Razia Khan[1]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University

Craven & Foster (1992) found that observers could distinguish illuminant chromaticity changes from surface color changes in Mondrian scenes. The change in illuminant did not affect the photoreceptor excitation ratios across edges; they concluded that the visual system detected surface changes as ratio constancy violations. In 3D scenes, with multiple illuminants and matte surfaces at many orientations, changes in the positions or chromaticities of light sources need not leave edge ratios invariant. We examine how well observers can distinguish changes in light source position from matched changes in achromatic surface colors in such scenes. **Stimuli**: We rendered stereo pairs of scenes containing 4-sided achromatic pyramids with randomized heights and facet albedos under a combination of a collimated light source and a diffuse light source. On each trial, observers viewed a set of pyramids illuminated by a light source perpendicular to the ground plane for 1500ms, immediately replaced by a second scene that differed in collimated source direction or surface albedos. On light change trials, the collimated source could move 2, 4, 6 or 8 degrees. Surface change levels were matched in magnitude of space average and variance in color signals, as were ratio changes between adjacent facets. There were no visible cast shadows. **Task**: Observers judged whether a light or surface change had occurred. **Analysis**: We computed d' estimates for each of four light and surface change conditions (240 trials/estimate). **Results**: Three naïve observers completed the experiment. Estimates of d' increased significantly from a mean of 0.7 at 2 degrees to 2.6 at 8 degrees, significantly greater than zero even with a 2 degree positional change. **Conclusion**: In 3D scenes with non-homogeneous illumination, observers can discriminate very small changes in the spatial distribution of light from matched surface changes despite the lack of ratio constancy between adjacent surfaces.

Acknowledgement: Support: NIH EY08266

E11 560 Memory color effects on color appearance under varying illumination

Maria Olkkonen[1] (maria.olkkonen@psychol.uni-giessen.de), Thorsten Hansen[1], Karl Gegenfurtner[1]; [1]Department of experimental psychology, Justus Liebig University Giessen

Humans generally perceive approximately constant object colors despite large variations in illumination. Color constancy is presumably mediated by several mechanisms operating on different levels, ranging from photoreceptor adaptation to contextual effects. We have recently shown that color appearance of familiar objects can be biased towards that object's typical color, which might be an additional mechanism for color constancy. Here we investigate whether these top-down influences are robust to changes in illumination. We asked 10 observers to adjust the color of eight fruit and vegetable objects displayed on a monitor to either their respective typical colors or to an achromatic color. In addition, observers made the achromatic settings with homogeneous discs and 1/f noise patches. We used a neutral illuminant (D65) and four other illuminants that were taken from the cardinal axes of DKL color space (bluish, yellowish, greenish and reddish). The achromatic settings generally shifted close to the illuminant chromaticity. Observers showed nearly perfect color constancy under the bluish, greenish and reddish illuminants, and good constancy under the yellowish illuminant. Constancy was best with the disc stimuli. The fruit achromatic settings shifted with the illuminant nearly to the same degree as the disc settings, and the fruit typical settings shifted as much as monitor gamut allowed. As previously found with a neutral illuminant, there was a bias in the fruit achromatic settings towards the opposite direction from the typical settings under all illuminants. Thus, observers had to compensate for the top-down influences of object identity on color appearance regardless of lighting condition. The robustness of the memory color effect indicates that it is a plausible additional mechanism for color constancy, acting by pushing color appearance of a familiar object towards its typical color under any illuminant chromaticity.

Acknowledgement: Supported by German Science Foundation Ge-879/5.

E12 561 Neural correlates of color category processing

Elisabeth Fonteneau[1] (e.fonteneau@gold.ac.uk), Jules Davidoff[1]; [1]Department of Psychology, Goldsmiths College, University of London

Previous research using behavioral techniques reveals that the sensory color continuum can be modified by category. Within-category stimuli (Green0-Green1) now look more similar and are harder to distinguish whereas between-category stimuli (Green0-Blue0) look more different and are easier to distinguish even though their distances in color space are equal. We report the first evidence for the neurophysiological architecture of color categories. We compared event-related brain potentials (ERPs) elicited by physically identical colors (Green0) in three different color contexts in an oddball paradigm while twenty participants performed an unrelated color task. Two of the contexts were different color categories (large distance: Green0-Red0 vs. small distance: Green0-Blue0) and the third context was different colors from the same category (Green0-Green1). Our results showed that deviant colors stimuli in all three different contexts elicited a positive deflection in the posterior regions - the change-related positivity - compared to standard stimuli. In addition, both magnitude of color difference and category difference reduced the latencies of the change-related positivity (34 msec and 20 msec respectively). No amplitude effect was found to correlate with either color magnitude or color category. We conclude that the change-related positivity reflects color category as well as color deviancy processing. Moreover, category effects were not lateralised and suggest that, even if color categories are derived from the color terms of a speaker's language, the changes to color appearance have been effected at a site within visual cortex.

Acknowledgement: This research was funded by EC grant No 012984 for Stages in the Evolution and Development of Sign Use (SEDSU).

E13 562 Color preferences across contexts as predicted by colorimetric variables

Karen B. Schloss[1] (kschloss@berkeley.edu), Stephen E. Palmer[1]; [1]University of California, Berkeley

A common assumption is that people have a single set of stable color preferences. We investigated color preferences in different contexts to find out whether this assumption is justified and, if not, what sort of systematic regularities and/or differences might hold. We tested participants' preferences for 37 colors sampled systematically from the Munsell space: 8 hues (unique red, green, blue, and yellow plus their approximate angle bisectors of orange, purple, cyan, and chartreuse) at 4 brightness/saturation levels, plus 5 achromatic colors at corresponding lightnesses. Subjects rated their preference for each color in each of a variety of imagined contexts: room walls, couches, dress-shirts/blouses, t-shirts, etc., in addition to context-free ratings of pure color preference. Cross-context correlations for the 37 colors varied widely, but many of the differences were systematic. Regression analyses showed that models based on colorimetric variables (participant-rated redness/greeness, blueness/yellowness, lightness/darkness, and saturation) predicted, on average, 65% of the variance across contexts, but different variables were differentially important in predicting color preferences, depending on the task. For example, hue dimensions (blue/yellow and red/green) explained the majority of the variance for the context-less ratings of pure color, with little effect of either lightness or saturation. In all other contexts, however, one or both of the latter variables was important. For example, saturation accounted for the most variability in both wall and couch color preference, with a clear preference for less saturated colors in both tasks. Analyses of individual differences showed variability in the importance of these factors as well. Our results show that although people do not have a single set of stable color preferences across tasks, their preferences are nevertheless orderly and can be predicted from colorimetric variables.

URL: http://socrates.berkeley.edu/~plab/projects.htm

E14 563 The hedonics of colour

David Simmons[1] (david@psy.gla.ac.uk), Katy Asher[1]; [1]Department of Psychology, University of Glasgow

Which colours make us feel happy? And which sad? As last year (Simmons, VSS 2006) we approached the colour-emotion relationship issue systematically by running a series of experiments in which participants were presented with an array of three coloured patches, chosen from a limited set of ten, on a neutral gray background. The colour set was chosen based on pilot experiments and the colours were specified using CIE coordinates. A series of four experiments were performed using 39 participants. In the first two, participants were asked to choose which of the three colours made them feel the happiest; in the second two, which of the three made them feel most sad. All possible three-colour combinations from each set were tested, allowing a happiness and sadness hierarchy to be established for each colour set. For the happy-sad dimension there was a clear effect of saturation, with the more saturated colours tending to evoke more "happy" responses and less "sad" responses. The saddest colours in a given set were always the least saturated. However, hue was also found to be important for happiness in that the most happy responses were reported for a sunny yellow in both test sets. Taken together with the results from Simmons (2006), we suggest that there are four universal factors which strongly influence emotional responses to colour. The first is an arousal component related to the perceived depth of the colour (far-away things tend to be bluer and grayer). The second is a pleasure component related to the saturation of the colour. The third is an aversion to yellow-green and brown due to unpleasant associations, whilst the fourth is a strong affinity to sunny yellows due to associations with fine weather. These rules are largely consistent with extant data on colour and emotions and inform current theories of visual aesthetics.

Perceptual Learning III

Author Presents: 2:00 - 3:45 pm

E15 564 Effects of experience and task type on unsupervised categorization of novel, 3D objects

Theresa Cooke[1] (theresa.cooke@tuebingen.mpg.de), Christian Wallraven[1], Heinrich Buelthoff[1]; [1]Department of Cognitive and Computational Psychophysics, Max Planck Institute for Biological Cybernetics

Rosch et al. (1976) and others have argued that the shape of objects is a fundamental determinant of category structure. In a previous study, we observed that after ten hours of visual exposure to a series of novel, 3D objects, subjects asked to perform free categorization in a sequential presentation task did so primarily on the basis of shape differences (6/10) as opposed to texture (1/10) or a combination of both (3/10) (weight of texture relative to shape: M=26%, SE=10%). In contrast, no such effect was found after ten hours of haptic exposure, i.e., shape and texture were equally weighted (M=55%, SE=8%). We hypothesized that, prior to experience, subjects are equally likely to use any weighting strategy, but that lengthy visual experience makes shape-dominated groupings more likely. Thus, in Experiment 1, subjects categorized objects either without any prior experience or after 1h of similarity judgments. Mean shape/texture weight was not significantly different from 50% in either condition, a result in agreement with our hypothesis. In Experiment 2, we tested whether the same pattern would hold for two different types of categorization tasks. In the first task, 10 naïve subjects viewed all objects simultaneously and sorted them into any number of groups. In the second task, 10 naïve subjects were sequentially shown two pairs, each consisting of the target and one of two category prototypes, and indicated which pair of objects was drawn from the same group. Contrary to our expectation, subjects in the array task relied on texture differences (M=80%, SE=7%), while subjects in the pair task relied more on shape (M=32%, SE=3%). These results demonstrate that shape differences do not always act as the key determinants of category structure; the sensory modality used to experience objects, the length of exposure, as well as task parameters also play a role.

E16 565 Learning effects on dual-task

Xiaohua Zhuang[1] (xzhuang@eden.rutgers.edu), Xiaotao Su[1], Zoltan Vidnyanszky[2], Thomas Papathomas[1,3]; [1]Lab of Vision Research, RuCCS, Rutgers University, Piscataway, NJ, [2]Neurobiology Research Group, Hungarian Acad-

emy of Sciences - Semmelweis University, Budapest, Hungary, [3]Department of Biomedical Engineering, Rutgers University, Piscataway, NJ

Goals: To investigate how practice affects performance in dual-task conditions using motion speed and motion direction discrimination tasks.

Methods: We used random-dot motion stimuli in the primary-task and secondary-task apertures, placed symmetrically with respect to fixation. There were two identical tasks in each aperture, in a two-interval forced-choice paradigm. In speed discrimination experiments, observers reported the interval of higher speed either in only one aperture (single-task), or in both apertures (dual-task). In direction discrimination experiments, observers reported the off-principal-axis direction, either in single-task or dual-task mode. Performance was measured in terms of thresholds, using Quest staircases. We computed the ratio R: dual-task threshold in the secondary aperture divided by single-task threshold [Lu & Itti, JoV 2005]. There were two R values for each experiment: Rsame, when the speeds (or directions) in the two apertures were the same; and Rdiff, when they were different. A significantly larger magnitude for Rdiff relative to Rsame indicates it was hard to attend to two different values of the same dimension (slow versus fast for speed, or principal versus off-principal axis for direction).

Results: Before training, the ratio Rdiff was significantly higher than Rsame, but the difference between these two ratios tended to decrease with practice. After training, this difference reached a stable value. Changing the speeds and the retinal position of apertures after training (placing them on the vertical meridian instead of the horizontal) eliminated the learning effects: the difference between Rdiff and Rsame increased significantly, indicating that learning was position-specific and/or stimulus-specific.

Conclusions: The results indicate that observers can learn to allocate attention more efficiently simultaneously to two locations, independently of the degree of similarity between the attribute values in the stimuli.

E17 566 Visual search training does not eliminate the dual-target cost in search for two types of target

Tamaryn Menneer[1] (T.Menneer@soton.ac.uk), Mark E. Auckland[1], Nick Donnelly[1], Kyle R. Cave[2]; [1]School of Psychology, University of Southampton, UK, [2]Department of Psychology, University of Massachusetts, Amherst

Previous research demonstrated performance costs in search for two targets compared with two independent single-target searches (Menneer et al., in press). This dual-target cost indicates that simultaneous maintenance of two target representations is difficult. The current study measured whether extensive search practice leads to generalization across a complex class of targets, and whether that generalization eliminates the dual-target cost.

Search for two differently-colored target classes (x-ray images of guns/knives and IEDs/bombs) was initially as accurate as single-target search for the more complex and unfamiliar target (IEDs) but less accurate than single-target search for the easier target (guns/knives). After 11 sessions (5280 trials) of training, accuracy had improved in all conditions, and dual-target search was less accurate than either single-target search. Testing with novel target images from these same classes revealed a drop in accuracy compared with the final training session, showing generalization was limited. A separate experiment showed that simultaneous search for two similarly-colored targets (x-ray images of guns and knives) was as accurate as single-target search for the harder target class (knives), and remained so with practice (20 sessions, 9600 trials). There was a trend towards a drop in accuracy between the final training session and test session. Experiments were not conducted with screening personnel.

Implications: (1) When members of a target class are sufficiently similar, generalization to novel target exemplars occurs during training, indicating that robust target representations have been learned, but there is a slight loss in accuracy compared with the training stimuli. (2) Simultaneous maintenance of two very different target representations cannot be learned, and results in poorly guided search. (3) Accuracy improves with learning, but when targets are very different, dual-target search accuracy is lower than in single-target searches. (4) Dual-target search is reasonably effective when targets share color but have complexly varying shapes.

Acknowledgement: Supported by the Human Factors Program of the Department of Homeland Security's Transportation Security Laboratory.

E18 567 The Specificity of Learning Position Discrimination: Noise and Stimulus Features

Roger Li[1,2] (oroger@berkeley.edu), Charlie Ngo[1], Dennis Levi[1,2], Jussi Saarinen[3]; [1]School of Optometry, University of California-Berkeley, [2]Helen Wills Neuroscience Institute, University of California-Berkeley, [3]Department of Psychology, University of Helsinki, Finland

Perceptual learning improves position discrimination. Here, we ask whether the learning transfers across (1) positional noise levels and (2) feature orientations. Our stimulus was comprised of two horizontal line segments each made up of 5 discrete Gabor patches (10 cycle/deg). In some runs, binary "positional" noise was added to the right segment by jittering the Gabor patches in vertical direction. The observer's task was to localize the vertical position of the right segment relative to that of the left segment. The experiment was conducted in 5 phases. On day 1, the pre-training session consisted of four stimulus conditions: with or without positional noise, and horizontal or vertical "carrier" orientations. Observers practiced the alignment task with noise from day 2 to 6 with a vertical carrier, and subsequently from day 8 to 12 with a horizontal carrier. Performance for all four conditions was re-evaluated in the two post-training sessions on days 7 and 13. Each session consisted of 1000 responses (13-kilo trials in total). Practicing position discrimination with a vertical carrier in noise improved performance significantly (by 23%). The learning effect transferred completely to the untrained stimulus with zero noise (20% improvement) and partially to the untrained horizontal carrier orientation with noise (13% improvement). Practicing with the horizontal carrier in the second training phase resulted in a further significant improvement (17% - a total of 30% from day 1). Using an efficient reverse correlation technique (Li et al. 2004 & 2006), we reveal a dramatic perceptive field retuning in the first phase training, with no further changes in the second. Improvement in the second phase was due to a reduction in internal noise. Our findings show that learning generalizes across noise levels and feature orientations, however as evidenced by the phase 2 learning, there are two separate mechanisms for learning position discrimination.

Acknowledgement: NIH Grant R01EY01728 (DL) & Academy of Finland Grant 111843 (JS)

E19 568 Location Specificity of Perceptual Learning of Depth Discrimination in Random-Dot Stereograms

Liat Gantz[1] (LGantz@uh.edu), Susana T.L. Chung[1], Ronald S. Harwerth[1]; [1]College of Optometry, University of Houston

Perceptual learning (PL) has been shown to improve depth discrimination thresholds in random-dot stereograms (RDS). A previous study demonstrated that PL of RDS is consistent with a narrower tuning of neurons underlying the response and not with internal noise reduction, but effects of subjects diverting attention to a specific target location were not considered. This study examined location specific effects with PL of depth discrimination in RDS. Two vertically separated 4.3 X 4.3 ardeg, 500 msec duration, dynamic RDS patterns of 50% density, containing 6.7′ X 6.7′ dot elements, were offset by 0.43 deg from a central fixation spot. Six normal subjects, assigned a training side (right or left), judged the depth of the bottom test relative to the upper reference stimulus, with audio feedback. Pre- and post-learning at the untrained location thresholds were determined for 100 trials. Practice blocks of 200 trials were repeated in the trained location until thresholds leveled off. Untrained and trained normalized pre- and post-learning threshold ratios were compared. Stereothresholds and standard errors decreased systematically with training. Rapid learning occurred within 2000 trials, leveling off thereafter. Pre- and post- learning threshold ratios in trained and untrained locations were not statistically significant (Paired T-Test, P=0.4), excluding a location-specific learning effect. The absence of a location-specific PL effect implies that neural tuning does not underlie the learning. Because previous findings excluded internal noise reduction, the improvement in depth discrimination is most likely due to an improvement in task performance at higher levels of visual processing.

Acknowledgement: Supported by NIH grants R01 EY01139, R01 EY12810 and P30 EY07751.

E20 569 Stimulus-Specific Perceptual Learning for Chromatic, but not Luminance, Contrast Detection

Carly Thurston[1] (cthurston@ucsd.edu), Karen Dobkins[1]; [1]UCSD Dept of Psychology

Purpose: Improvement on a perceptual task is dependent, in part, on the plasticity of the visual area underlying the task. Here, we compared perceptual learning on a contrast detection task for chromatic (red/green, isoluminant) and luminance stimuli, subserved by magnocellular (M) and parvocellular (P) subcortical pathways, respectively, to investigate differences in plasticity between the two pathways. To ensure that improvements in sensitivity reflect learning specific to the targeted pathway, subjects were trained on one stimulus type and improvements were compared between the trained vs. untrained stimulus.

Methods: Using standard 2-AFC methods, contrast sensitivity for chromatic (CHR) and luminance (LUM) gratings (0.27cpd, 4 Hz, 7x7 deg, 9 deg eccentric to fixation) was measured using a staircase procedure. The experiment took place over three days: pre-training, training, and post-training. During pre-training and post-training, the two stimulus types were interleaved across trails (150 trials/staircase), whereas training consisted of only one stimulus type for each subject (5 staircases/150 trials each). Learning ratios (LR) were calculated as Sensitivitypost/Sensitivitypre, separately for "trained" and "untrained" stimuli, with LR values > 1.0 reflecting learning. Fourteen subjects participated (7 CHR-trained, 7 LUM-trained).

Results: For CHR-trained subjects, LR for the trained stimulus was 1.42 (p=0.032), which was significantly higher (p=0.030) than for the untrained stimulus (1.05, p=0.06), suggesting stimulus specific learning. For LUM-trained subjects, LR for the trained stimulus (1.23, p=0.01) was not significantly higher than for the untrained stimulus (1.04, p=NS). The lack of a specificity effect for LUM-trained subjects was due to a large amount of variability in the LR for the untrained CHR stimulus.

Conclusions: Since CHR-trained, but not LUM-trained, subjects exhibited stimulus specific learning, LUM-training may not selectively tap the M pathway, either because the LUM task invokes the P pathway or because the learning takes place at a higher level in visual processing.

E21 570 Visual-spatial perceptual learning is specific to the context of trained stimulus display durations

Angela Vavassis[1] (vavassis@alcor.concordia.ca), Michael, W. von Grünau[1]; [1]Psychology Department & Center for the Study of Learning and Performance, Concordia University

Purpose: Psychophysical studies have repeatedly demonstrated that visual search tasks can undergo perceptual learning. For difficult visual discriminations, the improvement in visual search speed and accuracy, characteristic of perceptual learning, has been shown to be specific to trained target locations. The current compilation of psychophysical studies aimed to assess a characteristic of perceptual learning specificity in difficult visual discrimination search tasks not previously examined. More specifically, these studies investigated whether perceptual learning is specific to the context of stimulus display durations in which trials are embedded during training. Methodology and Results: In experiment 1 (VSS 2006), testing was subdivided into a series of training sessions, spanning two consecutive days, and a test session on a third consecutive day. During training, rapidly presented stimulus displays (50msec) were presented randomly amongst all other stimulus display durations (100msec-500msec). The test session consisted of rapidly presented displays only (50msec). Target detection accuracy for 50msec trials significantly improved between the first training session and last training session (p = .010). Accuracy for 50msec trials significantly deteriorated between the last training session and the test session (p = .024). A pair-wise comparison of 50msec trials between the first training session and the test session revealed that performance returned to pre-training accuracy (p = 1.000). In experiments 2 and 3, manipulations to the testing protocol revealed that the effect is indeed robust and independent of the overall length of the testing session and of the imposed delay separating the final training session from the testing session. Conclusion: Findings from this study imply that visual-spatial perceptual learning in difficult visual discrimination search tasks is specific to the context of trained stimulus display durations.

Acknowledgement: Natural Sciences and Engineering Research Council of Canada (NSERC) and Fonds Québécois de Recherche sur la Société et la Culture (FQRSC)

E22 571 Optimal Feature Integration in Image-Based Discrimination Task

Melchi Michel[1] (mmichel@cvs.rochester.edu), Robjert Jacobs[1]; [1]Department of Brain and Cognitive Sciences, University of Rochester

Purpose: A number of studies have demonstrated that people often integrate information from multiple perceptual cues in a statistically optimal manner when judging properties of surfaces in a scene. For example, subjects typically weight the information based on each cue to a degree that is inversely proportional to the variance of the distribution of a scene property given a cue's value. We wanted to determine whether subjects similarly use information about the reliabilities of low-level visual features when making image-based discriminations, as in visual texture discriminations. Methods: Three experiments used a modified version of the classification image technique. A basis set consisting of 20 low-level visual features (resembling narrow-band textures) was generated. Prototypes for visual categories were defined as specific linear combinations of elements from this basis set. Stimuli were constructed by corrupting prototypes with additive Gaussian noise defined in our basis space. In each trial, subjects were asked to determine which of two prototypes was embedded in a noisy test stimulus. The variance structure of the noise was varied across experimental conditions, and the template for an ideal observer was calculated based on the feature covariance matrix. Logistic regression was used to calculate classification images for the subjects over the course of training, and these images were cross-correlated with the ideal template. Conclusions: As the variance structure of the noise was changed, subjects modified their templates in a manner corresponding to the resulting changes in the ideal template. The data suggest that subjects were sensitive to our features and weighted each feature based on its reliability as defined by the feature covariance matrix. We conclude that human observers indeed use information about the reliabilities of low-level features when making image-based discriminations.

Acknowledgement: This work was supported by NIH research grant RO1-EY13149.

E23 572 The adult amblyopic visual system exhibits greater plasticity

Chang-Bing Huang[1] (huangcb@mail.ustc.edu.cn), Zhong-Lin Lu[2], Yifeng Zhou[1]; [1]Vision Research Lab, School of Life Sciences, University of Science and Technology of China, Hefei, Anhui 230027, P.R.China, [2]Laboratory of Brain Processes (LOBES), Departments of Psychology and Biomedical Engineering, and Neuroscience Graduate Program, University of Southern California, Los Angeles

Several resent studies found that training amblyopes to detect contrast with/without flankers or identify positional offset can improve the visual acuity in the amblyopic eyes (Polat et al., 1996; Polat et al., 2004; Zhou et al., 2006). However, provided the general observation that perceptual learning is highly specific to the training set (e.g., grating spatial frequency), one might expect perceptual learning of limited use as a clinical tool. Generalizability of learning is a necessary condition for perceptual learning to be an effective treatment. We provide the first systematic evaluation. We measured the magnitude and generalizability of perceptual learning in adults with anisomotropic amblyopia and their controls. Ten amblyopes (Group I) and 15 normal adults (Group II) were trained in the amblyopic eyes (amblyopes) or the non-dominant eyes (normals) in a contrast detection task at their cutoff spatial frequencies. Another seven normal adults (Group III) were trained at the average cutoff spatial frequency of Group I. Contrast sensitivity functions were measured in the trained and untrained eyes before and after training. We found that the amblyopic subjects improved their contrast sensitivity more than normal adults (10.66 vs 4.88 dB) at their respective cutoff spatial frequencies; Group III did not show any significant learning. Learning effects generalized to a broader range of spatial frequencies in the amblyopic (5.02±0.70 octaves) group than the normal group (2.03±0.34 octaves). Moreover, learning transferred to the untrained eyes in Group I, but was specific to the trained eyes in Group II. Our results suggest that the amblyopic visual system is more plastic --- learning can be generalized to a wider range of conditions. Improvements in amblyopic eyes are not at the expense of the fellow eyes. Both observations may provide important theoretical basis for using perceptual learning to treat amblyopia.

E24 573 Perceptual Learning and Adaptation in the Perception of Self Motion

Frank Durgin[1] (fdurgin1@swarthmore.edu), Kristina Simmons[1]; [1]Department of Psychology, Swarthmore College

When perceptual systems adapt they may be sacrificing accuracy for precision. By allocating the existing coding apparatus so as to tune its range to the locally experienced stimulus space, adaptation processes can enhance the discriminability of likely stimuli. For example, the tight coupling of perception and action during locomotion provides an important informational substrate for improving perceptual discrimination. We have found that the perceptual discrimination of optic flow speed is automatically tuned to walking speed such that perceived flow rates are reduced during walking. However, contrary to threshold elevation accounts of this phenomenon, perceptual discrimination is actually reliably enhanced for flow speeds appropriate to walking. To measure this we used a 2IFC speed discrimination task administered in a wide-area virtual reality apparatus that allowed us full control over the visual speeds presented during natural walking. In two experiments it was found that discrimination performance deteriorated dramatically for visual speeds less than 40% of walking speed, but showed striking and consistent improvement for visual speeds near to and above walking speed. It is as if the entire coding space available for visual motion is dynamically reallocated when walking -- leaving slow visual motions undetectable, but enhancing the discrimination of self-motion-relevant visual speeds. Although many vivid demonstrations of perceptual aftereffects seem to show that perceptual systems are susceptible to error and bias, techniques that look for the gains in perceptual precision and sensitivity may be more revealing.

Acknowledgement: Swarthmore faculty research grant

Biological Motion I

Author Presents: 2:00 - 3:45 pm

E25 574 Quantifying the Contribution of Structure Information in Direction Discrimination of Scrambled Walkers

Lawrie McKay[1] (lawrie@psy.gla.ac.uk), Phil McAleer[1], David Simmons[1], Frank Pollick[1]; [1]Department of Psychology, University of Glasgow, UK

It has been shown that it is possible to reliably discriminate the direction of a point light walker even when all the points have been scrambled, provided the trajectories are preserved (Troje & Westhoff, 2006). We investigated the strength of this motion signal by pitting it against a competing motion signal in the opposing direction that did or did not contain form information. To achieve this we split motion-captured 15-point walkers randomly into two subsets of points that contained opposing direction information. In the structure present condition one subset of points maintained their original joint locations and trajectories, whilst the others were scrambled to new joint locations and had their trajectories switched so that they were moving in the opposite direction. In the structure absent condition both subsets of points were scrambled and given opposing trajectories. For the structure present condition we defined the unscrambled points to have the "signal" direction and determined how many unscrambled points were required before direction was reliably reported in this direction. For the structure absent condition we randomly assigned one set of points to have the "signal" direction and measured how many points were necessary before motion was reliably reported in this direction. We performed an experiment involving 12 observers that used an adaptive procedure to determine the thresholds for discriminating walker direction. Results showed that in the structure absent condition thresholds were significantly higher than those for the structure present condition. Contrasting these thresholds gives a measure of the relative weight of the structural information in determining walker direction. In addition to highlighting the importance of structural cues in direction discrimination of point light walkers, the techniques used to generate the displays may also prove useful in biological motion based neuro-imaging work.

Acknowledgement: ESRC-MRC, Autism Speaks

E26 575 Seeing pedestrians at night: The benefits of biological motion are robust to clutter

Richard Tyrrell[1] (tyrrell@clemson.edu), Joanne Wood[2], Alex Chaparro[3], Trent Carberry[2], Byoung Sun Chu[2], Ralph Marszalek[2]; [1]Department of Psychology, Clemson University, [2]School of Optometry and Institute of Health and Biomedical Innovation, Queensland University of Technology, [3]Department of Psychology, Wichita State University

Collisions between vehicles and pedestrians are more common at night and insufficient conspicuity has been implicated as a causal factor. Incorporating the phenomenon of biological motion – placing reflective markers on a pedestrians' major joints – has been shown to make pedestrians more conspicuous to drivers at night. However, most on-road tests have been conducted in scenarios relatively free of visual clutter. We tested whether the presence of extraneous points of light degrades drivers' ability to detect pedestrians wearing reflectors in several different configurations. Twelve younger (21-34 years) and 12 older (61-78 years) volunteers drove an instrumented vehicle 12 laps around a 1.8 km closed-road circuit at night and pressed a button whenever they realized that a pedestrian was present. Two pedestrians were positioned on the road's shoulder wearing either all black clothing or all black clothing with 663 cm2 of silver retroreflective markings in four different configurations. One pedestrian walked in place at a point that was, on half of the laps, surrounded by reflective cones and posts (clutter). To test the effects of pedestrian motion, the other pedestrian stood still during half the laps and walked in place during the other half and was always surrounded by clutter. Reflector configuration dramatically influenced conspicuity. Without reflective markers, or with a reflective vest, most pedestrians were never detected. When pedestrians wore reflectors on their ankles and wrists, however, younger and older drivers responded at a mean distance of 285 m and 141 m, respectively. Importantly, the presence of visual clutter did not significantly influence response distances ($p>.05$). Pedestrian motion enhanced conspicuity, particularly for older drivers. These results confirm that the phenomenon of biological motion can dramatically enhance the nighttime conspicuity of pedestrians and indicate that this effect is robust to the presence of visual clutter.

Acknowledgement: Funding: Linkage grant from Australian Research Council

E27 576 Temporal summation, form, and motion complexity in biological and non-biological motion.

Eric Hiris[1] (ejhiris@smcm.edu), Hillary Leech[1]; [1]Department of Psychology, St. Mary's College of Maryland

Purpose: Past research has shown that compared to non-biological motion, biological motion is different because it (a) has longer temporal summation periods and (b) temporal summation depends upon the cycles pre-

Sunday Posters

sented. We sought to determine whether the inclusion of form or more complex types of non-biological motion eliminated these temporal summation differences. Method: Four point-light target motions were used: rotation of randomly placed dots (simple motion), a rotating square (simple motion with form), a front-end loader (complex non-biological motion with form), and a human walker (complex biological motion with form). A staircase procedure was used to determine the number of mask dots necessary to reach threshold in a left/right facing task or clockwise/anti-clockwise rotation task. Masks were created from scrambled versions of both facings or both rotation directions of the target motions. The targets were presented for one of seven durations from 165 to 2824 msec. Results: The motion of the front-end loader and the human walker had similar temporal summation curves and these temporal summation curves were distinctly different than the temporal summation curves associated with rotating dots or a rotating square. Conclusions: The complexity of the motion involved in the display, regardless of whether the motions are biological or non-biological, may determine temporal summation functions. Temporal summation differences between biological and non-biological motion described in past research may have resulted from the simplicity of the non-biological motion used in those studies.

E28 577 Motion and the Uncanny Valley

Gavin White[1] (gavin@psy.gla.ac.uk), Lawrie McKay[1], Frank Pollick[1]; [1]Department of Psychology, University of Glasgow

As the visual appearance of an artificial agent becomes more humanlike it has been proposed that observers find the agent less acceptable and this phenomenon has been described as the "uncanny valley" (Mori, 1970). However, there is little evidence to support the existence of the uncanny valley and the further hypothesis that character motion would deepen the valley. To explore this phenomenon we first constructed a stimulus set that provided an uncanny valley pattern of responses to static form and then explored the effect of motion in modulating this pattern. Specifically, we used computer animation software (Poser, 3D Studio Max) to obtain 7 body models (robot A, robot B, mannequin, skeleton, zombie, low and high resolution human) and obtained independent ratings of human likeness and acceptability to images of these models. Plotting acceptability ratings versus human likeness ratings revealed the predicted "uncanny valley" in acceptability just before the highest levels of human likeness. Next we animated these forms using 3D motion capture data that had been processed to depict different levels of realistic motion. These different levels of realism included the original natural movement and movements with increasing levels of degradation. The motion degradation process involved periodically freezing and unfreezing degrees of freedom of single joints along the moving arm so that the movement appeared, to varying degrees, jerky and mechanical in nature. Results indicated that the natural motion generally improved the acceptability ratings of all but the highly realistic figure which became less acceptable when animated. All levels of degraded motion generally brought acceptability down to values below that obtained from static form alone. These results clearly show the impact of motion on the acceptability of computer characters, but failed to produce the previously predicted deepening of the uncanny valley.

Acknowledgement: Nuffield Foundation

E29 578 Dynamic “Bubbles”: A novel technique for analyzing the perception of biological motion

Steven Thurman[1] (sthurman@uci.edu), Emily Grossman[1]; [1]Department of Cognitive Sciences, University of California, Irvine

Background. “Bubbles” is a relatively novel psychophysical technique (Gosselin & Schyns, 2001) that effectively isolates the information in a stimulus most critical for its perception and categorization. In this paradigm, observers make forced-choice discriminations on stimuli in which small, randomly selected regions are visible from within a heavily masked image. Performance increases when the visible region includes informative most salient to the task. After many trials, the data reveal a pattern of differential saliency of information across the stimulus. Although this technique has been used extensively with static images, particularly faces (Schyns et al., 2003), it has not yet been extended to the study of dynamic events. The current study measures the temporal saliency of visual features of point-light biological motion. Method. Point-light “bubbles” animations are constructed by smoothly inserting randomly-selected temporal intervals (667 ms) of a biological motion walker into a 3 sec sequence of motion-matched noise. Observers discriminate the presence or absence of biological motion on each trial. Performance is maintained near threshold using a double-interleaved staircase that manipulates the number masking noise dots. Trials are sorted on the basis of observer performance (hits and misses), and frequency distributions of the frames visible in those trials are generated. Results. Our results reveal a distribution of information saliency across the gait cycle of a point-light walker. Optimal sensitivity approximates a sinusoidal function with peaks corresponding to the temporal intervals with opponent motion (e.g. those in which arms and legs cross). Conclusion. These results highlight the importance of mid-level optic flow features and support the hypothesis that opponent motion is a critical component for detecting point-light biological motion (Casile & Giese, 2005). This is the first known implementation of “bubbles” with dynamic stimuli and illustrates a technique that can be extended to other instances of dynamic event perception.

E30 579 Replacing point lights with complex dissimilar elements disrupts biological motion perception

Amelia Hunt[1] (ahunt@wjh.harvard.edu), Fred Halper[1]; [1]Vision Sciences Laboratory, Harvard University

The rapid and seemingly effortless extraction of detailed information from visually impoverished point-light displays of humans walking is often held up as a compelling example of the perception of form from motion. Here we show that motion information is actually not sufficient for the impression of a human walker to be extracted from a point-light display. We manipulated the 13 small dots out of which the typical point-light walker is constructed. Attempts to use size, color, or shape changes to disrupt walker perception had only modest impact on its robustness. But when all the local elements of the walker were replaced with complex unique objects*, such as animals and food items, perception of the walker was severely disrupted. Of thirty-five naïve observers presented with this array for one full gait cycle (3667ms), none perceived a human walker, even though movement paths were unchanged. A new group of ten observers' ratings of how much the display resembled a human walking confirmed this finding, with a mean rating of 6.75/7 for the standard point-light walker, and 2.60/7 for the walker made from objects. Ratings of walkers constructed from simple but dissimilar elements (letters) and from complex but identical elements (an alarm clock) differed significantly from the standard walker and from the object walker, but not from each other. This pattern suggests that the Gestalt principles of simplicity and similarity play an important role in the extraction of human form information from the motion of the elements. We conclude that the spontaneous perception of a human walking is not an inevitable consequence of the motion of the points in a point-light walker, but depends on the points themselves being relatively simple and uniform.

http://visionlab.harvard.edu/Members/Amelia/objects.swf for a demonstration

E31 580 Life is Not Just in the Fast Lane: Dissociating the perceptions of speed and animacy

Paul A. Szego[1] (szegopa@mcmaster.ca), M.D. Rutherford[1]; [1]Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, Canada

The ability to discriminate animate objects from inanimate ones is fundamental to social cognition. Previous research focusing on low-level motion cues to the visual perception of animacy has revealed a robust and reliable association between the perception of speed and the perception of animacy: Objects perceived as moving relatively faster are also perceived as animate more often than relatively slower objects. To test whether these perceptions could be dissociated, we presented participants with displays of two objects travelling in succession across a screen in opposite directions. Using a within-subjects design, participants were instructed to report which object appeared alive on half the trials and faster on the other

Sunday Posters

half, in a two-alternative forced-choice task. Experimental trials presented objects appearing to move with or against gravity by "rising up" and "falling down" on a vertical screen; control trials presented objects travelling leftwards and rightwards. "Rising" objects were judged as animate more often than "falling" objects, perhaps due to the perceived presence of an internal power source allowing the object to violate gravity. Conversely, the "falling" objects were judged as faster than "rising" objects, suggesting that the pairing of speed and animacy can be dissociated. Additionally, objects travelling from left-to-right were judged as both faster and animate more often than objects travelling right-to-left. A follow-up experiment using the same stimuli and procedures on bilingual people who are fluent readers in a language read from right-to-left revealed no speed or animacy bias for horizontal directions. These experiments imply that judgements of speed and animacy can be influenced by higher-order visual processes, such as those related to highly familiarized concepts of motion forces (e.g., gravity), directionality (e.g., reading), and possibly highly trained motoric responses, such as those reinforced by reading.

E32 581 Animacy and direction from point-light displays: Is there a life detector?

Dorita H. F. Chang[1] (5dc16@qlink.queensu.ca), Nikolaus F. Troje[1,2]; [1]Centre for Neuroscience Studies, Queen's University, Kingston, Canada, [2]Department of Psychology, Queen's University, Kingston, Canada

Directional information can be extracted from scrambled point-light displays that are devoid of all structural cues prompting the suggestion of a distinct local mechanism in biological motion perception that may serve as a general "life detector" (Troje & Westhoff, 2006). We investigated this hypothesis by testing the perception of both animacy and direction from point-light stimuli. Coherent and scrambled point-light displays of humans, cats, and pigeons that were upright or inverted were embedded in a random dot mask and presented in saggital view to two groups of naïve observers (n = 12/grp). The first group assessed the animacy of the walker on a six-point Likert scale and the second group discriminated the direction of walking. Across blocks, stimulus duration varied from 200 - 1000 ms. Coherent stimuli appeared more animate than scrambled stimuli ($p < 0.001$) and inversion decreased animacy ratings ($p < 0.001$), although more substantially for coherent than for scrambled walkers ($p = 0.007$). Similarly, discrimination accuracies were higher for coherent versus scrambled stimuli ($p < 0.001$) and inversion decreased performance ($p < 0.001$), but more substantially for coherent than for scrambled walkers ($p = 0.004$). Both animacy ratings and discrimination accuracies did not differ for animal type (ps > 0.200) nor stimulus duration (ps > 0.300). The results indicate that like the ability to discriminate direction, the perception of animacy from scrambled displays is orientation-specific. We suggest that the responsible mechanism uses a dynamic, gravity-dependent framework to assess the presence of life in the environment and is remarkably robust, operating efficiently at limited exposure times.

E33 582 Point-light walkers with and without local motion features for determining direction

Daniel R. Saunders[1] (drsaunders@canada.com), Julia Suchan[1], Nikolaus F. Troje[1]; [1]Department of Psychology, Queen's University, Kingston, Canada

In 1978, James Cutting published an algorithm to generate point-light displays that resemble the movements of the joints of a human walker. The method has since been used frequently to create stimuli for research on biological motion perception. More recently, Troje and Westhoff (2006) found that pattern of local movement of the feet was used to derive the direction in which a point-light walker is facing, even when structural information is removed. The results of previous studies that direction could not be determined using a scrambled version of Cutting's walker, may be explained by the significantly different motion of the feet between Cutting's walker and motion-captured humans.

To compare the two stimuli, 14 participants performed a detection task and a direction task. Walkers consisted of 11 points presenting a sagittal view. In the detection task, walkers were embedded in a scrambled walker mask consisting of 50, 100, or 200 dots. Participants had to decide which of two successive intervals contained the walker. In the direction task, participants judged whether the walking figure was oriented towards the left or the right. The mask consisted of randomly appearing stationary dots (50, 200, or 750) with limited lifetime. Half of the walkers were spatially coherent and half of them were scrambled.

Observers performed equally well for the two walkers in the detection task. However in the direction task, the error rate for Cutting's walker was significantly higher than for the motion-captured walker. Most of the difference came from the scrambled walker condition, where error rate increased from 39% to 48%.

We conclude that Cutting's walker lacks critical features which signal direction in real walking motion, and suggest that studies which have presented the local motion of the Cutting walker as a stimulus need to be revisited.

E34 583 Sex classification of point-light walkers: Viewpoint, structure, kinematics

Anna Halevina[1] (ahalevina@yahoo.ca), Nikolaus F. Troje[1]; [1]Department of Psychology, Queen's University, Kingston, Canada

Biological motion point-light walkers convey information about the sex of a walker. As has been shown earlier, retrieving this information depends on the viewpoint: Frontal views are easier to classify than profile views. However, what happens if a walker is shown from a varying viewpoint as is the case when we see a walker walking on a circle? Multiple viewpoints should facilitate activation of a three-dimensional representation which might help classification. On the other hand, the additional rotation might mask intrinsic (that is, relative) motion diagnostic for the sex of the walker and therefore hinder classification. In the current study, observers had to indicate perceived sex of point-light displays of individual walkers shown either in frontal view (0 deg), half profile view (30 deg), profile view (90 deg), or in a condition in which the viewpoint rotated from -50 to 50 deg over the display time of 2 sec. In addition, we manipulated the information provided. Walkers contained either only structural information, only kinematic information, or all information. The results replicated earlier findings showing that performance at frontal and half profile view is much better than at profile view and that kinematic information is required for sex classification whereas structural information has very little diagnostic value. In addition, we could show that rotating views of a walker are clearly resulting in worse classification than frontal or half-profile views, but were classified much better than profile view walkers. We conclude that three-dimensional representations do not facilitate sex classification from biological motion. Diagnostic information about sex is primarily contained in the kinematics within the fronto-parallel plane and the motion due to rotation of the walker aggravates retrieval of this information.

E35 584 "Life Detection" in Central and Peripheral Vision

Kathryn Williamson[1] (umwill37@cc.umanitoba.ca), Lorna Jakobson[1], Nikolaus Troje[2]; [1]Department of Psychology, University of Manitoba, [2]Department of Psychology, Queen's University

Gunnar Johansson (1973) was the first to demonstrate that human observers can perceive animate activity solely from information about the movements of dots attached to the joints of an otherwise invisible figure. From even brief exposure to these dynamic "point light" displays, viewers are able to extract surprisingly detailed information, including information about the actor's gender and mental state (e.g., Troje, 2002). Recently, Troje and Westhoff (2005) have suggested that several independent processes are involved in biological motion perception, the most basic of which is a simple form of "life detection" that is automatically triggered by low-level, local motion cues. In support of this, they found that, even when configural information was disrupted through spatial scrambling of the dots comprising a point light walker, participants were still able to judge the direction the walker was facing quite accurately, provided the moving dots were presented in their normal (upright) orientation. Stimuli in this study were presented in central vision and viewing times were unlimited. In the present study, we replicated this basic result using very brief exposure durations (200 and 170 ms). We also went on to show that viewers could achieve above-chance direction discrimination performance with upright, scrambled displays when the targets were presented in peripheral vision. Performance in the periphery, however, varied as a function of the side of presentation and the direction the walker was facing. Specifically, while participants were better at processing right-facing (compared to left-facing) walkers in the right visual field, they were equally accurate at processing right- and left-facing walkers in their left visual field. This interaction was seen both with configural and scrambled displays. This interesting result is discussed with reference to recent studies examining hemispheric differences in spatial attention and body representation, and in the operation of the "mirror neuron" system.

Acknowledgement: This research was supported by an NSERC grant to LJ

E36 585 Amblyopic perception of biological motion

Benjamin Thompson[1] (ben.thompson@mcgill.ca), Bruce C. Hansen[1], Robert F. Hess[1], Nikolaus F. Troje[2]; [1]McGill Vision Research, McGill University, Montreal, Canada, [2]Department of Psychology and School of Computing, Queen's University, Kingston, Canada

Background. It is currently believed that the cortical deficit associated with amblyopic vision extends beyond striate cortex into extrastriate areas. Biological motion perception has been localized to a specific extrastriate cortical region (STS) which receives input from both dorsal and ventral visual processing streams. We used a variety of biological motion perception tasks to assess the function of this extrastriate region in amblyopia.

Methods. Amblyopic observers viewed biological motion stimuli with either their amblyopic or fellow fixing eye. A range of tasks were used to better characterize the ability of amblyopic eyes to perceive biological motion. Detection of a point light walker was measured using both scrambled walker masks and linear motion masks to modulate task difficulty. Walking direction discrimination was also measured using both scrambled walkers, which provided only motion information, and unscrambled walkers. These stimuli were embedded in linear dot masks of various densities.

Results. Amblyopic eyes showed a deficit in biological motion detection. Amblyopic eyes did not however show a similar deficit for walking direction discrimination and could perform this task with both unscrambled and scrambled walkers.

Conclusion. Amblyopic eyes are impaired at segregating a point light walker from a noise mask. However the ability to extract information from the biological motion of the walker dots showed little impairment.

Acknowledgement: supported by CIHR grant #MT18-108 to RFH

E37 586 Biological motion perception in healthy elderly

Andrea Piotrowski[1] (umpiotro@cc.umanitoba.ca), Lorna Jakobson[1], Nikolaus F. Troje[2]; [1]University of Manitoba, [2]Queen's University

Biological motion perception refers to the ability to perceive and interpret the movements of animate objects, in the absence of form cues (Johansson, 1973). To date, only one study has examined this ability in elderly observers (Norman et al., 2004). These authors reported that, particularly at longer exposure durations (400 ms), biological motion perception was well-preserved in older adults. Norman et al. assessed participants' ability to recognize specific activities that, in some instances, were partially occluded. In Experiment 1 of the present study, a walker was displayed (for 200 ms) in a frontal view on half of the trials; on the remaining trials a spatially scrambled walker was presented. Stimuli were shown either in isolation, or in a scrambled walker mask comprised of 25 to 150 dots. The task on each trial was to decide whether a coherent walker was present. In Experiment 2, a walker appeared on each trial, in a profile view, and participants indicated whether it was facing left or right. The stimulus was presented alone or in a field of masking dots, as described above. Healthy elderly and young adults performed essentially at ceiling levels on both tasks when no mask was added. The presence of masking dots, however, had a much more deleterious effect on the performance of elderly participants than on that of young adults. Indeed, elderly participants' performance fell to chance levels as more masking dots were added. While the two groups differed in terms of education, and scores on both the Token Test and Digit Symbol, these differences could not account for the impairment seen in elderly participants on the biological motion perception tasks. We conclude that healthy elderly show a marked impairment in their ability to perceive biological motion in the presence of visual noise, at short exposure durations.

Acknowledgement: This research was supported by an NSERC Grant to LJ.

E38 587 Sparing of Sensitivity to Biological Motion after Early Visual Deprivation

Terri Lewis[1,2,3] (LewisTL@mcmaster.ca), Alejo Freire[1], Daphne Maurer[1,2]; [1]Department of Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, Canada, [2]Department of Ophthalmology, The Hospital for Sick Children, Toronto, Canada, [3]Department of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Canada

The perception of biological motion is mediated mainly by neural networks in the posterior region of the superior temporal sulcus, an extrastriate area that receives input from both the dorsal and ventral visual cortical streams. We evaluated the functional integrity of those networks after early visual deprivation by measuring sensitivity to biological motion in six patients who had been treated for dense congenital bilateral cataracts at 2 - 10 months of age and later tested at 12 - 25 years of age. Their task was to discriminate point light biological motion displays depicting human movement from scrambled versions of the same displays and to indicate whether the person appeared in interval 1 or 2. To estimate thresholds, we added noise dots to the displays and used a staircase to estimate the number of noise dots that could be tolerated for 71% discrimination accuracy. Surprisingly, patients' sensitivity to biological motion was entirely normal: every one of the six patients had thresholds within the normal range of thresholds produced by three age-matched controls. Yet, the same deprivation causes marked deficits in the perception of global motion and global form, aspects of vision that depend on the integrity of the dorsal and ventral visual streams, respectively. We speculate that sensitivity to biological motion is spared because some of the neurons involved are stimulated by self body movement during the period of visual deprivation, perhaps via a homologue of the macaque mirror system.

Acknowledgement: Support: CIHR grant MOP-36430

E39 588 Systematic variation in sensitivity to biological motion in typical adults.

Martha Kaiser[1] (marthakaiser@gmail.com), Maggie Shiffrar[1]; [1]Psychology, Rutgers University - Newark

People communicate vast amounts of social information through their movements. Typical adults demonstrate an impressive level of visual sensitivity to these movements. The accurate perception of such socially relevant information is a necessary first step in social behavior. Significant deficits in social behavior are characteristic of autism spectrum disorders (DSM-IV). This raises the question of whether impairments in visual sensitivity to human motion are associated with autism spectrum disorders. Children with autism are compromised in their ability to detect the presence of point-light displays of human motion (Blake et al., 2003). Here we ask whether such deficits also exist within the typical adult population. The Autism-Spectrum Quotient (AQ) measures the degree to which adults with normal intelligence present traits associated with the autistic spectrum (Baron-Cohen et al., 2001). By correlating performance on biological motion perception tasks with performance on the AQ, we assessed whether variations in visual sensitivity to human action are associated with the presence of autistic traits in typical adults with normal intelligence and language skills.

Participants were Rutgers University undergraduates. Point-light displays of a walking person and of a moving tractor were constructed from motion capture data. Following a blocked design, the unmasked point-light person or tractor was presented as coherent or scrambled. Participants reported whether or not they detected the presence of the person or tractor. All observers performed above chance. Overall, person detection was superior to tractor detection. Observers with low AQ scores (less autistic traits) better detected the person than the tractor. Observers with high AQ scores (more autistic traits) showed no significant difference in their ability to detect the person and tractor. Follow-up experiments with point-light masks and inverted displays yielded consistent results. These findings suggest that variations in autistic traits influence visual sensitivity to socially relevant movements in normal populations.

E40 589 Incidental processing of biological motion in parietal patients

Lorella Battelli[1,2] (Battelli@wjh.harvard.edu), Bradford Mahon[2], Ian Thornton[3]; [1]Laboratory for Magnetic Brain Stimulation, Beth Israel Hospital, Boston, [2]Department of Psychology, Harvard University, MA, [3]Department of Psychology, University of Wales Swansea, UK

Purpose: It is known that biological motion processing can proceed in a passive, bottom-up manner. Using an incidental processing paradigm, Thornton and Vuong (2004) recently demonstrated that observers respond more quickly to target figures walking in the same direction as to-be-ignored flankers (dynamic congruency effect), indicating that the to-be-ignored items still exert an influence on behavior. Is such bottom-up processing sufficient for explicit awareness? Here we report results from two parietal patients who show a total inability to explicitly recognize isolated biological motion figures, despite intact low-level motion perception. Will these patients still show a flanker effect? Method: Two parietal patients were tested on flanker tasks involving a) biological motion (BM) stimuli and b) complex non-biological rotating (CR) patterns. In both tasks central target figures were presented simultaneously with two other items (flankers) presented on either side of the target. Response dimensions were left/right for BM and clockwise/counter-clockwise for CR stimuli respectively. Flankers moved in either the same direction as the target (congruent) or in the opposite direction (incongruent). Subjects were instructed to ignore the flankers. Results: Both patients performed the CR task at normal levels. In contrast, performance was severely impaired in the BM task. Specifically, they were at chance in explicitly determining the direction of motion of the central target. However, reaction times indicated that the patients still showed a dynamic congruency effect. That is, they were much faster to respond in the congruent than in the incongruent trials. Conclusions: Our patients? accuracy and reaction times were normal in the CR task, indicating intact low-level motion processing and a general ability to extract targets in a flanker display. Their failure to explicitly recognize the BM stimuli appears to be independent from the incidental processing and may reflect a stimulus specific, high-level deficit.

E41 590 Gender Differences in Event Recognition of Videogame Baseball Pitches

Katherine Olson[1] (keo34@csus.edu), Emily Wickelgren[1]; [1]Department of Psychology, California State University, Sacramento

Past studies have found gender differences for cognitive spatial tasks. Prior research by Shechter (1991) found that gender differences exist in the contribution to visual apparent-motion correspondence of the distance-disparity cue and the interaction between the processing of the cues. Only a few studies have focused on the perceptual aspect of gender differences. Kaiser (1985) found that men chose the correct trajectory path far more often than women both in a motion condition and in a no-motion condition. Shepard and Metzler (1988) found that men perform higher on these spatial tasks than women. Wickelgren (submitted) found that males were more accurate in identifying computer generated oscillating events of varying trajectory forms than females. To see if this difference is observed in more real world situations, we chose to look at men and women's visual ability to perceive and identify different video game baseball pitches. Based on past research, we believed that men would show higher accuracy than women.

Fifteen undergraduate men and fifteen undergraduate women participated in one session of ten blocks of 25 trials. On each trial, the computer randomly displayed one of five pitches. Afterward, the participant was asked to identify the pitch. After each identification, they were given feedback on their accuracy and told which pitch they had just viewed.

The results suggest that men were significantly more accurate than women in overall accuracy. We also examined only the participants who had experience playing baseball video games. Again, we found that men were significantly more accurate in their identifications than women. These findings suggest that the gender differences observed in Wickelgren's (submitted) study may generalize to other more real world situations. Further studies on identification of actual pitches are in progress.

Acknowledgement: We thank Lori Schleppenbach for her assistance and display generation and data collection.

E42 591 The Relation between Motor Cortex Activity and Perception of Form Coherence for Biological Motion Stimuli

Shannon Fitzhugh[1] (trabosh@temple.edu), Thomas Shipley[1], Peter Marshall[1]; [1]Psychology Department, Temple University

In humans, biological motion is easily perceived from minimal displays where 13 lights mark the 12 major joints of the human body and the head. Viewing point light displays of human action activates the motor system (Saygin et al. 2004). Here we use electroencephalography (EEG) to study the associations between motor cortex activation and biological motion perception. Specifically, we use desynchronization of the mu rhythm over central electrode sites as an index of covert motor system activation during action observation (Pineda, 2005). Desynchronization occurs not only with action execution, but also with imagined action, and observation of human actions (Muthukumaraswamy et al., 2004). The current study directly explores the relation between observers' perception of form in biological motion stimuli and desyncronization of the mu rhythm.

Participants viewed point light displays of eight familiar actions (walking, running, cartwheel, jumping jacks, throwing a baseball, hitting a tennis ball, kicking a soccer ball, and hitting a baseball). The form coherence of the point light displays was continuously varied by adding random location offsets to each point. The resulting display perceptually oscillated from a coherent, easily perceived, form to incoherent, independent element motions. Participants observed the point light displays while EEG was collected using a 21-electrode EEG cap. Participants then watched the same displays while rating the displays for clarity of form, using a rating dial.

Preliminary analyses indicate that the power in the mu band (7-13Hz) at central electrode sites was negatively correlated with reported form coherence. As the form became more coherent, the mu rhythm was desynchronized. Similar relations were not observed for form coherence of a non-biological stimulus (a point-light rotating circle). These results suggest a tight temporal link between ongoing perception of action and motor cortex activity during observation of biological motion.

E43 592 Brain areas involved in biological motion perception: What is involved and what is necessary

Ayse Pinar Saygin[1,2,3] (a.saygin@fil.ion.ucl.ac.uk); [1]Institute of Cognitive Neuroscience, University College London, [2]Wellcome Trust Centre for Neuroimaging, University College London, [3]Department of Psychology, University College London

Introduction: While fMRI in normals can identify regions activated and thus potentially "involved" in a particular process, patient studies may be required to establish causal relationships between brain areas and performance. I used these two complementary methods to study biological motion perception.

Methods: In the fMRI study, 12 healthy participants viewed point-light biological motion or scrambled biological motion. In the neuropsychological study, a large group of brain-injured patients (47 left and 12 right hemi-

Sunday Posters

sphere; lesion site initially nonselective) and 19 age-matched controls discriminated biological motion from scrambled biological motion in the presence of a variable number of noise dots.

Results: In the fMRI study, comparing biological motion to scrambled motion revealed bilateral activation in lateral temporal and in inferior frontal/premotor cortex. In the neuropsychological study, voxel-wise lesion analysis revealed that damage to very similar temporal and frontal regions was associated with deficits in biological motion processing. Therefore, the neural activity in normal adults agreed with the lesion data from the group of patients. Indeed, ROIs derived from the group lesion data via formal cluster analysis and thresholding showed significant neural activity for biological motion (but not for scrambled motion) in the normal controls.

Overall, compared with controls, both left and right hemisphere lesioned patients had significant deficits in biological motion perception. Patients' impairments did not correlate with lesion size or behavioural scores on other tasks (except face recognition).

Thus, specific regions in superior temporal and inferior frontal/premotor cortex appear to be both involved in and necessary for intact biological motion perception. The involvement of premotor cortex in biological motion perception may reflect the contribution of the mirror neuron system in the perception of these stimuli.

Acknowledgement: I would like to thank M.I. Sereno, N. Dronkers, E. Bates, D. Hagler, S. Wilson, F. Dick, J. Driver and G. Rees for help and comments, the UCSD Center for Functional MRI and VA Northern California Health Care System for providing access to imaging and patients. Support contributed by the National Science Foundation (BCS 0224321 to Sereno), the National Institutes of Health (RO1 DC00216 to Bates/Dronkers), and the European Commission (Marie Curie FP6 Mobility grant to Saygin).

Face Perception: Parts, Wholes, Features, and Configurations

Author Presents: 4:00 - 5:45 pm

E44 593 Asymmetrical Distribution of Face-directed Fixations in Audiovisual Speech Perception Reflects Viewer's Strategy

Ian Everdell[1,2] (ite@biomed.queensu.ca), Heidi Marsh[1,5], Micheal Yurick[1,5], Kevin Munhall[1,2,3,5], Martin Pare[1,2,4,5]; [1]Biological Communications Centre, [2]Centre for Neuroscience Studies, [3]Department of Otolaryngology, [4]Department of Physiology, [5]Department of Psychology

Speech perception under natural conditions requires the integration of auditory and visual information. Understanding how a viewer assimilates the information contained in these two sensory modalities requires a detailed description of both the speech information and information processing. To understand better the process of gathering facial information, we have quantified the distribution of gaze fixations of humans performing an audiovisual speech perception task with dynamic talking faces. Here we examined the degree of gaze fixation asymmetry to determine whether left-right biases reflect the face stimulus or the strategy of the viewer. Most participants preferentially fixated the right side of the faces, suggesting a left visual field bias, and their bias persisted even when they viewed horizontally mirrored faces, different talkers, and static faces. This bias was usually present in the very first fixations, but participants showed stronger gaze fixation asymmetries when viewing dynamic faces, in comparison to static faces or face-like objects, and especially when their gaze was directed to the talker's eyes. Correlation analysis revealed that the degree and side of bias of gaze asymmetry during audiovisual speech (i.e., a dynamic stimulus) are predicted by the same parameters measured during simple face processing (i.e., a static stimulus). Although viewing dynamic faces in these experiments significantly enhanced speech perception, we did not find any correlation between task performance and gaze fixation asymmetry. Similarly, asymmetry did not appear to be related to other measures of laterality (handedness and eye-dominance). These results suggest that the asymmetrical distribution of gaze fixations reflect the participants' viewing strategies rather than being a product of asymmetry within the faces themselves. That these strategies did not predict audiovisual speech perception suggests that the process of gathering information from a talker's face involves a large visual span that is independent of the ability to assimilate information.

Acknowledgement: This work was supported by fundings from the National Institute on Deafness and other Communication Disorders (grant DC-00594) and the Natural Sciences and Engineering Research Council of Canada to K.G. Munhall and from the Canadian Institutes of Health Research and the EJLB Foundation to M. Paré. I.T. Everdell holds an Ontario Graduate Scholarship, and M. Paré holds a New Investigator Award from the Canadian Institutes of Health Research.

E45 594 The influence of number of eye fixations on face recognition

Janet Hsiao[1] (jhsiao@cs.ucsd.edu), Garrison Cottrell[1]; [1]Department of Computer Science & Engineering, UCSD

Researchers have shown that eye movements during visual perception are linked to the underlying cognitive processes. In face recognition, it has been reported that we have one or more preferred fixations and a tendency to use a regular sequence of eye movements for specific tasks (e.g., Walker-Smith, Gale, & Findlay, 1977). In the current study, we conduct a face recognition experiment to examine the influence of number of fixations in face recognition. Participants were presented with face images at the study phase and asked to recognize the same faces at the test phase. We restricted the number of fixations on the face image randomly at the test phase to one, two, three, and no restriction (i.e. free viewing). We show that participants are able to recall the faces with just a single fixation, and they have better performance when two fixations are allowed. Nevertheless, there is no further improvement with more than two fixations. It may suggest that we only need two fixations to recognize a face. We also show that, when comparing the fixations that participants made during the study and test phases, participants have a significant tendency to scan the face from left to the right and this tendency is consistent across the study and the test phases. Nevertheless, the fixations made during the study phase are significantly more divergent in both location and duration than those during the test phase. The results suggest that different eye movement strategies are used for the study and the test phases, and the first two fixations in face recognition may have a functional role in retrieving informative facial information.

E46 595 Spatial location of critical facial motion information for PCA-based performance-driven mimicry

Fatos Berisha[1] (f.berisha@ucl.ac.uk), Alan Johnston[1], Peter McOwan[2]; [1]Department of Psychology, University College London, London, UK, [2]Department of Computer Science, Queen Mary, University of London, London, UK

Visual information from different areas of the face does not contribute equally to human observers' ability to categorise faces. The spatial location of task-specific diagnostic information in static images of faces has been revealed using occlusion masks with randomly located circular Gaussian windows, or 'bubbles' (Gosselin & Schyns, 2001, Vision Research, 4:2261-2271). Our study tested whether the 'bubbles' method could reveal spatial locations of facial information pertinent for photo-realistic animation of an automatically created and driven moveable face model generated from example footage of a face in motion (Cowe, 2003, PhD Thesis, UCL, London). The face model was created by vectorising a sequence of a face in motion, extracting the image changes and motion fields using an optic flow algorithm and calculating a set of basis actions by application of PCA. This model, or avatar, was driven by instances of the same sequence, processed in the same way, but occluded with 5000 random 'bubble' masks (23 'bubbles', standard deviation: 5pixels). Resulting mimicries were compared to the 'ground-truth' mimicry obtained by a non-occluded driver sequence, using a Pearson correlation metric measuring the similarity between PC coefficients extracted from the occluded driver sequences and those from the 'ground-truth'. 'Bubbles' resulting in mimicries that were highly correlated with the 'ground-truth' mimicry were added up and divided by the sum of all 'bubbles'. The resulting image highlights those facial areas transmitting visual information important for photo-realistic mimicry. The most important areas are those around and including the mouth and eyes. These regions overlap but are not identical to areas of maximum pixel-value variance. Visual inspection of resulting mimicries shows that the PCA face model is robust enough to enable recovery of some aspects of the expression in the avatar in those areas occluded in the driver sequence, but the expression is generally muted.

E47 596 Natural Image Statistics Suggest a Basis for Representations of Head Rotation

Hugh R. Wilson[1] (hrwilson@yorku.ca), Frances Wilkinson[1]; [1]Centre for Vision Research, York University, Toronto, Canada

Introduction: Learning algorithms based on natural image statistics have been capable of generating oriented receptive fields akin to the properties of V1 neurons. Here we ask whether an analogous approach can be taken to study the basis of face viewpoint representations. This extends our previous work showing that deviations from head symmetry can be used to discriminate among head orientations near the frontal view.

Methods: Male and female faces were digitized at 16 points around the perimeter of the head. Each head was digitized in 9 different horizontal rotations from -40° to +40° in 10° steps. For each of these rotations front, 24° up, and 24° down vertical rotations were digitized, making a total of 27 views of each head. The 27 views of all heads were then submitted to a principal component (PC) analysis. Psychophysical experiments were conducted to determine whether observers could correctly discriminate head orientation from the head outline alone.

Results: PC analysis showed that three components accounted for 97% of the variance. PC1 (56%) was positively weighted for rightward rotations and negatively weighted for leftward rotations, with no weighting on front or up/down views. PC2 (29%) was heavily weighted for front views and did not discriminate between left and right rotations, so it functions as an estimator of bilateral symmetry. PC3 (12%) was positively weighted on upward views and negatively weighted on downward views with insignificant weighting on horizontal rotation. Psychophysical results showed that observers could accurately estimate head orientation from head outlines alone.

Conclusions: Principal Components can be learned readily by Hebbian neural networks. Thus, we hypothesize that neural representations in face selective areas will reflect the small number of PCs that are theoretically necessary for representations of head rotation. Comparisons with neurophysiology appear to support this hypothesis.

Acknowledgement: Supported by NIH Grant EY002158 & NSERC Grant #OP0007551

E48 597 Stimulus requirements for perceiving a face: an analysis based on "totem poles"

Carrie Paras[1] (paras@unr.nevada.edu), Kyle McDermott[1], Shernaaz Webster[1], Michael Webster[1]; [1]Department of Psychology, University of Nevada Reno

Much of the research on face perception has focused on the processes involved in classifying or recognizing individual faces. We examined the stimulus properties that invoke these processes, by asking which image characteristics are necessary to classify a stimulus as a face. These requirements are not well defined but are presumably weak, for vivid faces can often by seen in random or natural images such as cloud or rock formations. To characterize possible facial configurations, we measured where observers perceived faces in semi-random and naturalistic images defined by symmetric 1/f noise. Images were grayscale with an rms contrast of 0.35, and were symmetric about the vertical midline. In these stimuli many faces can be perceived along the vertical axis, and appear stacked at multiple scales, reminiscent of totem poles. Subjects identified which faces they saw, and marked the center and outline of the face parts. These drawings were analyzed to examine the distribution of properties defining the faces. This analysis confirms the importance of stimulus dimensions such as symmetry, orientation, and contrast polarity in face perception, and reveals the relative salience and characteristics of features and their configurations. In particular, seeing a face required seeing eyes, and these were largely restricted to dark regions in the images. Other features were more subordinate and showed relatively little bias in polarity. In further measurements we also characterize the influence of chromatic variations in the images. Notably, many faces were rated as cleary defined, suggesting that once an image area is coded as a face it is reinterpreted and perceptually completed. We examine this process by asking how the same image areas are classified when salient facial features are present or absent. Collectively these measurements help to reveal the basic perceptual templates underlying the initial stages of face coding.

Acknowledgement: Supported by EY10834

E49 598 Classification images for sampled stimuli: Comparing face processing in typical and autistic observers

Masayoshi Nagai[1] (masayoshi-nagai@aist.go.jp), Patrick J. Bennett[2,3], Melissa D. Rutherford[2], Carl M. Gaspar[2], Diana Carbone[2], Masako Nara[1], Hijiri Ishii[4], Takatsune Kumada[1], Allison B. Sekuler[2,3]; [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]Department of Psychology, Neuroscience & Behaviour, McMaster University, [3]Centre for Vision Research, York University, [4]Kololo Gakusya (Social Welfare Public Corporation)

Classification images (CIs) can reveal observers' strategies in a variety of visual tasks. However, one weakness of the CI method is that many trials are needed to obtain stable data (e.g., 10,000 trials for 128 x 128 face images in Sekuer etal., 2004). We examined whether CIs can be obtained with fewer trials, thereby making it possible to use the method with clinical populations. Because the number of required trials roughly increases with the number of independent pixels, we reduced the number of pixels in our stimuli while maintaining overall stimulus size. We used the same upright faces and task used by Sekuler et al. (2004). However, instead of presenting the entire face, one pixel in each 2 x 2 region was randomly sampled, and the remaining pixels in that region were set to zero contrast. With these sampled faces, we obtained CIs from six typical and two autistic observers. After 1,450 trials, sums of squares (SS) were calculated from each CI by squaring each value and summing across the entire face. To examine the structure in more detail, CIs were filtered with a 10x10 convolution kernel, and SS values were calculated for seven regions: the forehead, nose, mouth, and the left and right eyes and cheeks. Permutation tests showed that SS values from the left and/or right eyes were significantly greater than chance levels for all observers. Additionally, the SS value from the forehead was statistically significant in one normal and one autistic observer. In conclusion, we successfully obtained face CIs for normal and autistic observers in relatively few trials. Moreover, the results with sampled faces are qualitatively similar to those obtained with normal faces. We currently are testing more autistic observers to determine how face-processing is affected by autism.

Acknowledgement: This study is supported by the CIHR-JSPS Japan-Canada Joint Health Research Program and the Canada Research Chair programme.
URL: http://staff.aist.go.jp/masayoshi-nagai/index.html

E50 599 On the distances between internal human facial features

Frédéric Gosselin[1] (frederic.gosselin@umontreal.ca), Isabelle Fortin[1], Caroline Michel[2], Philippe Schyns[3], Bruno Rossion[2]; [1]Département de psychologie, Université de Montréal, [2]Faculté de psychologie, Université catholique de Louvain, [3]Department of Psychology, University of Glasgow

That human face processing rests mainly on configural cues is the contemporary zeitgeist in the face recognition literature (e.g., Maurer, Le Grand, & Mondloch, 2002). Surprisingly, this hypothesis is supported by rather weak empirical evidence. We will not critically review the evidence here. Instead, we shall focus on two crucial but neglected points: If face processing is mainly configural then surely (1) real-world faces must vary configurally, and (2) human observers must be sensitive to these configural variations for faces over a range of realistic sizes. To address (1), four participants (to estimate between-subject error) each annotated 515 Caucasian portraits on 20 internal facial landmarks. All participants re-annotated 10% of these portraits, to estimate intra-subject error. One participant also annotated 309 Asian portraits in the same fashion. We translated, rotated, and scaled all face annotations to minimize the mean square of the distance between these annotations and their average. The differences between post-alignement face annotations reflect the configural differences between these faces. Ideal observers performed only modestly in gender, race, expression, and identity discrimination tasks on the basis of aligned face annotations. Next we turned to (2): Are human observers sensitive to this modest configural information available in real-world faces over a range of realistic sizes? Ten participants were submitted to a matching-to-sample (ABX) task. Each pair of stimuli were produced by applying two randomly chosen aligned Caucasian face annotations to a randomly chosen, aligned Caucasian portrait, preserving intact its parts but altering its configural cues. Participants completed the task at multiple viewing distances. Preliminary results indicate that human observers are capable of using real-world configural cues only at close range. We will apply multiple linear regression to the face annotations and response accuracy to quantify the importance of individual facial landmarks.

E51 600 The ecological utility of inter-feature distances for human face discrimination

Carl Gaspar[1] (gasparcm@mcmaster.ca), Patrick Bennett[1,2], Allison Sekuler[1,2]; [1]Department of Psychology, Neuroscience and Behaviour, McMaster University, [2]Centre for Vision Research, York University

Many studies have shown that humans can discriminate faces on the basis of changes in the spatial arrangement of features. However, it is not known whether sensitivity to differences in distances among features is sufficient to support real-world face identification. The current study examined if inter-pupillary distance (IPD) or nose-to-mouth distance (NMD) could serve as ecologically-valid cues for face discrimination. Observers discriminated faces that differed in IPD or NMD and then performed a realistic face identification task (Bruce et al., 1999). The primary question was whether IPD and/or NMD discrimination thresholds were correlated with face identification accuracy. Observers also performed a control task requiring them to discriminate face contrast. This control task is unlikely to rely on processes that encode spatial relations, but (like the other tasks) requires vigilance and focused attention. IPD and NMD discrimination thresholds followed Weber's law, and were not significantly affected by variation in facial identity or size. Interestingly, a composite measure of IPD and NMD thresholds was significantly correlated with face identification accuracy, even after controlling for the relation between face identification and contrast discrimination. This result suggests that face identification is supported in part by the encoding of spatial relations. However, anthropometric data from a large population of adult faces reveals that variation in IPD and NMD is small relative to the thresholds measured in most of our observers. Therefore, neither IPD nor NMD cues on their own would be particularly useful for discriminating or identifying faces in natural contexts.

Acknowledgement: NSERC grants 42133 and 105494, and the Canada Research Chair programme.

E52 601 The composite face effect is not correlated with face identification accuracy

Yaroslav Konar[1] (konary@mcmaster.ca), Patrick J. Bennett[1,2], Allison B. Sekuler[1,2]; [1]Department of Psychology, Neuroscience, & Behaviour, McMaster University, [2]Centre for Vision Research, York University

Judgments about the top halves of two faces are influenced by irrelevant differences in the bottom halves of the faces. For example, subjects typically take longer to correctly determine that the top halves are the same if the bottom halves differ. Interestingly, this so-called composite face effect (CFE) is greatly diminished if the top and bottom halves of the face are misaligned. These results have been attributed to automatic, holistic processing of aligned faces, which presumably aids recognition in naturalistic contexts. However, to our knowledge there has been no measurement of the association between the CFE and face identification. In the current experiment, we measured the correlation between the CFE and accuracy in a face identification task in a group of 24 young adults.

We used the stimuli and methods of Le Grand et al. (2004) to measure the CFE. Each trial consisted of two successively-presented faces, and subjects determined if the top halves differed. (The bottom halves always differed and were irrelevant to the task). The top and bottom halves of each face were aligned or misaligned in separate blocks of trials. For each subject, the CFE was defined as the difference between RT on "same" trials in the aligned and misaligned conditions. Subjects also participated in an identification task (Bruce et al., 1999). On each trial, a target face and a lineup of 10 faces were presented. The task was to determine if the target was present in the lineup and, if so, to select the face that matched the target. The dependent variable was percent correct.

There were large individual differences in both tasks. However, performance in the two tasks was not correlated ($r=-0.2$, $p=0.34$). This result suggests that the mechanisms that produce the chimeric face effect may not facilitate accurate face identification.

Acknowledgement: This research was supported by NSERC grants 42133, and 105494, and the Canada Research Chair programme.

E53 602 Holistic face processing can be independent of gaze behavior: Evidence from the face composite effect

Adelaide de Heering[1] (adelaide.deheering@psp.ucl.ac.be), Bruno Rossion[1], Chiara Turati[2], Francesca Simion[2]; [1]Unite de Cognition et Developpement et Laboratoire de Neurophysiologie, Universite Catholique de Louvain, Louvain la Neuve, Belgium, [2]Dipartimento di Psicologia dello Svilupo e della Socializzazione, Universita degli Studi di Padova, Padova, Italy

People tend to perceive identical top halves (i.e. above the nose) of two face stimuli as being different when they are aligned with distinct bottom halves. This face composite illusion has been demonstrated almost 20 years ago (Young et al., 1987), and is generally considered as the most compelling evidence that facial features are integrated into a holistic representation. Here we recorded eye movements during the face composite effect, i.e. when the top and the bottom parts of a composite face stimulus are integrated into a single holistic face representation. The behavioral results showed a strong face composite effect when subjects maintained fixation to the top part of the face stimulus. Fixation sites and eye movements were virtually identical when the top and bottom parts were aligned (composite illusion) or misaligned (no illusion), indicating that holistic face processing can be independent of gaze behavior. These findings reinforce the view that holistic representations of individual faces can be extracted early on from low spatial frequency analysis, independently of overt attention.

E54 603 Face discrimination does not rely on configural information.

Pamela M. Pallett[1] (ppallett@ucsd.edu), Donald I. A. MacLeod[1]; [1]Deparment of Psychology, University of California, San Diego

Successful processing of configural information is considered essential to face recognition. The face inversion effect, in which recognition of upright faces is better than inverted faces, supports this assertion. However, it is less clear whether configural information is crucial to our ability to discriminate between faces. Faces vary both featurally and configurally, but hair, eye, lip and skin color may change dramatically while configuration remains relatively constant. Configuration is useful for recognition, but discrimination between faces relies on isolating differences. Therefore, it may seem more appropriate to rely on face features rather than face configuration when discriminating between faces. If so, there might be no benefit of expertise when discriminating around normally configured faces and no inversion effect. To test this, we measured discrimination thresholds with upright, inverted and contrast-negated faces. Each condition included five test points on a continuum of compressed to expanded faces, centered on an average face. The test points included an extremely expanded, slightly expanded, normal, slightly compressed and extremely compressed face. Observers scrolled through the continuum of faces around each point until they selected a just noticeably expanded or compressed face. Results indicate no benefit for discriminability around the average face. Rather, discrimination was best around the expanded faces, and became progressively worse with increasing compression for the upright and inverted but not contrast-negated faces. With the contrast-negated faces, performance was best around the extreme distortions and thresholds peaked around the normal configuration. The fact that there was no dip in discrimination thresholds around the normal configuration suggests that humans are not experts at discriminating between normally configured faces, and therefore probably rely on featural differences. Furthermore, the results showed no inversion effect: observers' discrimination thresholds for upright faces did not differ significantly from the thresholds for inverted and contrast-negated faces.

Acknowledgement: This research was supported by NIH grant EY01711.

E55 604 Looking for Holistic Processing in Face Perception

Brandon Wagar[1] (bmwagar@uvic.ca), Daniel Bub[1], James Tanaka[1]; [1]University of Victoria

Holistic processing, considered to be a hallmark of face perception, implies that the whole is greater than the sum of its parts. In several standard demonstrations of holistic face processing, differences in an irrelevant feature (e.g., eyes) influence perceptual discriminations of a relevant feature (e.g., mouth). Theoretically, this influence could arise from a simple summation of relevant and irrelevant features, suggesting that influences of the whole do not definitively prove holistic processing. We made use of a set of face stimuli constructed so that incremental differences in a single feature led to systematic changes in performance when pairs of faces were presented for same-different judgments. We then assessed the nature of face processing in a prosopagnosic (patient LR) and controls by incrementally varying the degree of difference in relevant and irrelevant features. Participants saw two faces and judged if the relevant features (i.e., eyes) were identical while ignoring differences in the irrelevant features (i.e., mouth). Critically, the systematic variation of face similarity allowed us to test for additive (effects of the whole) versus interactive (holistic) effects of irrelevant features. The implications of these findings are discussed in reference to holistic perception and its impairment in prosopagnosia.

E56 605 Holistic processing, crowding, and perceptual and decisional dependencies

Brianna Sullivan[1] (bms287@psu.edu), Michael Wenger[1], Jennifer Bittner[1], Rebecca Von Der Heide[1]; [1]Psychology, The Pennsylvania State University

This study examines the extent to which holism in visual perception can be revealed by way of the presence or absence of crowding. Martelli, Majaj, and Pelli (2005) used crowding to propose an operational definition for holism. Specifically, they posited that holistic perception of an object is implicated if that object can be identified when the entire object is presented within an isolation field (defined as an area proportional to one-half eccentricity). Conversely, parts-based processing is implicated if identification is impaired when the entire object is within an isolation field, with an attenuation or elimination of that impairment when each part of the object is isolated by critical spacing. Martelli et al. found evidence of crowding----increases in threshold for contrast as a function of eccentricity for faces and words—suggesting that foveally-presented objects are processed holistically, and peripherally-presented objects are processed by parts. We consider this operational definition from the perspective of general recognition theory (GRT, Ashby & Townsend, 1986). GRT provides theoretical characterizations of perceptual and decisional independence and separability, with violations of independence and separability allowing for multiple characterizations of holism. In this experiment, we use accuracy of identification responses to link Martelli et al.'s operational definition to the definitions of holism provided by GRT. A set of schematic faces were presented under conditions modeled on those used by Martelli et al. Results show that we are able to use these simple schematic figures to replicate the patterns documented by Martelli et al.: specifically, evidence for the benefit of a facial context in foveal presentation, and impairment in peripheral presentation. At the same time, however, our GRT analyses suggest important disparities between the current operational and theoretical definitions of holistic processing.

E57 606 Revisiting the role of spatial frequencies in the holistic processing of faces

Olivia S. Cheung[1] (olivia.cheung@vanderbilt.edu), Jennifer J. Richler[1], Thomas J. Palmeri[1], Isabel Gauthier[1]; [1]Vanderbilt University

Goffaux and Rossion (2006; G&R) reported that 1) holistic processing (HP) is supported by low- but not high-spatial frequencies (LSF, HSF) and 2) HP has a perceptual locus. We addressed each of these claims in two experiments using sequential matching tasks with face composites. In Experiment 1, observers judged whether target parts of two faces (e.g., tops) were the same while ignoring irrelevant parts (e.g., bottoms). In G&R, a 'partial' design was used, with irrelevant parts always being different. In our study, a 'complete' design was used where task-relevant and task-irrelevant parts could be same or different, enabling the measures of both sensitivity and response bias. This is important because previous studies using the complete design have reported differential response biases based on stimulus characteristics such as alignment and orientation (e.g., Wenger & Ingvalson, 2002). We replicated the G&R results using the partial design trials, finding greater evidence for HP with LSF compared with HSF. However, results using the complete design revealed that there was a significant difference in response bias for HSF compared with LSF, indicating that the effects in G&R arose from differential response biases. In Experiment 2, we used a version of the complete design where participants responded to both parts of the face, and again found significant differences in response bias for HSF and LSF. Critically, analyzing these results based on General Recognition Theory (Ashby & Townsend, 1986) revealed strong evidence for decisional holism, with less consistent perceptual contributions. In summary, our results show that 1) differences in HP between LSF and HSF reported by G&R can be accounted for by differences in response bias and 2) HP has a strong decisional component.

Acknowledgement: This work was supported by a grant from the James S. McDonnell Foundation to the Perceptual Expertise Network.

E58 607 Comparing the loci of holistic processing in people and models

Michael L. Mack[1] (michael.mack@vanderbilt.edu), Jennifer J. Richler[1], Isabel Gauthier[1], Thomas J. Palmeri[1]; [1]Department of Psychology, Vanderbilt University

Recognizing faces is thought to rely on holistic processing, where the entire face is recognized as a unitary visual object (e.g., Farah et al., 1998). Recent work using analyses from General Recognition Theory (Ashby & Townsend, 1986; GRT) that distinguishes between possible loci of holistic effects has found stronger evidence for a decisional rather than perceptual component (Wenger & Ingvalson, 2002, 2003; Thomas, 2001; Richler et al., 2006); these results introduce important constraints for models of face processing. Using this same GRT framework, the present research identified the loci of holistic processing in simulations produced by one well-known model of face recognition by Cottrell and colleagues (Cottrell et al., 2002) that accounts for the typical kinds of holistic effects observed in people. While this model accounts for holistic effects, is the locus of this holistic processing perceptual or decisional? We first trained the model to identify a collection of individual faces, and then tested the model using a same-different composite face task, using other faces. In this task, a study face is shown, then a test face is shown where the top and bottom can be the same or different as the test face; same-different judgments are made to both parts in turn. As with data from people, the model's same-different responses to the tops and bottoms of the test faces were analyzed using Multidimensional Signal Detection Analysis (Kadlec, 1999). While the results showed some evidence for a decisional component, as observed with people, evidence for a perceptual component was far more consistently found, a divergence from holism localized in people. These results suggest the necessity of refining existing models of face recognition to incorporate potential decisional sources of holism in face processing.

Acknowledgement: This research was funded by a grant from the James S. McDonnell Foundation and NSF Grant HSD-DHBS05

E59 608 Comparing Thompson's Thatcher effect with faces and non-face objects

Elyssa Twedt[1] (Elyssa.L.Twedt@vanderbilt.edu), David Sheinberg[2], Isabel Gauthier[1]; [1]Department of Psychology, Vanderbilt University, Nashville, [2]Department of Neuroscience, Brown University, Providence

The classical Thatcher effect (TE) is experienced when global inversion of a face makes it difficult to notice the local inversion of its parts (Thompson, 1980). The TE can be quantified by comparing the ease with which observers compare a normal and locally-transformed image, when both images are shown upright vs. inverted. Here we compared the classical TE for images of adult faces to a wide variety of other categories, including grimacing faces, baby faces, animal faces, buildings, scenes, and various types of letterstrings. If the TE reflects a special form of configural processing for faces, faces should show a much larger TE than all other categories. Because a ceiling on the TE may arise if the accuracy with which changes are detected is very high for inverted pairs, we used two levels of transformation, allowing us to match conditions in terms of performance with inverted pairs. Faces showed a larger TE in RT than all other matched categories, apart from high frequency words. However, several nonface categories, including building and close-up scenes, yielded robust TEs in RTs, and in accuracy, the TE was comparable for faces and cars. A separate analysis compared TEs for low and high frequency words and their scrambled versions. Error rates revealed larger TEs for words than for scrambled words. Response times showed larger TEs for low frequency strings, regardless of whether they were words or scrambled versions of the same strings. Familiarity may influence the perception of the global orientation whereas word frequency may facilitate detection of local changes. Our results suggest the TE is not exclusive to faces - it does not appear to uniquely depend on factors such as expertise or the grotesque appearance of the transformation (as measured by independent ratings), although the string results suggest that familiarity is important.

Acknowledgement: This work was supported by a grant from the James S. McDonnell Foundation to the Perceptual Expertise Network

E60 609 Using the Temporal Dynamics of the Face Inversion Effect as a Means to Identify Contributing Configural and Part Dimensions

Noah Schwartz[1] (nschwart@usc.edu); [1]Department of Psychology, University of Southern California

The face inversion effect (FIE) is a well studied phenomena in which inverted faces are recognized significantly slower and with less accuracy than upright faces (Yin, 1969). In the following study, we expose a differential time course to upright versus inverted face processing. We then leverage these results to indirectly quantify the relative contribution of nine different internal facial dimensions to the processing of upright and inverted faces.

Subject ability to detect differences between three morphed faces was measured using an adaptive threshold estimation procedure in a same-different delayed match-to-sample task. Test stimulus duration varied in five log-spaced steps from 25 ms to free viewing. Within each trial, both faces were either presented upright or inverted. At 25 and 53 ms, thresholds for upright faces did not differ significantly from inverted faces. When viewing upright faces at durations greater than 53 ms, however, performance increased relative to inverted faces, reaching a peak at 107 ms and gradually decreasing as duration increased. These results suggest a temporal dynamic to the FIE as face specific processes are engaged after the face has undergone some degree of initial processing.

In a second experiment, JNDs for individual part dimensions (eyebrow, eye, nose, and mouth shapes) and configural dimensions (eyebrow-eyebrow, eyebrow-eye, eye-eye, eye-nose, and nose-mouth distances) were measured using the same method described above for two subjects at 25 ms, 107 ms and free viewing. Upright and inverted JND measures were combined into a composite score and compared to a similar score derived from the whole face measures taken previously. When ranked by Euclidean distance from whole face scores, mouth shape, eye-eye distance and eye-nose distance were ranked highest suggesting that the differences in perceptibility between upright and inverted faces over test stimulus duration may be due to similar changes in perceptibility in these dimensions.

E61 610 Subject Error Patterns Expose a Bias Toward Configural Information When Viewing Inverted Faces

Shuinn Chang[1] (shuinn@gmail.com), Marisa Crawford[2], Noah Schwartz[1]; [1]Department of Psychology, University of Southern California, [2]Neuroscience Program, University of Southern California

In the current study, we use the error-from-sample (EFS) paradigm (McEntire and Schwartz, VSS06) to determine which internal face dimensions are used in upright and inverted processing, respectively. EFS is a delayed match-to-sample XAFC paradigm in which the alternatives do not contain the target, but instead contain probes that each differ from the sample in a single dimension by a magnitude equal to the subject-specific JND for that dimension. Because the subject believes that a correct answer exists, the selection process requires subjects to passively discount any alternatives based on information about the sample that remains strongest in subject memory; the subject then selects the alternative that violates this information the least. As a result, the frequency of errors for a given dimension is inversely proportional to the relative strength of that dimension in subject memory, and is inversely proportional to the extent to which the subject is using each dimension to perform the matching decision.

JNDs for part dimensions (eyebrow, eye, nose, and mouth shapes) and configural dimensions (eyebrow-eyebrow, eyebrow-eye, eye-eye, eye-nose, and nose-mouth distances) were measured for each subject using morphed faces presented in an adaptive threshold estimation procedure in a same-different task. Subjects then performed a 3AFC-EFS task in which probes differed by 1 JND unit from the sample stimulus. Confirming earlier findings, subjects committed relatively fewer configural errors when viewing upright faces and relative fewer part errors when viewing inverted faces. However, this change accounted for a 5.1% shift in error rates with subjects still committing part errors on over 60% of inverted trials. These results suggest that while subjects may use part and configural information differentially as a function of face orientation, they still rely significantly more on configural information than part information regardless of the orientation of the face when making a matching decision.

E62 611 Long-range and short-range relations in the perception of the vertical position of the eyes in inverted faces.

Alla Sekunova[1] (alla_ks@hotmail.com), Jason Barton[1]; [1]Department of Ophthalmology and Visual Sciences, UBC

A recent report (Goffaux and Rossion, 2006) found that, while horizontal shifts of eye position are easily discriminated in inverted faces, vertical shifts are more difficult to perceive. Along with the demonstrated difficulty in perceiving vertical shifts of the mouth, this has suggested that the perception of vertical feature position may be relatively more vulnerable to changes in orientation. The reasons for this are unclear. One possibility is that vertical eye shifts differ from horizontal eye shifts in that horizontal shifts can be appreciated via 'short-range' relations to nearby features (e.g. the other eye), whereas vertical shifts might be indexed to more distant facial features. To test this hypothesis we contrasted shifts in vertical mouth position, horizontal eye position, and two types of shifts in vertical eye position. In one, both the eyes and brows were shifted en bloc, as in the prior study. In the second, only the eyes were shifted vertically, so that the unchanged brows acted as a short-range relation to index this type of shift. Subjects performed an oddity paradigm with both upright and inverted faces. We replicated the large inversion effects for vertical mouth position

Sunday Posters

and vertical eye-and-brow position, and the small inversion effect for horizontal eye position. The critical condition, the vertical eye-alone position, showed less inversion effect than the vertical eye-and-brow position. This suggests that at least part of the effect of inversion on perceiving vertical eye position is due to the lack of short-range second-order relations for this type of shift. A failure to appreciate changes in configuration that depend upon long-range relations could be due to inefficient sampling of the whole face structure in inverted presentation, whereas preserved perception of short-range relations would be consistent with preserved local processing.

E63 612 The Perception of Age in Human Faces: Upright & Inverted Results

Patricia Costello[1] (coste006@umn.edu); [1]Gustavus Adolphus College

Faces convey a substantial amount of information about their owners including emotional state, gender, and age. Perception of age plays an important role in how we interact socially with others. Although face processing continues to be intensely researched, the factors involved in the perception of age have been largely ignored. Any theory of face recognition is incomplete without an understanding of age perception since age is an important facial characteristic. This study seeks to understand how people's age and gender influence their age judgment of an unknown face. Age estimation accuracy was also assessed for two different exposure times in order to determine how much viewing time is needed to best estimate age. College age participants viewed male and female faces ranging from 20 to 80 years old for either 100ms or 1000ms and estimated how old each face was. All participants also categorized the faces as "young" or "old" based on their individual criteria. A second inverted condition was added for the 100ms exposure time in order to investigate a possible face inversion effect in age perception. In general, participants were more accurate for their own age group and less accurate for older faces. Both males and females were more accurate for male faces, but accuracy was high even at 100ms exposures. Participants were more likely to underestimate older faces in the inverted compared to the upright condition. Male participants considered females "old" after the age of 35, while females considered both males and females "old" after about age 50. These findings could be interpreted using an evolutionary psychology framework.

Reading

Author Presents: 2:00 - 3:45 pm

E64 613 Diagnostic features for uppercase and lowercase letter recognition

Catherine Éthier-Majcher[1] (c.ethier-majcher@umontreal.ca), Daniel Fiset[2], Caroline Blais[1], Martin Arguin[1,3], Daniel Bub[2], Frédéric Gosselin[1]; [1]Université de Montréal, Département de Psychologie, and Centre de Recherche en Neuropsychologie et Cognition, [2]University of Victoria, Department of Psychology, [3]Centre de recherche, Institut Universitaire de Gériatrie

"A word is unreadable unless its letters are separately identifiable." Taken from the recent article of Pelli, Farell and Moore (2003), this sentence underlines the crucial importance of letter identification for visual word recognition. Congruently, a fundamental purpose in the study of visual letter recognition is the discovery of the features responsible for accurate letter identification. In the last three decades, researchers have proposed sets of individual features, which predict relatively well letter identification performance and letter confusions. However, these descriptions are usually based more on intuitions regarding the information underlying letter similarity or on confusion matrices than on empirical data directly assessing the information used to recognize letters accurately. In the present study, we aim to reveal the potent features (Gosselin & Schyns, 2002) mediating uppercase and lowercase letter identification in Arial font letters. For this purpose, we explicitly determined the portions of each individual letter which drives its accurate identification. Six participants each identified 26,000 uppercase and lowercase Arial font letters (for a total of 312,000 trials) sampled in image location and spatial frequency by Bubbles (Gosselin & Schyns, 2001). Separate analyses for each individual letter revealed the potent features for uppercase and lowercase Arial font letter identification. The results show that high spatial frequencies support the identification of features that discriminate among visually similar letters (e.g., 'O' and 'Q' in uppercase). In contrast, low spatial frequencies carry information about the features that are shared among subsets of visually similar letters. These observations are discussed in relation to a letter identification model in which low spatial frequencies are processed initially to determine the subset of the alphabet the target belongs to. Then, high spatial frequencies are processed for information allowing unique letter identification.

E65 614 Visual processing of words and spatial information for action

Yann Coello[1] (yann.coello@univ-lille3.fr), Angela Bartolo[1], Alexia Weisbecker[1]; [1]Dept of Psychology, University of Lille, France

There is converging psychophysical and neuropsychological evidences for distinct processing of object attributes within the ventral and dorsal stream of the visual system depending on the purpose of the behaviour, i.e. semantic categorisation or goal directed action. Motor act can however be triggered according to linguistic information processed within the ventral stream or spatial information processed within the dorsal stream but with different time constraints due to differences in the magno-parvocellular neural latencies. We tested the influence of presenting congruent or incongruent spatial information when processing linguistic stimulus (or the opposite) to specifying a right or left motor response. We found that the time to respond to a linguistic stimulus (the word "DROITE" (right) or "GAUCHE" (left) displayed within a rectangular frame) was 186ms greater than that to react to a spatial stimulus (a target-dot to the right or left side of the rectangular frame). No interference effect on spatial accuracy and reaction time was observed when responding to the spatial cue whatever the linguistic context. On the contrary, a strong interference of non-congruent spatial information on both reaction time and response accuracy was found when responding to the linguistic cue but predominantly for responses with short reaction time (300 to 400ms). Response selection can thus be influenced by non-relevant visual information suggesting that the ventral and dorsal visual streams are activated simultaneously and compete to specifying the relevant visual signal for action but with different time constraints.

Acknowledgement: Supported by European Science Foundation, Eurocores CNCC CRP grant, and ANR "neurosciences, neurologie et psychiatrie" program from the French Ministry.

E66 615 TMS stimulation of V5 interferes with single word reading

Sheila Crewther[1] (s.crewther@latrobe.edu.au), Robin Laycock[1], Paul Fitzgerald[2], David Crewther[3]; [1]School of Psychological Science, La Trobe University Melbourne, Victoria, [2]Psychological Medicine, Monash University Melbourne, Victoria, [3]Brain Sciences Institute, Swinburne University of Technology Melbourne, Victoria

Word reading is a skill commonly associated with parvocellular and ventral pathway processing rather than magnocellular dorsal stream processing. However there is considerable evidence for a magnocellular/dorsal impairment in developmental dyslexia. Such controversial views can be viewed in terms of the hypothesis of Bullier and colleagues (2001) which suggested that the magnocellular latency advantage underlying the earliest feedforward signals from primary visual cortex V1 into the dorsal stream play a significant role in the initial global analysis of the scene and early activation of transient attention prior to retroactive feedback to (V1) and the ventral stream. Such a dorsal feedback loop could be expected to be important for fast and accurate automated reading so we investigated the necessity of of V1 and dorsal area V5 in word recognition using transcranial magnetic stimulation (TMS).

Eleven healthy young adults viewed brief presentations of single words followed by a mask of white noise, with stimuli duration adjusted such that word detection was at least 80% correct (mean duration = 56ms), in a three-alternate-forced-choice paradigm. On each trial a paired-pulse of TMS was delivered to either V1 or V5 at randomly selected onset asynchronies between 0 and 221ms post word onset. Preliminary analyses suggest that TMS stimulation of V1, either early at or before 32ms, or later at approximately 95ms inhibited word recognition. TMS induced disruption over V5 showed greater variability between participants, with accuracy primarily disrupted with stimulation between 60ms and 160ms. These findings suggest that the dorsal stream plays a functional role in single word reading.

E67 616 fMRI-RA evidence for a neural representation in the "Visual Word Form Area" based on whole words

Laurie Schwarz Glezer[1] (lsg5@georgetown.edu), Xiong Jiang[1], Maximilian Riesenhuber[1]; [1]Department of Neuroscience, Georgetown University Medical Center, Washington, DC

Successful reading requires the brain to correctly recognize printed words. Recent research has identified an area in the left fusiform gyrus that responds preferentially to written words, termed the "visual word form area" (VWFA). Studies using fMRI rapid adaptation (fMRI-RA) techniques have provided information about the invariance properties of the representation in the VWFA. However, the neural code for individual written words in the occipitotemporal cortex is still not well understood. Here, we used an fMRI-RA paradigm to examine neuronal tuning specificity and the nature of the word representation in the VWFA. Subjects (n=7) performed a primed semantic decision task in the scanner. We examined three conditions: 1) a "same" condition, in which the same word was presented twice (as prime and target) in each RA trial, 2) a "1L" condition in which the prime and target words differed by one letter, and 3) a "different" condition, in which the target word shared no letters with the prime. All words were real high frequency nouns. Our assumption was that the two words in the "different" condition should activate disjoint neuronal populations, leading to maximum release from adaptation, whereas suppression should be strongest in the "same" condition with the two stimuli activating the same neurons. Our results indeed showed that there was significant adaptation in the VWFA for the "same" condition when compared with the "different" and "1L" conditions (p=0.004 and p=0.001, respectively). Interestingly, average BOLD contrast response levels did not differ significantly between the "1L" and "different" conditions (p=0.852), suggesting that even though the two words in the "1L" condition shared sub-lexical units (e.g., letters or bigrams), there was no adaptation when compared to the "different" condition. This suggests that in the VWFA words are processed as whole word units and not as sub-lexical units.

Acknowledgement: NIMH P20 MH66239

E68 617 Size of the Visual Span May Explain Reading-Speed Differences for Horizontal and Vertical Text

Deyue Yu[1] (yuxx0207@umn.edu), David Gerold[1], Gordon E. Legge[1], Allen MY Cheong[1], Heejung Park[1]; [1]Department of Psychology, University of Minnesota

Purpose: Previous research has shown that reading speed is substantially reduced by arranging letters in words vertically compared with the normal horizontal arrangement. According to an experiential hypothesis, the difference occurs because most English speakers almost always read horizontal text and seldom read vertical text. We have explored an alternative perceptual hypothesis. It has been proposed that the size of the visual span—the number of letters recognized reliably without moving the eyes—is a visual factor limiting reading speed. We hypothesized that reduced visual-span size in the vertical direction accounts for the reduced vertical reading speed.

Methods: Five normally sighted adults participated. Visual span profiles, plots of letter-recognition accuracy as a function of letter position left or right (horizontal arrangement) and above or below (vertical arrangement) the midline, were measured with trigrams (strings of three random letters). Size of the visual span was defined as the area under this profile, converted to bits of information transmitted. Reading performance was measured using RSVP (Rapid Serial Visual Presentation) for horizontal and vertical words.

Results: The mean horizontal reading speed was 524 wpm, and was 1.7 times greater than the mean vertical reading speed. As predicted by the Perceptual hypothesis, the mean horizontal visual span (42 bits) was larger than the mean vertical visual span (35 bits). Based on the relationship between visual-span size and reading speed in other studies, a difference of 7 bits in the visual-span size is expected to produce a difference in reading speed by a factor of 1.6 which is close to the observed value.

Conclusions: Our results indicate that a perceptual explanation may account for the difference in horizontal and vertical reading speed. These results do not exclude the possibility that both the size of the visual span and reading speed are influenced by reading experience.

Acknowledgement: Supported by NIH grant EY02934.

E69 618 Effect of line spacing on reading speed in normally-sighted subjects with an artificial scotoma

Jean-Baptiste Bernard[1] (bernard@incm.cnrs-mrs.fr), Anne-Catherine Scherlen[2], Françoise Vitu-Thibault[3], Eric Castet[1]; [1]Institut de Neurosciences Cognitives de la Méditerranée - CNRS - Université Aix-Marseille - France, [2]Ecole Nationale d'Ingénieur de Saint-Etienne - France, [3]Laboratoire de Psychologie Cognitive - CNRS - Université de Provence - France

Different visual factors like character size, contrast or font have been reported in the clinical litterature to affect reading speed for subjects with macular scotomas. In this study, using a gaze-contingent display, we examined whether increasing line-spacing improves reading performance in subjects with an artificial central scotoma.

7 normally-sighted subjects (23-43 years) had to read sentences as fast as possible and without making mistakes. On each trial, a sentence, covering 3 or 4 lines, was displayed on the monitor. We used a set of 1000 sentences extracted from French litterature with strict constraints inspired from the MNREAD chart (e.g. number of characters for each sentence and word, frequency of each word). Line spacing was 0.5x, 1x or 2x the standard spacing, and letter size (x-height) varied from 0.52 to 2 degrees (step: x1.4). Gaze location was recorded at 500Hz with an EyeLink II eye-tracker and was used to draw a square-shaped gaze-centered mask (6x6 or 10x10 degrees). Reading time for each sentence was measured to compute reading speed.

Our main finding is that interline spacing does not affect reading speed, contrary to a recent RSVP study (Chung, 2004). We also find that the modulation of reading speed as a function of character and scotoma size has the same characteristics as those reported in the clinical litterature, suggesting that our paradigm is a valid scotoma simulation tool. Altogether, our results suggest that vertical crowding is not a major limiting factor of reading speed when the eyes are free to move. From a practical point of view, the lack of effect of line spacing on reading speed suggests that an optimal aid for low-vision patients should magnify print size while keeping relatively small line spacing. This would allow to display more text information within a given area.

E70 619 Crowding accounts for the limits of amblyopic reading

Denis Pelli[1] (denis.pelli@nyu.edu), Shuang Song[2], Dennis Levi[2,3]; [1]Psychology and Neural Science, New York University, [2]School of Optometry, University of California at Berkeley, [3]Helen Wills Neuroscience Institute, University of California at Berkeley

Might the impairment of reading in amblyopia be a consequence of increased crowding (i.e. larger critical spacing)? We measured the reading rate of amblyopes as a function of letter spacing in central and peripheral vision. From these results, we estimate the "critical spacing for reading" (similar to critical print size). We find that the amblyopic reading deficit is large but very specific. Peripheral reading is unaffected. Central reading has greatly increased critical spacing, but normal maximum reading rate. We compared the critical spacing for reading with the observers' letter acuity and the critical spacing for identifying a letter among flankers, which is the classic measure of crowding (Bouma, 1970). For both normals and amblyopes, in both central and peripheral vision, we find that the critical spacing for reading equals the critical spacing for crowding.

Acknowledgement: EY04432, EY01728

E71 620 MagnoFly: game-based screening for dyslexia

James Ferwerda[1] (jaf2@cornell.edu), Brendan Rehon[1]; [1]Program of Computer Graphics, Cornell University

Dyslexia is a complex reading disorder that affects approximately five percent of the population. Recent research suggests that deficits in the motion sensitive magnocellular pathways of the visual system may play an important role in some forms of the problem [Stein & Walsh '97, Pammer & Wheatly '01, Talcott et al. '02]. Evaluating magnocellular motion sensitivity in young children could help identify those at risk for developing dyslexia, however existing psychophysical tests of motion perception are time consuming, boring, and difficult to administer, especially to children. To address this issue we have developed a computer game called MagnoFly that measures a player's magnocellular function using motion coherence patterns. In the game, the player's task is to protect babies from swarms of flies with bug spray. Initially the swarms move randomly, but over time one swarm begins to move coherently toward a baby. The player gains points by spraying the aggressive swarm, but loses points by spraying indiscriminately. Over the course of the game a background process varies the coherence of swarm motion, and thereby measures the player's magnocellular motion threshold. At the end of the game, a report is generated to allow specialists to review individual results and determine if further evaluation for dyslexia is indicated. This work demonstrates the potential for using computer games as an enjoyable and effective platform for vision testing.

Acknowledgement: This work was supported by NSF award 0113310 and the Cornell Program of Computer Graphics.
URL: http://www.graphics.cornell.edu/~jaf/projects/magnofly/

E72 621 Training Direction Discrimination Rapidly Remediates a Wide Spectrum of Reading Deficits

Teri Lawton[1] (plearn@earthlink.net); [1]Reading Screening & Remediation, Perception Dynamics Institute, Del Mar, CA

This study examined the effects of training in direction discrimination on reading performance in 7-year-old students to assess whether dyslexics are deficient in motion processing. A literacy skills test battery was administered to each participant before and after training to divide participants into groups of efficient and inefficient readers. Each of these groups was randomly split into three subgroups. Subgroup 1 (control) received no special training beyond school's reading program; subgroup 2 (control) received training in a word game; Subgroup 3 (treatment) received training in direction discrimination by judging the direction of motion (left vs. right) of vertically oriented sinusoidal gratings of varying spatial frequency. Efficient readers were initially 3-5 fold more sensitive in direction discrimination and read twice as fast as dyslexics. The direction discrimination contrast threshold was measured using a staircase procedure. Over the course of training (biweekly 10 minute sessions for 15 weeks), contrast sensitivity increased an average of 5-14 fold (depending on background structure) for dyslexics and 7 fold for efficient readers. For dyslexics, direction discrimination training improved most reading skills 1-3 grade levels, increasing reading fluency 2-4 fold, whereas dyslexic children in the control groups barely improved. Training on motion discrimination also improved a child's reading comprehension, spelling, and pronunciation. The more training, the more reading skills improved. This study suggests that the core deficiency of many poor readers is an impaired ability to discriminate the direction of motion, which may be caused by spatial and temporal sequencing problems resulting from magnocellular neural timing deficits. Sluggish magnocellular neurons would make it difficult to attend in direction discrimination tasks, since the magnocellular neurons would not signal in advance of the linked parvocellular neurons. This would cause a deficit in attentional focus, preventing the linked parvocellular neurons from isolating and sequentially processing the relevant information.

URL: www.movingtoread.com

E73 622 Age, Memory, and Polarity: The Ability to Remember Text, as Affected by Age, Paper versus Computer, and Polarity (Black vs. White Text and Background)

Faith Florer[1] (flf1@nyu.edu), Jemma Lampkin[1], E. Corey Lawrence[1], Veronique Pardieu[2], Katherine Lu[3]; [1]New York University, [2]Universite de Tours, [3]Stuyvesant High School

We explored whether older (40-50 years) or younger (20-30 years) readers would recall more words from nonfiction text when text was read on paper vs the computer, and when participants read black text on white background or white text on black background. After reading, participants worked on a distractor task; then participated in a 20 word explicit or implicit memory test. We tested subjects after a one-minute delay. We found that older readers recalled more words when text was white on a black computer background. Conversely, they recalled more when text was black and backround paper was white. The benefits of black text on the computer is consistent with the literature showing that glare adversely affects reading when people have low vision. The results suggest that visual variables, rather than comfort level conferred by the familiarity of paper, are more likely to affect how material is retained when older people are reading. Younger people recalled more on paper than the computer, regardless of the polarity (white vs. black) of the text, consistent with past studies.

Special Populations: Disorder and Disease

Author Presents: 2:00 - 3:45 pm

E74 623 Is residual vision in monkeys with unilateral lesion in the primary visual cortex like normal, near-threshold vision?

Masatoshi Yoshida[1,2] (myoshi@nips.ac.jp), Kana Takaura[1,2], Tadashi Isa[1,2,3]; [1]Dept Developmental Physiol, Natl Inst Physiol Sci, Okazaki, Japan, [2]School of Life Science, The Grad Univ for Adv Stud, Hayama, Japan, [3]CREST, JST, Kawaguchi, Japan

Some of the patients with damages in the primary visual cortex (V1) retain their ability to localize visual targets in their affected hemifield ('blindsight' or 'residual vision'). One of the controversies about blindsight is whether it is a form of near-threshold vision or qualitatively different from normal vision. However, the extent of damage of the patients was not necessarily complete and restricted within V1, thus leaving the question unsolved. Here we used monkeys with unilateral lesion in V1 as an animal model of blindsight and examined whether the monkeys' residual vision is a kind of attenuated vision that can be mimicked by presenting near-threshold stimuli to their intact visual hemifield. After the unilateral removal of V1, two monkeys were tested with a visually guided saccade task with a target in one of five possible directions either in the intact or affected hemifield. The monkeys correctly localized the saccadic targets presented in the affected hemifield (70-95 % correct), while the accuracy of the saccade was worse than that of the intact hemifield, as quantified by the variance and the systematic errors in the saccadic end points. Then the monkeys were tested with near-threshold stimuli in the intact hemifield. Near-threshold stimuli were constructed either (1) by reducing luminance contrast or (2) by increasing spatial ambiguity. In both near-threshold conditions (70-90 % correct), the variance and the systematic errors in the saccadic end points were far smaller than that of the affected hemifield. The saccadic reaction time in the near-threshold condition was longer than that of the affected hemifield. These results suggest that the behavioral effects of V1 lesion are not limited to vision, but V1 lesion affected visuomotor processing including the saccade control system and/or decision process. We conclude that the residual vision of monkeys with V1 lesion is not like normal, near-threshold vision.

E75 624 Hemianopic gaze dynamics in a naturalistic task

Tim Martin[1] (tmartin@cvs.rochester.edu), Kristin Kelly[1], Meghan Riley[1], Mary Hayhoe[2], Krystel Huxlin[1]; [1]Deptartment of Ophthalmology, University of Rochester Medical Center, [2]Department of Brain and Cognitive Sciences, University of Rochester

Homonymous hemianopia, unilateral blindness caused by damage to early visual cortex, causes deficits in many every-day visually-guided activities, including driving, walking and reading. Previous work has reported abnormal fixation distribution in such individuals when in visual search tasks. However, little is known about the functional consequences of these abnormal fixation patterns in complex, naturalistic settings. We measured eye position while three homonymous hemianopes (HH) and four visually-intact controls performed a model-building task. Subjects were seated at a real table and asked to assemble 10 models consisting of four slats attached together with three bolts and nuts from a wooden construction set (Baufix - Mennie et al., 2003). Overall performance in hemianopes was remarkably similar to that of controls. Hemianopes were not impaired in their speed or ability to complete the task, nor were their fixations less accurate than controls. This is remarkable because many of the saccades were made into the blind visual field. Such saccades must be programmed on the basis of spatial memory, since visual input is absent. There were some subtle differences in performance: hemianopes exhibited significantly more look-ahead fixations (LAF) while also spending a greater proportion of time fixating task-irrelevant parts of the table than controls. State transition matrices and pathfinder associative networks found the sequence of eye movements in hemianopes less predictable than in controls. Since LAFs might provide spatial information for planning subsequent movements, this data is consistent with a heavier reliance on visual memory in programming accurate eye and hand movements . This might be associated with a greater need for frequent updating of the internal representation using LAFs.

Acknowledgement: The authors would like to thank Brian Sullivan and Kelly Chajka for help in data collection.

E76 625 Consequences of central vision loss for eye movements in natural tasks.

Brian Sullivan[1] (brians@mail.utexas.edu), Jelena Jovancevic[2], Mary Hayhoe[1], Gwen Sterns[3]; [1]Center for Perceptual Systems, University of Texas at Austin, [2]Center for Visual Science, University of Rochester, [3]Ophthalmology Department, Rochester General Hospital

Patients with central vision loss typically use a preferred retinal locus (PRL) in peripheral retina to fixate objects. Research on the use of PRLs has focused primarily on basic eye movement measures and high acuity tasks such as reading. It is not known how these findings generalize to many everyday tasks, and to what extent task affects PRL selection. We studied PRL usage during three natural tasks performed by a subject with bilateral central scotomas (~20° in diameter) due to Stargardt's disease. The tasks included making a sandwich, building a model, and catching a bounced ball. Binocular eye movements were recorded using an Eyelink II tracking system. The subject was calibrated by centering gaze onto a large fixation cross extending beyond the scotomas. The gaze record indicated that the subject could reliably center gaze on the cross. Additionally, the calibration method was validated using a similar technique during fundus imaging. The subject's fixation patters were compared with those of normal sighted subjects. In general, the subject preferred to use PRLs in the lower left visual field quadrant. While making a sandwich or building a model, the retinal area used as a PRL varied considerably from <10deg2 to >100deg2 depending on the sub-task performed. Additionally, the location of the PRLs varied depending on the location of objects in the scene, relative to the body. While catching, the subject was able to peripherally pursue the ball at gains of 0.5-1.0 over part of its path. Peripherally guided pursuit could be achieved over a range of retinal locations covering >200deg2. In summary, many retinal locations can provide the information critical for guiding the current action in natural vision. This may be a consequence of the reduced spatial resolution required to guide many actions, and the low acuity gradient in the spared retina.

Acknowledgement: Supported by NIH EY-05729 and RR06853

E77 626 Possible Role of Peripheral Vision in Individuals with Retinitis Pigmentosa and those with Usher Syndrome

Valentina Arena[1,3] (v.arena@city.ac.uk), Alison Finlay[2], Brice Thurin[2], Bencie Woll[3]; [1]Department of Language and Communication Science, City University London, [2]Department of Optometry and Vision Science, City University London, [3]Deafness, Cognition and Language Research Centre, University College London

It has been speculated that the lack of auditory experience in Deaf individuals may lead to changes in their ability to perceive visual stimuli. In particular Deaf subjects have found to perform better for motion stimuli tasks appearing in the periphery than in the central of the Visual Field. Retinitis Pigmentosa (RP) is a progressive retinal disease that leads to restriction in the peripheral Visual Field. People with Usher Syndrome (US) Type 1 are born deaf and communicate with Sign Language; they develop RP during their teens. We speculate that rearrangement of peripheral visual function occurs with the progression of RP. Indeed, it has been empirically observed that signers with US reduce the space within which they sign (signing space) as RP reduces their visual field. Two explanations have been suggested: some role of visual feedback in sign production (in addition to proprioceptive feedback); or an attempt to induce the conversational partner to adapt the size of his signing space to fall into the reduced cone of vision of the person with US. We used infra-red cameras to measure the positions of markers placed on the hands of subjects while they described pictures representing arrangements of dolls' house furniture. Four groups were studied: signers with US, normally sighted deaf signers, normally hearing people with RP, and normally hearing/sighted people. We also measured each participant's visual field using a standard Visual Field test (Goldmann perimeter). This was compared to participant's signing or gesturing space. Results indicate a correlation between the size of the visual field and the size of signing and gesturing in the presence of visual impairments for both the Usher and RP groups. These findings support the hypothesis of a role for visual feedback in calibration of the size of sign and gesture space.

E78 627 Make the clocks tick right: Influence of computer-based vision restoration therapy on temporal-information processing in partially blind patients.

Dorothe A. Poggel[1,2] (dapoggel@bu.edu), Bernhard Treutwein[3], Berhard A. Sabel[4], Hans Strasburger[1,5]; [1]Generation Research Program (GRP), Ludwig-Maximilian University Munich, Bad Toelz, Germany, [2]Center for Innovative Visual Rehabilitation, Boston VA Medical Center, Boston, MA, [3]IuK, Ludwig-Maximilian University Munich, Germany, [4]Institute of Medical Psychology, Otto-von-Guericke University Magdeburg, Germany, [5]Department of Medical Psychology, University of Goettingen, Germany

Background: Patients with visual field loss after cerebral lesions show impaired temporal-information processing in partially defective but also in perimetrically intact visual field regions (Poggel et al., CNS 2006). We investigated effects of a computer-based training designed to restore light detection on dynamic visual field properties in partially blind patients. Methods: In nine patients with cerebral visual field loss, we measured double-pulse resolution thresholds (DPR, minimum perceivable duration of temporal gap between two light pulses) and simple reaction times (RT) across the visual field, before and after three months of Vision Restoration Therapy (VRT). Patient performance was compared to normative values (Toelz Temporal Topography study, Poggel & Strasburger, 2004). Results: Perimetrically determined light detection performance (i.e. intact visual field size) increased over the three-months training period (30 minutes of training per day). Averaged over the entire visual field, DPR remained constant, but there was a slight improvement of RT (-21ms; p=0.327). However, DPR (-15ms; p<0.001) and RT (-111ms; p<0.001) improved markedly in areas of residual vision, with effect size depending on the level of intactness of the respective visual field region. Compared to performance of healthy subjects, patients' DPR and RT were still impaired after training, with large inter-individual variability between patients, however. Conclusions: Training-induced improvement of light detection in patients with visual field loss thus generalizes to dynamic visual functions. Temporal-information processing improves relative to baseline, but not all patients reach normal level of performance. The results show improvements of residual visual impairment that remain unnoticed in perimetric testing.

Acknowledgement: Study supported by a grant of the Deutsche Forschungsgemeinschaft (Str 354/3-1) to HS.

E79 628 Numerical estimation in blind subjects: Evidence of the impact of blindness

Julie Castronovo[1,2] (j.castronovo@bham.ac.uk), Xavier Seron[2,3]; [1]Brain and Behavioural Sciences, University of Birmingham, UK, [2]Unité de Neurosciences Cognitives, UCL, Belgium, [3]Centre de Rééducation Neuropsychologique, Cliniques Universitaires Saint-Luc, Brussels, Belgium

Vision was for a long time considered as essential in the elaboration of the semantic numerical representation (e.g., Simon, 1999). However, early visual deprivation does not prevent the elaboration of a numerical representation with similar spatial properties as the one elaborated in sighted people: a mental continuum oriented from left to right (Castronovo & Seron, in press; Szücs & Csépe, 2005). Here we investigated the impact of blindness and its following experience on the third property of the semantic numerical representation: its obedience to Weber's law. According to the "sensory limitation hypothesis", vision presents an advantage over the other senses in the apprehension of numerosities. Early visual deprivation should therefore involve less proficient experience with numbers and more sensitivity to Weber's law. According to the "cognitive compensatory mechanisms hypothesis", blind people develop compensatory mechanisms to access and represent numerosities in daily life situations, in which sighted people are not used to rely on numerical information (e.g., locomotion). Blindness should therefore involve more experience with numbers and less sensitivity to Weber's law. A group of blind and sighted subjects undertook two numerical estimation tasks: 1) key-press estimation task; 2) auditory events estimation task. Blind and sighted participants' performance obeys Weber's law. However, blind participants also show better numerical estimation abilities than sighted subjects, especially in a numerical context involving proprioception. The theories postulating an important role of vision in the elaboration of numerical cognition and the "sensory limitation hypothesis" cannot account for these results. Blind participants' performance support the "cognitive compensatory mechanisms hypothesis" suggesting that because of their particular experience with numbers, blind people might have developed the ability to compensate for Weber's law, resulting better numerical estimation skills, especially in numerical context involving proprioception. Therefore blindness and its following experience with numbers might have a positive impact on numerical processing.

E80 629 Visual processing in infants with fragile X syndrome

Faraz Farzin[1,2,3] (ffarzin@ucdavis.edu), David Whitney[1,2], Randi Hagerman[3,4], Susan Rivera[1,2,3]; [1]Department of Psychology, University of California, Davis, [2]Center for Mind and Brain, University of California, Davis, [3]U.C. Davis M.I.N.D. Institute, [4]Department of Pediatrics, University of California, Davis

Many studies have reported that deficits in visual motion processing exist in groups with developmental disorders such as autism, Williams syndrome, and Dyslexia. More recently, evidence has shown that a selective motion processing deficit is present in adults with fragile X syndrome (FXS), the most common cause of inherited mental delay. Using a direction discrimination task, adults with FXS were found to have increased thresholds for motion but no difference on form perception compared to controls (Kogan et al., 2004). Here we examined low-level visual processing in infants with FXS to explore the developmental trajectory of this putative deficit. Using a forced-choice preferential looking paradigm, we measured detection thresholds for first-order (luminance defined) and second-order (contrast defined) moving and static stimuli. Detection thresholds for static first- and second-order stimuli were consistent for typical infants and those with FXS, which would be expected based on previous work. More interestingly, there was no difference in motion detection thresholds for the two groups, even for contrast defined second-order motion. The results indicate that infants with FXS have detection thresholds comparable to mental age-matched controls, and are important because they rule out a low-level motion processing deficit in infants with FXS. Evidently, any visual deficits manifested in FXS syndrome must arise at a later stage of development or at a higher stage of visual processing.

E81 630 The blinking emotionalattentional blink and the parietal lobe.

Ingrid Olson[1,2] (iolson@psych.upenn.edu), Marian Berryhill[1,2], Steven Most[3]; [1]Center for Cognitive Neuroscience, [2]University of Pennsylvania, [3]University of Delaware

Emotional stimuli engage attentional resources to the neglect of actively sought targets. This has been illustrated in a task termed "attentional rubbernecking" (Most et al,2005), in which attentional blinks are spontaneously induced by emotional distractors. In control subjects, this occurs when the target follows an emotional distractor by two items (Lag 2) and when it immediately precedes the distractor (Lag-minus-1). Neuroimaging and neuropsychology link preferential attendance towards emotional stimuli to the amygdala. Here, we asked whether the parietal lobe is also integral to directing attention to emotional images, by testing whether a simultanagnosic patient with bilateral parietal damage would exhibit an emotionally induced attentional blink. An RSVP stream of images was presented at a rate of 100-ms per item and contained an emotional distractor at either Lag 2 or Lag-minus-1. In contrast to controls, bilateral parietal damage was associated with an emotional AB (e.g. decreased target detection accuracy) only when the target preceded an emotional stimulus. However, when the presentation rate was slowed to 150 ms per item, the patient exhibited retroactive target-detection enhancement, similar to that found among control subjects. The combination of preserved retroactive effects but attenuated proactive effects suggest some specificity in the involvement of parietal areas with attention to emotional stimuli. These results highlight the involvement of parietal areas in attention to emotional stimuli and are consistent with reports that temporal attention (Husain et al, 1997; Duncan et al, 2003) as well as spatial attention is severely disrupted in patients with parietal damage.

E82 631 Synesthetic Color Appearance is immune to Brightness Contrast

Sang Wook Hong[1] (sang.w.hong@vanderbilt.edu), Randolph Blake[1]; [1]Department of Psychology, Vanderbilt Vision Research Center

PURPOSE: Recent theories of color-graphemic synesthesia posit that synesthetic color experiences arise from activation of some of the neural mechanisms involved in real color processing. But how early in color processing do synesthetic colors emerge? To investigate this question, we determined whether synesthetic colors are affected by brightness contrast. METHODS: Using a matching procedure, we obtained color appearance measurements from three color/orthographic synesthetes. Each participant carefully adjusted the hue, saturation and brightness of a 1-deg circular target situated on the right-half of a calibrated video monitor until it matched the color appearance of a small test figure appearing on the left-half of the monitor. In the synesthetic-color condition, the test figure was a fixed luminance (30cd/m2), achromatic alphabetic character that induced synesthetic color. This test figure was centered within an equal-energy-white (EEW), 3-deg circular background whose luminance varied from 10 to 30 cd/m2 over trials. The matching target adjusted by the observer also appeared within a 3-deg circular background whose EEW luminance (30 cd/m2) remained constant over trials. In the nonsynesthetic condition, the test figure was a real colored, non-alphabetic symbol that did not induce synesthesia; the symbol's chromaticity values corresponded to those estimated from the isomeric matching in which both backgrounds were 30 cd/m2. RESULTS AND DISCUSSION: In the nonsynesthetic condition, the matching luminance of the chromatic test symbols was inversely related to the background luminance against which those symbols were viewed; the colored symbols, in other words, were robustly susceptible to brightness contrast. In the synesthetic-color condition, however, the matching luminance of the synesthetic colors was invariant with background luminance; synesthetic colors, in other words, were immune to brightness contrast. Evidently, synesthetic color experiences emerge relatively late in the hierarchy of stages involved in color appearance.

Acknowledgement: Supported by EY13358

E83 632 Personifying Inanimate Objects in Synaesthesia

Jonathan Carriere[1] (jcarrier@watarts.uwaterloo.ca), Kelly Malcolmson[1], Meghan Eller[1], Donna Kwan[1], Michael Reynolds[2], Daniel Smilek[1]; [1]University of Waterloo, [2]Trent University

We report a case study of an individual (TE) for whom inanimate objects, such as letters, numbers, simple shapes, and even furniture, are experienced as having richly detailed, personalities. TE reports that her object-personality pairings have been there for as long as she can remember, are stable over time, occur independent of her intentions, and that this is true even for novel objects. In these respects, her experiences denote synaesthesia. We show that TE's object-personality pairings are indeed consistent over time; she correctly recognized 91% of the personality attributes for familiar objects (3.4 SD greater than the control mean of 47%), and 80% of the attributes for novel objects (2.3 SD greater than the control mean of 57%), when presented with a selection of attributes previously provided for the same or other objects. A qualitative analysis of TE's personality descriptions revealed her personifications are extremely detailed and multidimensional, with familiar and novel objects differing in specific ways – familiar objects having more social characteristics than novel objects in particular. We also show that TE's visual attention can be biased by the emotional associations she has with personalities elicited by letters and numbers. In a free viewing task the valence of TE's object-personality associations had predicted effects on object fixation tendencies. On average, TE fixated negative objects less often than positive objects. She also demonstrated attentional capture by negative objects, fixating negative objects longer than positive objects. Controls showed no significant differences. These findings demonstrate that synaesthesia can involve complex personifications for inanimate objects, which can influence the degree of visual attention paid to those objects.

Acknowledgement: This research was supported by the Natural Sciences and Engineering Research Council (NSERC) with a grant to D.S., a postdoctoral fellowship to M.R. and graduate scholarships to K.M. and J.C.

E84 633 Detection of imminent collisions by drivers with Alzheimer's Disease, Parkinson's Disease and Stroke

Lindsay M. Vaux[1] (lindsay-vaux@uiowa.edu), Rui Ni[2], Matthew Rizzo[1], Ergun Y. Uc[1], George J. Andersen[2]; [1]Department of Neurology, University of Iowa, [2]Department of Psychology, University of California, Riverside

A key task during driving is the ability to detect and avoid collisions. Detecting a collision in a field of moving objects requires a serial search (Andersen & Kim, 2001). Older observers have decreased ability to detect impending collisions (Andersen & Enriquez, 2006). This study aimed to assess collision detection abilities among different groups of at risk drivers with neurological disease. These included a stroke/brain lesion group (n = 22), a Parkinson's disease group (n = 8) and an Alzheimer's disease group (n = 7). A comparison group comprised drivers ages 65 years or older without neurological disease (n = 20). Test displays simulated a roadway scene with objects translating with constant speed and linear trajectory toward the observer. Independent variables were time-to-contact, TTC (1s or 3s) and number of objects (1 or 6). Sensitivity of collision detection was measured using d`. The main effects of number of objects $F(1,53)=154.2$ and TTC $F(1,53)=18.8$ were significant, indicating decreasing ability to detect a collision with increasing numbers of objects and increasing TTC. The main effect of clinical group was also significant, $F(1,53)=3.9$, as were the interactions between group, number of objects and TTC, $F(1,53)=2.86$. Collision detection sensitivity was highest for the elderly comparison group, followed by the stroke, Alzheimer's disease and Parkinson's disease groups. The decrease in sensitivity between the groups was greatest at the 3 sec TTC/6 object condition, compared to the other TTC and number of object conditions. These results suggest an increased risk of crashes among drivers with different neurological disorders. Further study is needed to determine effects of disease stage and specific lesion location and extent.

Acknowledgement: This work was supported by NIH AG13419-06 and NIA AG17177.

E85 634 Applied Psychophysics: Estimating The Cost of Implementing an Early Vision Screening Program

Russell J. Adams[1] (michelem@mun.ca), James R. Drover[2], Mary L. Courage[1]; [1]Psychology/Pediatrics, Science/Medicine, Memorial University, St John's NF Canada, [2]Retina Foundation of The Southwest, Dallas TX

One goal of psychophysics is to apply new knowledge and technologies to real world practical and clinical problems. Due to early CNS plasticity, a longstanding objective within developmental psychophysics is to create "clinic friendly" (simple and rapid) techniques for assessing vision in young children. Recently, new psychophysical methods have emerged for assessing visual acuity, binocular functioning, color vision, and contrast sensitivity. Our laboratory has combined the latest of these with standard optometric procedures (refractive error, ocular alignment/motility) to develop a screening battery for detecting early visual dysfunction. An important issue in such applications is their feasibility, specifically (1) whether tests are valid and (2) whether they are cost effective. Here we provide economic data on the application of this technology. Canadian preschool children (n = 946) were tested with our battery of psychophysical, optical and eye alignment tests, and those who failed any test (n =152) were referred for a gold standard optometric exam. We then calculated measures of clinical validity (sensitivity, specificity, positive/negative predictive value) for each test combination and estimated cost effectiveness ratios (CER) for the most valid combinations (validity > 85%). Included in this analysis were determinations of labor, transportation, equipment, materials, and professional fees. We estimated the effectiveness of each test combination to identify a previously undetected child with a vision disorder. CER ranged from $175 to $313 (CAN) per detected child ($1 CAN = $0.88 US). In general, 3-test combinations were most cost-effective ($205 CAN per detected child). Although autorefraction was the most effective single measure, at least one psychophysical test was included in all the best combinations. Our data suggest that given the significant medical and personal costs of failing to detect early visual pathology, vision screening is relatively inexpensive. Moreover, the new psychophysical techniques contribute significantly to the success of pediatric eye screening programs.

Acknowledgement: NSERC (Canada) Janeway Hospital Research Advisory Grant

Attention and Inhibition

Author Presents: 4:00 - 5:45 pm

E86 635 Electrophysiological evidence of inhibition of focused-attention in the distractor previewing effect

Eunsam Shin[1] (eshin1@uiuc.edu), Xiaoang Irene Wan[1], Monica Fabiani[1], Gabriele Gratton[1], Alejandro Lleras[1]; [1]Psychology, University of Illinois at Urbana-Champaign/Beckman Institute

In a color-oddball search task, when a target's color in the current search display has been passively viewed in a preceding target-absent display, the response time (RT) to the target is slower than when, instead, the distractor's color in the current search display was passively viewed. This phenomenon is known as distractor previewing effect (DPE). Goolsby et al. (2005) proposed that the color of items in target-absent displays is perceptually suppressed in the subsequent target-present display. Lleras et al. (submitted), however, proposed that the DPE reflects inhibition of focused

Sunday Posters

attention to items containing the target-absent feature in the previous display. We tested these two hypotheses using event-related brain potentials (ERPs). Sixteen young adults were presented with target-absent displays, comprising four identically colored items (one per quadrant), followed by target-present displays, containing one color-oddball item. Participants made a choice response based on the shape (triangle/circle) of the color-oddball in the search display. We found: (1) faster RT and higher accuracy in the distractor-color preview (DCP) than in the target-color preview (TCP) condition; (2) an earlier peak and larger N2pc component in the DCP than in the TCP at posterior recording locations with a latency of 200-400 ms after the search display onset; (3) no differences in early sensory ERP effects (e.g., N1 or P1) between the DCP and TCP conditions. These results support the idea that the DPE is driven by inhibition of focused attention to a failed feature rather than by perceptual suppression of a previewed feature.

E87 636 Role of striatal visual pathway in Inhibition of Return

Takuro Ikeda[1,3] (taikeda@nips.ac.jp), Tadashi Isa[1,2,3]; [1]Dept Developmental Physiol, Natl Inst Physiol Sci, Japan, [2]School of Life Science, The Grad Univ for Advanced Studies, Japan, [3]CREST, JST, Japan

Visual stimulus first captures attention thus facilitates subsequent reaction to that location but then the reaction is inhibited. The former facilitatory effect is termed attention capture, while the latter inhibitory effect is termed inhibition of return (IOR). These effects can be measured by the change of the saccadic reaction time (SRT) in the oculomotor psychophysical task. SRT to the saccadic target is changed by the preceding cue stimulus presented at the same location: SRT is shortened if the time interval between cue and target is short (100-200ms), while SRT is prolonged if the interval is longer (e.g. > 300ms). Recent works revealed that the superior colliculus (SC), known as a center of orienting response, is important for IOR. However, SC receives visual information from several regions such as visual cortex, frontal cortex including frontal eye field (FEF) and retina. So it is still unclear which visual information is essential for IOR. To address this question, we made a lesion in unilateral primary visual cortex (V1) in the macaque monkey and measured the SRT using visually guided saccade task with a cue stimulus described above. The cue stimulus was randomly presented either in the same or the different location to the saccadic target. We have found that the IOR effect remains if the saccadic target is presented in the ipsilateral visual field to the lesion but disappears if the saccadic target is presented contralaterally to the lesion, indicating that the striatal visual pathway is essential for IOR. However, the attention capture is still observed in the impaired visual field which suggests the involvement of the retino-collicular visual pathway in this effect. Thus, the attention capture and IOR might be mediated by the different neural systems in the brain.

E88 637 Does the distractor preview effect extend to search-irrelevant features?

Brian Levinthal[1] (levintha@uiuc.edu), Alejandro Lleras[1]; [1]University of Illinois at Urbana-Champaign

The distractor preview effect (DPE) refers to the finding that observers are slower to respond to a target in an oddball-feature search if that target's defining feature had previously characterized a set of distractors in a target-absent array (i.e. responses to a red target are slower if a set of red distractors has previously been viewed). Here, we tested whether the DPE is limited to search-relevant features. Participants viewed arrays consisting of three equidistant items (colored circles and triangles), searching for a uniquely colored target, and reporting its shape. Our experiment modified the typical procedure for eliciting a color-DPE such that in half of the trials, target absent presentations consisted of homogenous shapes. As such, we were able to examine a potential DPE for features irrelevant to the search task. Our results indicate that no such effect occurs for the search-irrelevant shape feature. This suggests that the mechanisms responsible for the DPE are selective to the task-relevant feature in the primary task. In other words, the inhibitory trace created in the target-absent trial is primarily associated with the feature that determines the absence of a target in that trial (the no-go feature). The lack of a DPE for search-irrelevant features is consistent with previous studies concerning the role of task-relevance in the DPE (Ariga, Lleras, and Kawahara, 2004). Results are discussed in the context of Lleras et al. (under review) and Wan and Lleras (submitted) theory of the DPE, which explains this effect as arising from inter-trial inhibition of focused attention to the no-go feature.

E89 638 What is being marked in visual marking?

Hengqing Chu[1] (hchu4@uiuc.edu), Brian Levinthal[1], Alejandro Lleras[1]; [1]Department of Psychology, University of Illinois, Urbana-Champaign

In visual search tasks, if a subset of the search items (without the target) is presented at least 400 ms before the full set is in view, visual search efficiency is improved as if only the second set of items had been searched. This phenomenon is known as visual marking, and is thought to involve inhibitory-tagging of old items. This study investigates whether this inhibitory-tagging is location-based or feature-based. Subjects searched for a sideway T among Ls of identical color and regular Ts and upside-down Ts of a second color, and report the orientation of the target T. In addition, to eliminate the contribution of bottom-up attentional capture by the onset of the second set of items, we included a 200ms blank display between the initial preview and the final search display. In Experiment 1, we tested four conditions: feature search (T amongst Ls), conjunction search (T amongst full set of distractors) and two preview conditions. In the same-location preview condition, the previewed items remained at the same location when the full search display was presented, whereas in the different-location preview condition, the previewed items appeared at previously unoccupied locations. Our results showed an identical degree of marking in the same- and different-location preview conditions, indicating that knowing the color of the previewing items was sufficient information for "marking" which items not-to-search in the full display. In Experiment 2, we further tested this feature-based marking by replacing the preview display with a color "blob", which indicated the color of the subset of items in the final display NOT to search. Search efficiency was identical in the blob condition compared to the same-location preview condition, even though there was a significant main effect, with RTs in the blob condition being significantly slower. Implications regarding theories of visual marking will be discussed.

Acknowledgement: This work was supported by a University of Illinois graduate fellowship to H. C.

E90 639 Greater disruption by sub-threshold task-irrelevant signals

Yoshiaki Tsushima[1] (tsushima@bu.edu), Yuka Sasaki[2], Takeo Watanabe[1]; [1]Department of Psychology, Boston University, [2]Martinos Center, Massachusetts General Hospital

While considerable studies have shown that a sub-threshold (undetectable) stimulus influences brain activity and performance, it is still unclear how sub-threshold stimuli are processed in the brain. Tsushima and Watanabe (VSS04 and 05) showed that task performance is more greatly disrupted by sub-threshold, task-irrelevant signals than supra-threshold signals. Here we examined the neural mechanism for this effect by an event-related fMRI paradigm. Subjects (n=6) viewed a sequence of 2digits/6letters at the center of the display and numerous moving dots in the periphery. The subjects were asked to report two digits by pressing buttons on the box held by themselves. In the background, some dots contracted toward the center of the display while the others moved randomly. The ratio of the number of contracting dots to the total number of dots was varied from trial to trial in 4 steps (0, 5, 10, 20%). The results showed that with sub-threshold 5% coherent motion, MT+ was significantly more highly activated than 0% and also supra-threshold 10% and 20% coherent motion. On the other hand, in the lateral prefrontal cortex (LPFC) that provides inhibitory control of irrelevant signals, fMRI activity with 5% coherent motion showed no significant difference from with 0% coherent motion, but was significantly lower than supra-threshold 10% and 20% coherent motion.These results indicate the following model: LPFC has a higher detection threshold for incoming signals than the visual cortex.

Sunday Posters

Sub-threshold task-irrelevant signals may be sufficiently strong to be processed in the visual system but not sufficiently strong for LPFC to "notice" and, therefore, to provide effective inhibitory control on the signals. Meanwhile, supra-threshold coherent motion may be "noticed", given successful inhibitory control by LPFC, and leave more resources for a task. Such neural mechanisms may have caused performance with sub-threshold distractors to be lower than with supra-threshold distractors.

Acknowledgement: Supported by NSF BCS-0345746, NIH R01 EY015980, Human Frontier Science Program Organization RGP18/2004, NSF BCS-PR04-137 Center of Excellence for Learning in Education, Science and Technology, the ERATO Shimojo Implicit Brain Function Project, National Center for Research Resources P41RR14075, the Mental Illness and Neuroscience Discovery Institute, and the Athinoula A. Martinos Center for Biomedical Imaging.

E91 640 Inattentional Blindness, Object Persistence, and Foveal Inhibition

Alex White[1] (alexander.l.white@yale.edu), Brian Scholl[1]; [1]Department of Psychology, Yale University

The importance of attention for conscious perception is especially clear in inattentional blindness (IB) -- the failure to consciously perceive salient unexpected objects (UOs) when attention is otherwise engaged. Surprisingly, IB is especially severe for UOs that appear at fixation -- literally right in front of your eyes -- compared to peripheral UOs. This effect has been explained by especially strong foveal inhibition when observers' attention is directed to the periphery. Because these experiments included a fixation mark, however, the visual system may instead have interpreted the UO not as a new object, but as a sudden change to the features of the fixation mark itself. Such interpretations may be automatically computed in mid-level vision, where object persistence is driven primarily by spatiotemporal factors rather than surface features. Observers in our tests of these explanations fixated centrally and had to judge which arm of a briefly presented (and masked) peripheral cross was longer. After three trials, a salient UO at fixation was presented along with the cross. The key manipulation involved the fixation mark, which was either a small cross (which was then completely replaced by the UO), or a much larger cross formed by two diagonal lines that spanned the entire display. If enhanced IB at fixation is due to the representation of persisting objects despite featural change, then less IB should be observed with the global fixation mark. In fact, however, IB in both conditions was dramatic (though not at ceiling) and did not differ -- even with twice as many observers as in other studies. We conclude that parafoveal attention may indeed require especially strong foveal inhibition, with severe consequences for conscious awareness. However, the existence of foveal inhibition does not rule out independent effects of object persistence on IB, as explored in additional studies of appearance vs. disocclusion.

URL: http://www.yale.edu/perception/

E92 641 Exploring parvocellular and magnocellular pathway contributions to location-based inhibition of return.

Benjamin A. Guenther[1] (bag2@uga.edu), James M. Brown[1]; [1]Department of Psychology, University of Georgia

Purpose: To probe for contributions from the parvocellular (P) and magnocellular (M) pathways to location based inhibition of return (IOR) we manipulated cue and target spatial frequency (SF), the visual field they appeared in, and whether they were presented alone or in 3-D objects. Earlier evidence (Brown, 2006) suggested conditions favoring P relative to M activity should produce greater IOR magnitude and vice versa. Thus, greater IOR was expected to higher SF targets presented in 3-D objects in the upper visual field. Conversely, less IOR was expected to lower SF targets presented alone in the lower visual field. Method: Cues and targets were gabor patches presented in the left/right or upper/lower visual fields, alone or in 3-D objects, using cue-to-target timing known to produce location-based IOR. Simple RT to target onset was measured. Different SF pairings were tested (1+12cpd; 1+4cpd; 4+12cpd). Results: The absolute SF of the cue and target and the relative frequency difference between them influenced IOR magnitude. When presented alone, the lowest frequency tested (1 cpd) always produced less IOR compared to its higher frequency counterpart, whether 4 cpd or 12 cpd. The results indicate greater P activity is associated with greater IOR magnitude and greater M activity is associated with less. This relationship was further supported by the changes in the patterns of IOR magnitude for the different SF targets when attention shifted between the upper (P dominant) and lower (M dominant) visual fields, and whether they appeared alone or in 3-D objects. P on M inhibition related to attention was also evident (Yeshurun, 2004). Conclusions: The differences in location-based IOR magnitude related to P and M activity support a close link between attentive processing, object processing and the P pathway (Yeshurun, 2004), and between inattentive processing and the M pathway (Srinivasan & Brown, 2006).

E93 642 Age Differences in Inhibition of Return and Inhibitory Tagging during Spatial Orienting of Attention

Linda Langley[1] (linda.langley@ndsu.edu), Nora Gayzur[1], Ana Vivas[2], Luis Fuentes[3], Alyson Saville[1]; [1]Department of Psychology, North Dakota State University, [2]Department of Psychology, City Liberal Studies, Affiliated Institution of the University of Sheffield, Greece, [3]Departamento de Psicología Básica y Metodología, Universidad de Murcia, Spain

Evidence suggests that two separate inhibitory processes are involved in attentional orienting, location-based inhibition of return (IOR) and stimulus-based inhibitory tagging (a secondary process initiated by IOR). In a follow-up study to Langley, Vivas, Fuentes, and Bagne (2005), we provide further evidence that aging has a greater effect on inhibitory tagging than IOR. In Experiment 1 we combined an IOR task with a Stroop paradigm. Typical IOR effects were found for both younger adults (mean age = 21 years) and older adults (mean age = 68 years), but younger adults' Stroop effects were reduced at inhibited locations, consistent with inhibitory tagging. Older adults' Stroop effects were unaffected by location. Time course analysis indicated that tagging effects were not simply slower to develop in older adults, but did not develop at all. In Experiment 2 the age pattern in IOR and inhibitory tagging was extended to a semantic priming paradigm. Together the findings suggest that older adults' attention performance reflects an intact ability to inhibit return of attention to examined locations but an impaired ability to inhibit responses to stimuli presented at those locations.

Acknowledgement: This research was supported by Grant P20 RR020151 from the National Center for Research Resources (NCRR) of the National Institutes of Health (NIH).

Sunday Posters

Monday Talk Sessions

Monday, May 14, 2007

Early Visual Development

Monday, May 14, 8:00 - 9:30 am, Hyatt Ballroom South
Moderator: Karen Dobkins

8:00 643 **Development of temporal contrast sensitivity in monkeys**

Lynne Kiorpes[1] (lynne@cns.nyu.edu), Kara Stavros[1]; [1]Center for Neural Science, New York University

Temporal vision, the ability to detect variations in luminance over time, is essential for motion perception. Studies of temporal vision development in infants are few and the results are somewhat contradictory. In particular, some studies show early development of critical flicker fusion frequency (CFF) compared to sensitivity to lower temporal frequencies (TF), whereas others show similar development for low and high TF. To learn more about temporal visual development, we measured full temporal contrast sensitivity functions (TCSF) in young macaque monkeys (Macaca nemestrina). We tested the ability of eleven animals, ages 5 wks to 4 yrs, to detect an unpatterned field of light the luminance of which was sinusoidally modulated over time at a range of TF from 1 to 40 Hz. Four monkeys were tested longitudinally.

The results from the youngest infants showed reduced sensitivity for all TF, and a reduced range of detectable TF. Sensitivity to high and low TF appeared to develop at different rates, with extrapolated CFF measures approaching adult values somewhat earlier than sensitivity to low TF. Also, adult levels of peak temporal contrast sensitivity were reached earlier compared to the maturation of peak spatial contrast sensitivity. These data suggest that the mechanisms limiting the development of spatial and temporal contrast sensitivity mature at different rates and that there is a developmental change in shape of the TCSF.

Acknowledgement: Supported by a Fight for Sight grant to KAS and NIH grant EY-05864 to LK

8:15 644 **Direction-reversal vep's are delayed in development of premature infants: early dorsal-stream vulnerability?**

Janette Atkinson[1] (j.atkinson@ucl.ac.uk), Deirdre Birtles[1,2], John Wattam-Bell[1], Andrew Wilkinson[3], Oliver Braddick[2]; [1]Visual Development Unit, Dept of Psychology, University College London, [2]Dept of Experimental Psychology, University of Oxford, [3]Dept of Paediatrics, University of Oxford

VEP responses to direction reversal have a consistently later onset than orientation reversal responses, in the early months of infant development (Braddick et al, Vision Research, 45, 3169 (2005)). Here we examine the effects of very premature birth on the development of these two cortical responses.

16 neurologically normal premature infants, (<33 weeks gestation with normal brain ultrasound), were tested between 2-4 months post-term age for steady-state VEP responses to (a) orientation reversals between opposite oblique gratings at 8 reversals/sec; (b) reversals of horizontal motion direction in a dot pattern at 2 reversals/sec. In each case the reversals were embedded in a sequence of stimulus changes to exclude local spatio-temporal contrast changes as a source of signals at the reversal frequency. The premature group was compared with 26 term-born infants matched for post-term age.

VEPs were assessed by signal:noise ratio (S:N) at the reversal frequency. For orientation reversal, the VEP signal:noise ratio (S:N) at the reversal frequency showed flat regression with age, and no difference between the groups. Direction-reversal S:N showed a linear increase with age, and was at a significantly lower level for the premature compared to the term group, implying approximately 4 weeks' delay in development of the directional response in the preterms.

We conclude that (a) the additional visual experience of healthy preterms provides no advantage in cortical development; (b) motion processing provides a sensitive indicator of deleterious effects of preterm birth on the visual brain. This may reflect the sensitivity of the motion system to subtle white-matter anomalies, not readily detectable by ultrasound but possibly observable on MRI. We discuss this result in the context of the 'dorsal stream vulnerability', shown by relative impairment of global motion compared to form processing, in a range of neurodevelopmental disorders (hemiplegia, Williams Syndrome, autism, dyslexia, fragile-X).

Acknowledgement: Supported by Medical Research Council G790850

8:30 645 **Teasing Apart Contributions of Visual Experience and Biological Maturation on the Development of Contrast Sensitivity**

Karen Dobkins[1] (kdobkins@ucsd.edu), Rain Bosworth[1], Joseph McCleery[1]; [1]Dept of Psychology, University of California, San Diego

Purpose: To investigate the extent to which early visual development is governed by visual experience vs. biological maturation, we asked whether contrast sensitivity (CS) for luminance and chromatic stimuli is better predicted by postnatal age (PNA) or biological age (BA, time since conception), the latter calculated as the sum of PN and gestational period (GP).

Methods: Using FPL, we measured CS in full-term 2-month-olds (n=44) and 6-month-olds (n=130) to chromatic (isoluminant, red/green) and luminance gratings (0.27 cpd, 4.2 Hz). GP was calculated by comparing subjects' birthdates with due dates, accounting for the known error in ultrasound dating (Sladkevicius et al 2005). To tease apart factors contributing to CS, we employed a multiple regression analysis to determine percent variance (r-squared) in CS accounted for by PNA and GP jointly vs. each factor alone.

Results: GP was not a significant predictor of either chromatic or luminance CS (0%; p=NS) in 6 month olds, while in 2-month-olds, it predicted 5% of the variance in both chromatic and luminance CS (p~0.09). PNA predicted a similar amount of variance, 7% and 9% (both p<0.002) for chromatic and luminance CS, respectively, in 6 month olds, while in 2-month-olds, it predicted 18% of the variance in chromatic CS (p=0.003), but only 1% in luminance CS (p=NS). Jointly, GP and PNA (which reflect BA), in 2-month-olds, predicted 24% of the variance in chromatic CS, which was greater than either GP or PNA alone. This was not the case in 6-month-olds, since GP did not account for any variance.

Conclusions: Early in development, chromatic CS is influenced by visual experience, while luminance CS is dominated by biological maturation. At older ages, only visual experience influences, and roughly equally so, chromatic and luminance CS. This suggests that, with age, effects of biological maturation decrease and effects of visual experience increase.

Acknowledgement: NIH/NEI R01-EY12153-06 (KRD)

8:45 646 Orientation perception in Williams Syndrome: discrimination and integration

Melanie Palomares[1] (mcp@ski.org), Barbara Landau[2], Howard Egeth[2]; [1]Smith-Kettlewell Institute, [2]Johns Hopkins University

Williams Syndrome (WS) is a rare neurodevelopmental disorder, which stems from a genetic deletion on chromosome 7. WS causes a distinct cognitive profile: a relative strength in language, but a profound weakness in visuospatial cognition. Our current study explores how orientation perception may contribute to the visuospatial deficits in WS. In Experiment 1, we found that WS individuals and normal 3-4 year olds had similar orientation discrimination thresholds that were three times higher than thresholds of normal adults. We also found that WS individuals and normal 3-4 year olds had mirror reversal errors for diagonal targets (±45 deg), which did not occur in normal adults. In Experiment 2, we found that sensitivities of WS individuals for detecting orientation defined contours were higher than sensitivities of normal 3-4 year olds, and were not significantly different from sensitivities of normal adults. Together, these results suggest that orientation discrimination in WS is impaired due to delayed or arrested functions at the level of normal 3-4 year olds, while integration of neighboring orientation information is functionally normal.

Acknowledgement: An NIH fellowship (F31-NS047979) to MP, NSF (0117744), March of Dimes (04-4601-87), and NIH (RO1-NS050876) grants to BL funded this research.

9:00 647 Five-to seven-month-old infants perceive the corridor illusion

Albert Yonas[1] (yonas@umn.edu), Carl Granrud[2], Maria Le[1], Kate Forsyth[1]; [1]University of Minnesota, [2]Universtiy of Northern Colorado

This study investigated 5-, 6- and 7-month-old infants' perception of the corridor illusion (n = 20 to 24 in each age group). The two older age groups were tested under monocular and binocular conditions and the youngest group viewed the displays binocularly. After 4 habituation trials, infants viewed two displays, presented side by side, during 8 test trials. In each display, the image of an object moved back and forth along a pictorial corridor. For adult observers, linear perspective created the impression that the objects approached and receded in depth. In the "constant size" display, changes in the object's image size were consistent with those of a constant sized object moving in depth: image size decreased as the object appeared to move farther away and increased as it appeared to move closer. In the "varying size" display, changes in image size were consistent with those of an object that became larger as it receded and smaller as it approached: image size increased as the object appeared to move farther away and decreased as it appeared to move closer. The infants in all age groups exhibited significant looking preferences for the varying size display. This preference could not have been based on retinal image size, because the same image sizes were shown in the two displays. The infants apparently perceived that the object in the varying size display changed in size as it moved, while the object in the constant size display remained the same size. Viewing conditions had no effect in any age group. This suggests that size may have been perceived on the basis of relational information rather than perceived change in depth. The results do suggest that 5- to 7-month-old infants perceive the corridor illusion and can achieve size constancy in pictorial displays.

9:15 648 Mooney image perception in preschool-aged children

Jennifer Yoon[1] (davie.yoon@gmail.com), Jonathan Winawer[1], Nathan Wittoft[1], Ellen Markman[1]; [1]Department of Psychology, Stanford University

Two-tone or 'Mooney' images can be difficult for observers to recognize. However, after a brief presentation of the original photograph from which the Mooney was created, adults experience rapid and long-lasting perceptual reorganization, such that after the initial presentation, the Mooney image becomes immediately and easily recognizable, even without the corresponding cue. Following a previously reported observation (Kovacs & Eisenberg, 2004), we present striking evidence that, in contrast to adults, preschool-aged children are unable to recognize Mooney images in most cases, even when presented side-by-side with the corresponding photo. This result is especially striking in light of the fact that the children often claimed the Mooney image was 'the same' as the corresponding photo. However, when asked to draw corresponding parts of the photo and Mooney images (e.g., kitten's eyes), children marked correct regions of the photo and nonsensical regions of the Mooney (e.g., flowers in the background). Children were able to identify corresponding parts in control trials with blurred or contrast-altered images, showing that neither deficiencies in drawing ability nor lack of task understanding or motivation were responsible for this effect. In contrast, adults in all cases either recognized the Mooneys without cueing or reported immediate 'pop-out' after viewing the corresponding photos side-by-side. These results document a dramatic lack of perceptual reorganization in young children, even with simultaneous cues that allow instant recognition in adults. We suggest that this robust phenomenon may provide an exciting window into the development of high-level perceptual and cognitive mechanisms and consider interventions (e.g., Bernstein et al, 2005; Bruner & Potter, 1964; DeLoache, 2004) that rescue young children's poor recognition abilities.

Acknowledgement: Caitlin McLean, Quin Yow, the developmental lab discussion group, Bing Nursery school staff, and the parents and children who participated

Biological Motion II

Monday, May 14, 8:00 - 9:30 am, Hyatt Ballroom North
Moderator: Niko Troje

8:00 649 Rapid Serial Action Presentation: New paradigm for the study of movement recognition

Thomas Serre[1] (serre@mit.edu), Martin Giese[2]; [1]McGovern Institute, Brain & Cognitive Sciences Department, M.I.T., Cambridge, MA, [2]ARL, Dept. of Cogn. Neurology, Hertie Inst. for Clinical Brain Science, Tübingen, Germany

Rapid Serial Visual Presentation (Potter, 1975) has been a central experimental paradigm for the determination of the temporal limits of visual object recognition. We present an extension of this technique for biological motion stimuli that requires subjects to detect specific human actions, which are embedded within a sequence of distractors. This new paradigm is used to investigate the temporal limits of the processing of biological motion based on form and spatio-temporal cues.

Method: Stimuli were based on randomly selected temporal segments drawn from point-light movies of 8 different actions (e.g., running, kicking, dancing, etc.). After presentation of the complete target action, subjects observed sequences consisting of 7 such temporal segments. Half of the sequences contained the target action, and the other half did not. Subjects had to indicate whether the target action was part of the presented sequence. The segments had durations of 6, 12 or 24 frames (corresponding to 200, 400 and 800 ms). In order to test the influence of the recognition of individual stimulus frames, sequences of static pictures with the same durations were also presented. These pictures were chosen randomly from the temporal segments.

Results and discussion: Recognition performance (d') with static frames was low and did not depend on the presentation time. This is consistent with Johansson's (1973) classical result that recognition of actions from static point light patterns is rather poor. Likewise, it seems difficult to match such patterns to a previously shown point-light stimulus. Performance for dynamic sequences is significantly better than for static stimuli already for 6 frames (200 ms). Performance for dynamic sequences increases strongly with the number of frames and levels off for 12 frames (400 ms). This suggests the existence of action-specific spatio-temporal pattern detectors that are optimally stimulated by short complex motion segments.

Acknowledgement: Supported by HFSP, Volkswagenstiftung and DFG.

8:15 650 The importance of skeletal information in biological motion perception revealed by ideal observer analysis

Hongjing Lu[1] (hongjing@psych.ucla.edu), Zili Liu[1], Bosco Tjan[2]; [1]Psychology Department, UCLA, [2]Psychology Department, USC

Theories of biological motion perception differ in their assumptions about the form of the internal representation. We used ideal observer analysis to quantify the information provided by different display types. Our working assumption is that displays that are more similar to the internal representation will be processed more efficiently. It follows that human efficiency with different types of displays may provide valuable clues as to the nature of the internal representation.

A walker was presented in four display types. A point-light displays points representing joints of the walker. A skeleton connects appropriately the joints of a point-light display. A silhouette displays the side view of the walker. A contour displays the outline of the silhouette. Observers either detected the presence of a walker, or discriminated walking direction (left or right). A walker stimulus was embedded in dynamic white noise. Contrast threshold was measured for each display type in separate blocks. The position of the walker was randomly jittered from trial to trial.

For both detection and discrimination, the lowest contrast thresholds for humans and the ideal observer were obtained with the silhouette display, which was expected since the total area of the walker was the largest in a silhouette display. However, efficiency in the detection task was higher with the skeleton (0.86%) and point-light (0.82%) displays than with contour (0.46%) and silhouette (0.51%) displays. In the discrimination task, efficiency was higher with skeleton (0.94%) and silhouette (1.01%) displays than with contour (0.49%) and point-light (0.45%) displays. Our findings suggest that the effective internal representation of biological motion may be closer to that of a skeleton, utilizing both the points of articulation and the structural links between them.

8:30 651 Isolating the neural encoding of the local motion component in biological motion

Yi Jiang[1] (jiang067@umn.edu), Sheng He[1]; [1]Department of Psychology, University of Minnesota

Visual objects presented under interocular noise suppression take different amounts of time to emerge from suppression depending on their familiarity and recognizability (e.g., upright faces emerge from suppression sooner compared to inverted faces. Jiang, Costello, & He, in press). This paradigm is capable of revealing automatic processing of certain stimulus features. Here we examined whether the local motion component of the point-light biological motion (BM) sequence could be extracted automatically. A standard high contrast dynamic noise pattern was presented to one eye, and a test motion sequence was introduced to the other eye. The test motion sequences could be upright BM, inverted BM, or their spatially scrambled counterparts. Interestingly, an upright scrambled BM took less time to emerge from suppression compared to an inverted scrambled BM against the identical suppression noise. This result suggests that the visual system can extract local motion information from scrambled BM in the absence of any global configural information. This is even more surprising given that observers could not explicitly distinguish between upright and inverted orientations of scrambled BM in a 2AFC task. We further measured the cortical responses using fMRI while observers explicitly viewed the BM sequences. Contrasting between intact point-light BM and scrambled control motion revealed strong activation in pSTS, LOC, hMT+, and EBA. More importantly, V3/V3a and pIPS were found to be sensitive to the orientation of the scrambled BM, responding more strongly to upright than inverted scrambled BM, even though these areas showed stronger activation to scrambled than intact BM. These results suggest that the local motion information in BM, independent of the global configuration, can be extracted automatically by the visual system. The current study also highlights the usefulness of the interocular suppression paradigm in isolating the feed-forward processes of visual information processing.

Acknowledgement: This research was supported by the James S. McDonnell foundation, the US National Institutes of Health Grant R01 EY015261-01, and the Eva O. Miller Fellowship from University of Minnesota.

8:45 652 Psychophysical dissociation between global and local mechanisms in biological motion perception

Nikolaus F. Troje[1,2] (troje@post.queensu.ca), Dorita H. F. Chang[2]; [1]Department of Psychology, Queen's University, Kingston, Canada, [2]Centre for Neuroscience Studies, Queen's University, Kingston, Canada

Visual perception of biological motion is a complex process that involves several independent mechanisms. Particularly, two such mechanisms have to be distinguished. One responds to the local motion of the feet of a moving animal and signals both the presence and the facing direction of the animal. The second integrates the global configuration of a set of moving dots into the coherent, articulated shape of a human or animal body. We hypothesize that the first one is evolutionary old, not specific to human motion, and not sensitive to learning, while the second requires individual learning and is therefore specific to human motion. Here, we conducted two experiments. The first one required an observer to derive the direction in which a stationary walker was facing. The walker depicted either a human walker, a walking pigeon or a walking cat masked by a varying number of stationary flickering dots. Walkers were shown either spatially intact or scrambled. Five blocks of 60 trials each were run to probe for learning effects. The second experiment was a 2AFC detection experiment. In each trial, two displays were shown. One contained only a mask of scrambled walkers while the other one also contained a coherent walker. Walkers depicted a human, a pigeon, or a cat. Again, five blocks with 60 trials each were run to test for learning effects. Results confirmed our hypotheses: For the first task which focused on the local mechanism, we found effects of the number of masking dots, and an effect of scrambling, but neither an effect of the nature of the walker, nor an effect of learning. In contrast, for the second task (requiring global shape-from-motion processing) we found much better performance for the human walker as compared to the non-human walkers, and a strong effect of learning.

9:00 653 Human Recognition of Action Blends

Frank Pollick[1] (frank@psy.gla.ac.uk), Phil McAleer[1], Michael Gleicher[2], Joris Vangeneugden[3], Rufin Vogels[3]; [1]Department of Psychology, University of Glasgow, [2]Department of Computer Sciences, University of Wisconsin, [3]Laboratorium voor Neuro- en Psychofysiologie, KU Leuven

Comparatively little is known about the mechanisms underlying recognition of human actions, and at least part of this is due to the fact that tools for the study of human action recognition are scarce. We have been using blended movements (Kovar & Gleicher, 2003) to study the recognition of movement prototypes and their in-between blends. Initial studies into human recognition revealed evidence for categorical responding and rapid transitions of action response as blend parameter varied between actions (Pollick, et al, SFN 05). Related electrophysiological studies of macaque superior temporal sulcus neurons, using three-way movement blends between knocking, lifting and throwing, have revealed that ISOMAP analysis of firing rates appear to preserve the physical structure of the blend space and that some neurons respond equally well to presentation of the motion of only the end-effector as to presentation of the motion of the whole body (Vangeneugden, Pollick & Vogels, SFN06). In this study we examined human judgments of dissimilarity between pairs of movements taken from the same set of movement blends used in the monkey study: 2-second movements involving the 18 evenly spaced three-way blends along with the 3 basis movements of knocking, lifting and throwing. From this set of movements, two display conditions were created; the first involved the whole-body represented as point-lights connected by lines, the second involved the motion of the single point at the end-effector of the moving arm. For both display conditions, participants viewed sequential presentation of all possible pairs of movements of that condition and provided a response of the dissimilarity of each pair. Average dissimilarity matrices were examined with ISOMAP, MDS and cluster analysis. Consistent with the neuronal data, human behavioral responses also appeared largely to preserve the blend structure. Moreover, whole-body results and end-effector results were quite similar in the nature of their low dimensional representations, although cluster analysis indicated that responses to the single point appeared less structured.

9:15 654 **Not just the face: asymmetry of emotional body expression**

Claire L. Roether[1] (claire.roether@medizin.uni-tuebingen.de), Lars Omlor[1], Martin A. Giese[1]; [1]ARL, Hertie Institute for Clinical Brain Research, University Clinic Tübingen

The two halves of the human face differ in strength of emotion expression. This has been shown in studies using 'chimeric' face pictures, in which one half of the face is replaced by the mirror image of the other. Left-left chimeras are often rated as more emotionally expressive than right-right chimeras, indicating higher expressiveness of the left hemiface. This finding has been interpreted as support for a 'right-hemisphere model' of emotion. However, some studies suggest a reduction or reversal of asymmetry for positive emotions, a finding considered as supporting the 'valence model'. We investigated movement asymmetries and differences in expressiveness between the two sides of the body in emotional full-body movement.

METHOD: Emotional gaits (angry, happy, sad, fearful) of thirteen right-handed lay actors were motion captured. Joint-angle trajectories (flexion angles of shoulder, elbow, hip and knee) were computed. Movement amplitudes and kinetic energies were compared between both body halves. 'Chimeric walkers' were created by animation of avatars, replacing the joint movements of one body side by those of the other, with appropriate temporal alignment. Perceived expressiveness of right-right and left-left walkers was assessed in a rating study, controlling for the influence of viewing angle. In addition, animations with the original trajectories and mirror-reversed animations were presented.

RESULTS AND DISCUSSION: For all four tested emotions movement energy and amplitude were larger for the left side of the body, especially for the upper extremities. Left-left chimeric walkers received higher expressiveness ratings than right-right walkers, implying greater expressiveness of the left hemibody (consistent with the 'right-hemisphere model'). The comparison between normal and mirror-reversed animations ruled out possible confounds by attention differences between right and left visual hemifield.

Acknowledgement: Supported by HFSP, Volkswagenstiftung and EU project COBOL (FP6-NEST).

Lightness and Brightness

Monday, May 14, 10:00 - 11:45 am, Hyatt Ballroom South
Moderator: Arthur Shapiro

10:00 655 **Spatial scale and simultaneous contrast phenomena**

Arthur Shapiro[1] (shapiro@bucknell.edu), Jared Smith[2], Emily Knight[1]; [1]Program in Neuroscience, Bucknell University, [2]Pennsylvania State University, Hershey Medical Center

Simultaneous contrast phenomena typically contain test patches that have identical luminance levels but different perceived brightness levels. We have examined a variety of simultaneous contrast illusions and have shown that when low-spatial frequencies are removed from the displays, the physical values of the test patches in the resulting images follow the same pattern as the perceived brightness levels (see "http://www.shapirolab.net/fvm2006"). Furthermore, if a wide enough range of higher spatial frequencies remains in the filtered image, the test patches do not have the scalloped pattern that has been problematic for many lateral-inhibition type models.

Here we examine two different paradigms with this approach: 1) Gilchrist has shown that equiluminant test disks placed on a photograph are perceived to have different lightness values (i.e., test disks in shadows appear bright; those in the illuminated areas appear dark). We placed seven test disks on a natural image and had observers rank the disks from brightest to darkest. The observer rankings were nearly identical to the physical luminance values of the disks following the removal of the low spatial frequencies from the image. 2) Anderson and Winawer have shown that gray objects viewed through layers of rendered clouds take on dramatic differences in lightness. We show that the test patches are physically different when the low spatial frequencies are removed from these images. We compare the results to psychophysical estimates of the reduction in contrast sensitivity produced by the top layers. We conclude that the visual system may eliminate spatial frequencies lower than the fundamental frequency of the area of interest. The appropriate scale may be influenced by edges, grouping, scission and attentional factors.

URL: www.shapirolab.net

10:15 656 **The role of layered decomposition in lightness perception**

Marc Albert[1] (mka@soton.ac.uk); [1]School of Psychology, University of Southampton, UK

Current models suggest that the visual system does not partition image luminance into multiple layers to compute lightness (Gilchrist et al., 1999; Adelson, 2000). Anderson and Winawer (2005) presented illusions that they argue are contrary to this view. However, I show that their displays and analyses are identical in all relevant respects to Metelli's (1974) transparency work, although Metelli did not use slow gradients or emphasize the term 'lightness illusion.' Indeed, I show that Adelson's effects are robust to many modifications that reduce or eliminate perceptual transparency, whereas Anderson and Winawer's effects appear to depend strongly on conscious transparency perception. Also, parts of the dark and light targets in Anderson and Winawer's displays are perceived to be in 'plain view', and thus under identical conditions of transparency/illumination, making transparency 'discounting' unnecessary. In contrast, the dark and light targets in Adelson's displays are everywhere perceived to be under different conditions of transparency/illumination. Moreover, I show that effects similar to Anderson and Winawer's occur in ordinary opaque perceptual occlusion displays, suggesting that layered luminance decomposition is not critical.

Although Anderson and Winawer's displays suggest a role for layered representations in lightness, the visual system need not compute background lightness using the kind of quantitative intrinsic images analysis that Anderson and Winawer advocate. In such displays, background lightness could be computed by 1) simply comparing the luminances of regions perceived to be in 'plain view' (as determined by simple heuristics), or applying a frameworks model to these regions, 2) spreading these relative lightness values up to abrupt real or illusory image boundaries (overrunning slow gradients), and 3) combining the previous result in a weighted average with a 2D frameworks or image statistics computation to determine the final lightness percept, with the relative weights determined by the perceptual salience of the layered decomposition.

10:30 657 Factors in gamut compression in the staircase Gelb effect

Alan Gilchrist[1] (alan@psychology.rutgers.edu), Ana Radonjic[1]; [1]Rutgers University

When a row of five squares varying in reflectance from black to white is suspended in midair and illuminated by a spotlight, there is a dramatic compression in the perceived range of grays, with the black square appearing light middle gray. Prior work has shown that this compression is eliminated by a coplanar white border surrounding the five squares, but not by a coplanar black border, and that the compression varies inversely with the number of squares in the group, an effect called articulation. To test the effect of a non-coplanar but retinally adjacent background one group of 10 observers was presented with the five-square display against a white remote background while a separate group viewed the display against a black background. Unlike the pronounced effect of the coplanar white or black background, the luminance of the remote background had no effect on the amount of compression. In Experiment 2 we studied the role of articulation by asking whether it is the number of rectangles in the display that is crucial, or the number of different gray shades. A separate group of 11 observers was shown each of three Mondrian displays presented in the spotlight: (1) 4 rectangles of 4 gray shades, (2) 46 rectangles of 13 gray shades, and (3) 46 rectangles of 4 gray shades. The compression was substantially reduced with 46 rectangles, compared to 4, and the black target was seen as significantly darker ($t(20)=2{,}38$, $p=0.027$; $t(20)=2.15$; $p=0.044$. But number of gray shades made no difference. We conclude that gamut compression is strongly influenced by the surrounding luminance when it is coplanar with the test display but not when it is located in a far depth plane, and that the compression depends on the number of elements, but not the number of gray shades, in the display.

Acknowledgement: NSF: BCS0236701 NIH: BM60826-02

10:45 658 Lightness Anchoring: One Anchor or Multiple Anchors?

Michael E. Rudd[1] (mrudd@u.washington.edu); [1]Howard Hughes Medical Institute, University of Washington

Gilchrist and colleagues1 distinguish two processes subserving lightness perception: scaling and anchoring. Scaling maps the range of real-world reflectances onto the range of perceived reflectances (lightness values). Anchoring determines where particular achromatic colors, such as white, gray, or black, lie within the perceptual range. Previous results suggest that the human visual system employs an anchoring rule based on the assumption that the highest luminance in the scene is white. Contemporary anchoring theories supplement this highest luminance rule with new anchoring principles including the Area Rule;[1] compromise between global and local highest luminance anchoring;[1] and compromise between anchoring to the global highest luminance and to the luminances of regions contiguous with the target.[2] These theories deal with the growing complexity of known lightness phenomena either by adding additional anchoring rules, or by positing that the old anchoring rules are applied within multiple anchoring frameworks. I will present examples of lightness phenomena that challenge existing multiple anchor theories, including evidence that the luminances of target non-contiguous regions having luminances lower than the target luminance can influence the target lightness,[3] and that increasing the luminance or area of a region having luminance intermediate between the target luminance and the highest luminance can affect the target lightness in a non-monotonic manner.4 These lightness phenomena can all be accounted for by a mechanism involving perceptual edge integration and contrast gain control acting between edges. Once this mechanism has been taken into account, a single anchoring rule is all that is needed: the surface associated with the largest integrated edge value appears white.

1. Gilchrist et al. (1999) Psychol. Rev., 106, 795-824.

2. Bressan (2006) Psychol. Rev., 113, 526-553.

3. Rudd & Zemach (2005) J. Vision, 5, 983-1003.

4. Rudd & Arrington (2001) Vision Res., 41, 3649-3662; Rudd & Zemach (in press) JOSA A.

11:00 659 A whiter shade of pale: Why only three terms for lightness?

David Attewell[1] (david_attewell@hotmail.com), Roland Baddeley[1]; [1]Dept. of Experimental Psychology, University of Bristol, U.K.

The visible world is highly variable, containing surfaces with a wide range of reflectances (between 4% and 90% for charcoal and snow respectively). As we can discriminate hundreds of levels of lightness, describing such a variable world effectively would seem to require a large vocabulary. Despite this, the languages of technologically primitive cultures, which developed within largely natural environments, possess only two basic lightness terms, while those of more technologically advanced cultures, which inhabit more man-made environments, have only three (e.g. black, white and grey). Why should this be? Here we show, using information theory combined with estimates of; i) the distribution of reflectances within different visual environments, and ii) the uncertainty in recall of surface reflectance across subjects after a minutes-long interval, that in woodland environments only two lightness terms may be stable within a language, while in urban and indoor environments up to three terms may be stable. Hence, by formalising lightness description as the transmission of lightness information from the environment (variation in surface reflectance) in the presence of noise (variation in recall of reflectance) we are able to produce veridical estimates of the number of lightness terms which may be stable within a language within a given visual environment. Determining why a language has the colour terms it does can provide valuable insight into the philosophical issues surrounding the relationship between language and our internal representation of the world. Traditionally, the linguistic partitioning of colour space (and its lightness dimension) is viewed as either; i) learned and arbitrary (Relativists), or ii) the result of ecological or physiological constraints (Universalists). Our results suggest that our basic lightness terms are an optimisation, given our cognitive limitations, to the reflectance characteristics of the visual environment we inhabit.

11:15 660 Achromatic Color Naming

Delwin Lindsey[1] (lindsey.43@osu.edu), Angela Brown[2]; [1]Department of Psychology, Ohio State University, [2]College of Optometry, Ohio State University

Berlin and Kay (1969) hypothesized that the naming of color across world languages is universally constrained. In previous work (PNAS, 2006, www.pnas.org/cgi/reprint/0607708103v1), we confirmed this hypothesis by examining the color naming patterns of the World Color Survey (WCS; www.icsi.berkeley.edu/wcs/data.html), a large database of color names in 110 unwritten world languages elicited using 330 Munsell samples from a standard color chart. In that study, we examined the 14336 purely chromatic color naming patterns using unsupervised k-means cluster analysis, and we found that the color naming patterns clustered into a set of universal chromatic color categories. Those universal categories glossed readily to single or composite color terms from English.

We now extend our analysis to the 7,830 achromatic WCS color naming patterns that included one or more of the ten achromatic samples, which English speakers call black, white, or gray. As the k-means parameter, K, which specifies the number of categories, varied between 2 and 10, we found that the achromatic categories that appeared glossed readily to composites of English color name categories: (1) Chromatic colors with either low or high Munsell value (lightness) were more likely than colors with middle lightness to be included in the set of achromatic color naming patterns. (2) "Warm" chromatic colors were associated with mid to light gray. (3) "Cool" chromatic colors were associated with dark gray or black. (4) Brown was associated with gray. (5) Brown-or-purple was associated with gray and black.

These results, together with our prior results for chromatic color naming patterns, are consistent with the view that color categorization is guided universally by a dimensionalization of color space that is similar to that seen in English speakers. This was true, regardless of the number of distinct words in a WCS informant's color lexicon.

URL: www.pnas.org/cgi/reprint/0607708103v1

11:30 661 Visual Perception of Refractive Materials

Roland Fleming[1] (roland.fleming@tuebingen.mpg.de), Frank Jäkel[1], Laurence Maloney[2]; [1]Max Planck Institute for Biological Cybernetics, [2]Department of Psychology, New York University

Most previous research on the perception of transparency uses Metelli's (1974) model of infinitely-thin neutral-density filters. However, many common transparent objects (ice cubes, chunks of glass, etc.) are solid bodies that refract light, which are poorly approximated with Metelli transparency. Here we report psychophysical and theoretical findings on the perception of refractive transparent objects.

Refraction distorts the patterns that are visible through an object, in a way that depends on 3D geometry, refractive index, and distances to the viewer and background. This distortion undermines many cues traditionally thought to be important for transparency perception (e.g. X-junctions), but compensates with a host of novel cues. Our first contribution is a theoretical analysis of the process of distortion and the estimation of scene parameters including 3D shape and refractive index. We consider a number of image measurements (e.g. intensity histogram, frequency spectrum and orientation fields) that the visual system could use to infer properties of refracting objects.

Our second contribution is a series of psychophysical experiments that measure the perceptual scale of refractive index, using maximum likelihood difference scaling. In each trial, subjects saw two pairs of images of transparent objects (i.e. four images) that differed only in their refractive index. Subjects had to indicate which pair appeared more different. The derived perceptual scale is non-linear (compressive) and cannot be predicted by simple pixel-wise RMS differences. In subsequent experiments we clamp other scene variables (thickness of the refractive object; distance to background) at different values, and measure the effects on the perceptual scale. Results show that subjects confound different factors that contribute to image distortion, suggesting that the visual system does not perfectly invert the optics of refraction. We suggest observers rely instead on several heuristic measures of image similarity.

Acknowledgement: RF supported by DFG grant FL 624/1-1 "Human Visual Perception and Classification of Materials"
URL: http://www.apgv.org/VSS_07/VSS_07_refraction.html

Visuomotor Control: Goal-Directed Hand Movements

Monday, May 14, 10:00 - 11:45 am, Hyatt Ballroom North
Moderator: Anne-Marie Brouwer

10:00 662 Humans optimally integrate memory and vision to plan pointing movements

Anne-Marie Brouwer[1] (abrouwer@cvs.rochester.edu), David Knill[1]; [1]Center for Visual Science, University of Rochester

Contemporary thinking is that visual short-term memory of absolute object location is rather imprecise. We investigated whether humans use a target's remembered location to help plan reaching movements when visual information about the target is available, and whether the extent to which they rely on remembered and visual information is optimal; that is, is predicted by the relative reliabilities of the two sources of information.

Subjects sequentially picked up and moved two different, virtual, "magnetic" target objects from a target region into a virtual trash bin with their index fingers. Targets could be of high or low contrast. In some trials, the position of the second target was shifted 1cm while the finger was transporting the first target to the trash (masked by screen flicker, so subjects were unaware of the shift). We regressed subjects' initial movement trajectories against the initial and shifted locations to infer the weights that subjects gave to remembered and visual location information. In a second experiment, we measured the reliability of vision and memory information in the task by adding conditions in which the second target only appeared after subjects put the first target into the trash (vision-only condition) and in which the second target was initially present, but disappeared during the transport of the first target (memory-only condition).

When both visual and remembered location information were available, subjects' initial movement trajectories were biased to the remembered target location. Moreover, they gave more weight to remembered location for the low contrast targets. The observed variances in the memory and vision only conditions of the second experiment are consistent with the different weights that subjects gave to memory and visual information in the low and high contrast conditions, suggesting that memory is used near-optimally to help plan pointing movements.

URL: http://www.cvs.rochester.edu/people/a_brouwer/

10:15 663 Humans control reach timing to balance sensory and motor uncertainty and maximize reach accuracy

Peter Battaglia[1] (batt0086@umn.edu), Paul Schrater[1], Daniel Kersten[1]; [1]Department of Psychology, University of Minnesota

Previous research has shown that the brain uses sophisticated representations of both sensory and motor uncertainty to optimize task performance. Knowledge of sensory uncertainty is used to near-optimally combine sensory information, while knowledge of motor precision can be used to plan movements that optimize expected gain. We conducted an experiment to examine how the brain combines its knowledge of sensory certainty and motor precision to perform a task that depended on both. Participants reached to the center of a 2D, isotropic, Gaussian distribution of dots within a 1200 ms time-limit. Participants traded off the amount of sensory and motor variability by selecting the reach initiation time. Specifically, before reach initiation the number of visible dots increased with time, thereby improving the certainty of the participant's estimate of the true target location. Once the reach was initiated, no new dots appeared and the remaining trial time was available for the reach. However, speed-accuracy trade-offs in motor control make early reaches (much remaining time) precise and late reaches (little remaining time) imprecise. Based on each participant's visual-only and motor-only target acquisition performance, we computed an "ideal reacher" that selected a reach initiation time with minimal predicted reach endpoint errors from the true target location. We found that people selected reach initiation times similar to those of the "ideal reacher", even in the absence of performance feedback. Further, when we manipulated the overall quality of the visual target stimuli, people shifted their reach initiation timing much like the "ideal reacher". We conclude that the brain jointly represents time-dependent sensory and motor variability relationships, and uses this knowledge to maximize performance in sensorimotor tasks.

Acknowledgement: Supported by NIH EY015261-01.

10:30 664 Comparing the latencies with which various attributes can be used to guide the human hand

Margot Veerman[1] (margotveerman@hotmail.com), Eli Brenner[1], Jeroen BJ Smeets[1]; [1]Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam

Neurons in different cortical visual areas respond to different visual attributes with different latencies. How does this affect our actions? We compared the latencies of adjustments to hand movements directed towards targets defined by luminance, size, orientation, color, shape and texture. Participants moved their hand as quickly as possible to a visual target that was accompanied by two reference objects. In some trials, the target and one of the references changed location at the onset of the hand's movement. We determined the latency to correct the movement of the hand in the direction of the new target location. It is reasonable to expect the latency to depend both on the attribute in question and on how conspicuous the distinction is within the attribute. For luminance-defined targets we found faster responses with less variability in latency when it was easy to distinguish the target object from the reference objects, than when it was difficult to do so. By considering the relationship between changes in response latency and variability that we found for responding to various differences in luminance, we show that responses for the attributes orientation, luminance and size are fundamentally faster than for color, form and texture. The latency of the latter responses is longer although the variability in latency suggests that the distinction is equally difficult. This dichotomy within the attributes is in accordance with a dorsal-ventral distinction of visual processing in the brain, whereby spatial attributes that are likely to be relevant for guiding our actions (orientation and size) are processed faster than other attributes that are more likely to be relevant for recognizing the object (color, shape and texture).

10:45 665 Eye movements in a spatially and temporally demanding interception task

Eli Brenner[1] (e.brenner@fbw.vu.nl), Jeroen BJ Smeets[1]; [1]Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam

When performing everyday tasks our eyes are usually directed at the object or objects that are relevant for what we are doing at that moment. Sometimes it is advantageous to plan ahead, in which case our eyes can move on before the current action has finished. Moreover the eyes are not necessarily directed towards the object with which we intend to interact, but can also be directed to a position at which we expect information that is critical for successfully performing the task to become available, such as the position at which a ball that one intends to catch or hit will bounce. Thus eye movements may indicate the information that is critical for guiding an action. We measured eye movements (and movements of the head and hand) during an interception task in which subjects had to hit moving virtual targets towards a goal. The eyes were usually pursuing the target as the hand moved towards it. Gaze was seldom directed at the hand. Subjects sometimes glanced at the goal before starting to move their hand. They started systematically shifting their gaze from the target to the goal, presumably in order to see whether their hit was successful, from about 80ms before the hand hit the target, which is about when visual information is no longer useful for guiding the hand to the best position on the target. The position at which the hand intercepted the target hardly varied across trials, so the fact that subjects pursued the target with their eyes, rather than looking at the interception point and waiting for the target to arrive, suggests that we are better at judging where a moving target will be at a given time when we pursue it.

11:00 666 Missing In Action: Obstacle Avoidance While Reaching

Craig Chapman[1] (cchapm4@uwo.ca), Melvyn Goodale[1]; [1]University of Western Ontario (Psychology)

When reaching to objects, our hand and arm rarely collide with non-target objects, even if our workspace is cluttered. The simplicity of these actions hides what must be a relatively sophisticated obstacle avoidance system. Recent studies on patients with optic ataxia and visual form agnosia have demonstrated that obstacle avoidance is an automatic process, likely governed by the dorsal stream (Schindler et al., 2004, Nature Neuroscience, 7(7):779-784, Rice et al., 2006, Experimental Brain Research, 174(1):176-188). The current study sought to quantify how normal participants react to changes in the size and position of non-target objects in and around their workspace. In the first experiment, 13 right-handed subjects performed reaches to a target strip in the presence of two non-target objects, which varied in depth and horizontal configuration. We found that objects with horizontal alignments that were asymmetric about midline created systematic deviations in reach trajectory away from midline, with participants seeming to maximize the distance away from the two objects. These deviations were significantly greater for objects nearer in depth and nearly disappeared when the objects were placed beyond the target strip, suggesting the obstacle avoidance system is sensitive to the depth at which an object becomes an obstacle. In a second experiment, we varied the height of the two objects, as well as the depth. Object pairs could now be both tall, both short, or one short and one tall (with the tall on the right or on the left). We replicated the first experiment, extending the finding to include sensitivity to the size of the objects. Here the deviations induced by short objects, while still significant, were significantly less than the tall-object deviations. Taken together, these experiments indicate a sophisticated obstacle avoidance system that is extremely sensitive and conservative in evaluating potential obstacles and deviating reach accordingly.

Acknowledgement: This research was supported by an NSERC grant to M.A.G., and NSERC scholarship to C.S.C.

11:15 667 Correct on-line adjustment but impaired response inhibition to perturbed targets in a patient with hemispatial neglect

Stephanie Rossit[1] (s.rossit@psy.gla.ac.uk), Rob McIntosh[2], Stephen Butler[1], Monika Harvey[1]; [1]Department of Psychology, University of Glasgow,UK, [2]Department of Psychology, University of Edinburgh, UK

We examined if a neglect patient (with a lesion to the right temporal lobe and insula) could either adapt his pointing trajectory or interrupt his movement in response to a rightward or leftward target shift. Spatial and temporal analysis of the movement trajectories indicated that the patient was as accurate as the control group when performing on-line corrections to target shifts, even when the shift occurred in the leftward direction. However, when asked to stop his movement "in flight" in response to a left or right target jump, his performance was considerably impaired, both in terms of timing and number of correct stop responses. Fast, on-line corrections to target jumps are thought to be the mediated by the visual dorsal stream, while stop responses require an intentional reprogramming which is thought to be dependent upon the conscious perception mediated by the ventral stream. Our findings indicate that the deficits present in hemispatial neglect are more closely related to damaged ventral areas of visual processing and further agree with previous neuropsychological evidence regarding the dissociability of these pathways for fast automatic movements versus slow, intentional motor control.

Acknowledgement: This work was supported by the FundaÁ„o para a CiÍncia e a Tecnologia (SFRH/BD/23230/2005), Royal Society of Edinburgh and Wellcome Trust. We would like to thank Satu Baylan for helping with data collection.

11:30 668 Hand trajectories reveal cognitive states

Ken Nakayama[1] (ken@wjh.harvard.edu), Joo-Hyun Song[2], Matthew Finkbeiner[3], Alfonso Caramazza[1]; [1]Department of Psychology, Harvard University, [2]Smith Kettlewell Eye Research Institute, [3]Department of Psychology, Macquarie University

We report two studies which demonstrate that motor behavior can reveal hidden cognitive states.

In our first study, observers were faced with a row of three squares on a screen. Single digits were presented on the middle square. The observers were instructed to touch the left square if the digits were between 1-4, the right square if the digits were between 6-9 and to press the middle square if the digit was a 5. Even though the response required was categorical (touch one of 3 squares), detailed measurement of hand trajectories revealed clear differences within categories. The initial direction of the trajectory reflected the numerical magnitude of the digit, with more leftward directions seen for smaller numbers.This provides strong support for an underlying analogue representation of digitally presented numbers and indicates that it is activated very quickly after the presentation of the digit.

In our second study, observers were required to touch a right (green) or left (red) square according to the object color designated by a target word at fixation (spinach, ketchup). The words were preceded by an unseen prime (red, green, boy), forward and backward masked. Highly curved trajectories were seen when the prime was incompatible with the color of the target word. The hand was directed to the wrong square and corrected mid-flight. These results reveal the existence of competing motor commands triggered by unseen words.

Taken together, the results challenge the assumption that behavior can be analyzed as a set of sequential stages, simply reflecting the outcome of earlier completed decisions. Motor behavior begins much earlier than has been previously assumed, thus providing a new window to view otherwise hidden cognitive states as they unfold over time (see also Spivey et al. PNAS, 2005).

Face Perception: Development, Learning, and Expertise

Monday, May 14, 2:30 - 4:15 pm, Hyatt Ballroom South
Moderator: James Tanaka

2:30 669 Discovering faces in infancy

Pawan Sinha[1] (psinha@mit.edu), Benjamin Balas[1], Yuri Ostrovsky[1]; [1]Department of Brain and Cognitive Sciences, MIT

A human infant can tell apart faces from non-faces when just a few weeks old, and possibly even sooner. This poses the question of how this ability arises. A prominent idea that attempts to account for the very early onset of this skill is that of an innately specified rudimentary face 'template' that predisposes infants to look at faces. The counterpoint to this proposal, a purely experiential account of early face preferences, has not been adequately tested. Is it possible that an infant's early visual input might be sufficient to permit rapid acquisition of a basic face concept? We address this question by testing the computational feasibility of learning a face-concept from inputs that correspond to a newborn's visual experience.

We commenced this research when one of us (PS) became a father recently. Using a headband-mounted miniature camera (with optics modified to approximately mimic the infant's reduced acuity), we were able to record video-clips from the baby's point of view. They revealed some interesting aspects of the baby's visual experience with regard to faces. Given that the newborn is held by the parents much of the time while awake, faces end up being the most prevalent object in the inputs. Faces are also the most salient by virtue of their ability to move and produce sound; they have few competitors since the baby spends the majority of the first few weeks indoors, in an environment where people are the primary animate entities. Furthermore, the infant's poor acuity significantly degrades images of objects beyond a few feet, adding to the close-up faces' salience. We find that these aspects of the baby's experience make it feasible for an unsupervised learning system to rapidly acquire a rudimentary face concept, even without any innately specified face-templates.

Acknowledgement: The John Merck Fund and the Simons Foundation

2:45 670 Holistic processing for faces is sensitive to image-plane but not depth rotations: Support for an innate face template.

Elinor McKone[1] (elinor.mckone@anu.edu.au); [1]School of Psychology, Australian National University

Rationale. Holistic processing for faces is well known to be sensitive to rotation of the face in the image plane, occuring for upright but not inverted (upside-down). This has two possible origins: an innate template coding upright faces; or greater experience with upright faces than inverted faces (either across the lifespan or during a critical period in infancy). These theories are potentially distinguishable by testing the effect of depth rotation on holistic processing. As with image-plane rotation, some depth views are more common than others: front-on is common, and profile is rare. If differential experience were the origin of the inversion effect on holistic processing, holistic processing should be weaker for profile views of upright faces than front-on. Method. Five experiments examined holistic processing with two independent techniques: the aligned-unaligned composite paradigm and the peripheral inversion method. Four depth views were tested (front, 22.5°, three-quarter, profile), view was manipulated between- and within-subjects, experiments used two face stimulus sets, with and without hair. Results. There were no effects of view on holistic processing. Even for profiles, holistic processing (e.g., aligned-unaligned difference) was found for upright but not inverted faces and was no weaker than for front-on or 3/4 faces. There was a view-frequency effect on overall performance: this arose from part-based (not holistic) processing, as evidenced by view effects being at least as strong for faces with disrupted configurations (misaligned, inverted, scrambled) as for upright intact faces. Conclusion. Results are contrary to the predictions of the differential experience hypothesis. Taken together with other findings about faces and objects, results are consistent with a theory in which an innate special face mechanism codes the structural form of an upright face in all views and supports holistic processing, while a generic part-based view-sensitive system used for objects can also be activated by faces.

Acknowledgement: Funded by Australian Research Council DP0450636
URL: http://psychology.anu.edu.au/people/mckone

3:00 671 Face identity adaptation effects across illumination change

Fang Jiang[1] (fxj018100@utdallas.edu), Volker Blanz[2], Alice O'Toole[1]; [1] The University of Texas at Dallas, [2]The University of Siegen

Previous studies have found that opponent after-effects for faces transfer partially across a three-dimensional viewpoint change (Jeffrey et al., 2006; Jiang et al., 2006). More recently, Jiang et al. (in press) show that the magnitude of adaptation transfer increases with the familiarity of the face. Here, we examined the transferability of face identity after-effects across illumination change (Exp. 1) and assessed the effects of familiarity on adaptation transfer (Exp. 2). Illumination and viewpoint changes are similar because both involve a transformation that depends on the 3D structure of an object.

In Experiment 1, participants identified anti-caricatures following adaptation to an anti-face with identical (consistent) or different (inconsistent) illumination. The consistent illumination condition produced stronger adaptation effects than the inconsistent illumination condition, indicating a partial transfer of adaptation effects across illumination change.

The purpose of Experiment 2 was to assess the effects of familiarity with varying viewpoints of a face on the transferability of adaptation across changes in illumination. Participants were familiarized with the faces in a learning session. In the single-view 4-presentation condition, participants saw each familiarization face 4 times from a 22.5° rotated view. In the single-view 16-presentation condition, participants saw each face 16 times from a 22.5° rotated view. In the multiple-view 16-presentation condition, participants saw each face 8 times from the frontal view and 8 times from the 45° rotated view. We found that high levels of familiarity, developed from 16 presentations of a single view, improved the strength of adaptation effects in the consistent, but not the inconsistent illumination condition. However, familiarization with multiple-views had no effect on the strength of adaptation in either illumination condition. These results have implications for understanding how view-invariant face representations are developed through experience.

3:15 672 Familiarity Modulates Holistic Processing in the Fusiform Face Area

Alison Harris[1] (aharris@alum.mit.edu), Geoffrey Aguirre[1]; [1]Department of Neurology, Hospital of the University of Pennsylvania

Face perception is often characterized as depending on holistic, rather than part-based, processing. However, attempts to find neural correlates of holistic processing in "face-selective" regions using functional magnetic resonance imaging (fMRI), relying primarily on stimulus inversion, have had mixed results. Here we report a set of experiments which extend the study of holistic processing in two ways: through use of a different stimulus manipulation, and by measuring how such processing is modulated by familiarity. Our stimuli utilize binocular disparity to create a percept of a face either behind or in front of a set of stripes (Nakayama et al., 1989). While the first case will be “filled in” by the visual system and perceived as a normal face occluded by stripes, the latter cannot be completed amodally and thus is perceived in terms of its constituent parts. We demonstrated this behaviorally using the “whole-versus-part superiority” effect (Tanaka & Farah, 1993): when whole faces were presented in front of the stripes, recognition performance dropped to the same level seen for isolated face parts. Therefore, these “stereo faces” provide a powerful means of assessing holistic and part-based processing. Using these stimuli, we examined the sensitivity of the “face-selective” fusiform face area (FFA) to holistic versus part-based processing in familiar and unfamiliar faces. Existing behavioral results suggest that while familiar faces are processed holistically, unfamiliar faces may be recognized by individual parts. Consistent with these prior results, preliminary data from an adaptation paradigm show an interaction between depth and familiarity in the right FFA, with greater adaptation in the Back (holistic) depth condition relative to Front (parts) for familiar but not unfamiliar faces. This suggests that the FFA is not dedicated to a single type of processing. Rather, activity in this one cortical region may encompass multiple mental operations with distinct behavioral signatures.

3:30 673 **Culture shapes eye movements during face identification**

Rachael Jack[1] (rachael@psy.gla.ac.uk), Caroline Blais[2], Christoph Scheepers[1], Daniel Fiset[3], Roberto Caldara[1]; [1]Department of Psychology, University of Glasgow, [2]Centre de Recherche en Neuropsychologie et Cognition, Département de psychologie, Université de Montréal, [3]Department of Psychology, University of Victoria

Face processing has been considered almost a unique and universal biological perceptual skill shared by human beings. People from different cultures identify familiar faces with little effort from a virtually unlimited number of different faces. Classification image techniques (Bubbles - Gosselin & Schyns, 2001; Caldara et al., 2005) and eye movement patterns (Henderson et al., 2001) have objectively identified the critical information used by the face system to achieve this complex perceptual categorization process: the eyes. However, literature on face processing has so far largely ignored culture. Evidence supporting cultural differences in perceptual strategies for affording visual information has expanded rapidly in the past decade. Westerners tend to engage analytic perceptual mechanisms for processing the visual environment, whereas East Asians use holistic perceptual mechanisms. Whether such perceptual cultural differences would expand to the biologically relevant class of faces and the important task of face identification remain to be clarified. In the present study, we investigated human eye movements of Westerners Caucasian and East Asian participants while they encoded and identified Caucasian and Asian faces. As expected, participants showed better performance for same- than other-race face identification. Strikingly, however, Caucasian and Asian participants used different but consistent scan patterns to adapt to the task, regardless of the race of the faces. Caucasians fixated more focally on the eye region than Asians during face encoding and identification stages, whereas Asians attended more to the central region of the face. These results demonstrate that face processing can no longer be considered as arising from a unique and universal series of perceptual events. Culture tunes eye movements for achieving face identification by using different visual information. These biological perceptual skills may be shaped by visual experience during social interactions and other cultural factors, and cannot be explained completely by the differences in faces per se.

3:45 674 **The behavioral plasticity of the other-race face effect: A test of the perceptual expertise hypothesis**

James Tanaka[1] (jtanaka@uvic.ca), Danielle Droucker[2], Daniel Fiset[1]; [1]Department of Psychology, University of Victoria, [2]Department of Psychology, University of Calgary

A robust finding in the face recognition literature is that people are better at recognizing faces from their own race than faces from another race. According to the perceptual expertise account, the other-race effect is due to differences in categorization of own- versus other-race faces rather than differences in perceptual exposure to them. As objects of expertise, own-race faces are categorized at the subordinate level of the individual (e.g., Joe, Tom, Bob) whereas other-race faces are categorized at the basic level of race (e.g., African American, Asian, Hispanic). If own-race recognition is a type of perceptual expertise, it is an open question as to whether people can be trained to become proficient in other-race face recognition. Following a previous expert training protocol (Tanaka, Curran & Sheinberg, 2005), Caucasian participants received two weeks of training where they learned to individuate African American (or Hispanic) faces at the subordinate level and classify Hispanic (or African American) faces at the basic level. During training, visual exposure was controlled such that participants received an equal number of training trials to African American and Hispanic faces. The main finding was that post-training recognition performance improved for novel faces from the subordinate level racial group, but no improvement was found for faces from the basic level racial group. These results indicate that perceptual categorization rather than perceptual exposure is critical for promoting transfer effects in other-race face recognition. In a subsequent experiment, we used the Bubbles technique (Gosselin & Schyns, 2001, Schyns, Bonnar, & Gosselin, 2002) to identify race-specific features that support other-race face recognition. The goal of these experiments is to identify how the demands of basic and subordinate level categorization can cause changes in perceptual sensitivity to the features that distinguish faces from different racial groups and faces within the same racial group.

4:00 675 **The neural correlates of face-like expertise in fingerprint examiners**

Bethany Schneider[1] (bschneid@indiana.edu), Jordan DeLong[1], Dean Wyatte[1], Karin James[1], Tom Busey[1]; [1]Department of Psychological and Brain Sciences, Indiana University, Bloomington

Upright faces produce a smaller, earlier N170 component than inverted faces but this relation reverses when noise is added. We suggest that the N170 latency delay with inversion and the amplitude reversal with noise are two signatures of different modes of processing for expert stimuli and that expertise might develop via configural mechanisms. As a test of this, we extend these findings into the domain of fingerprint examiners by presenting both upright and inverted faces and fingerprints in no-noise and noise-added conditions. We test both latent print examiners and novices. We establish the classic face inversion effect for faces presented in no-noise and replicate the amplitude reversal for faces in noise in both experts and novices. We establish the classic face inversion effect for fingerprints presented in no-noise and replicate the amplitude reversal for fingerprint in noise, but only for latent print examiners. Thus fingerprints appear to be processed similarly to faces in latent print examiners. The results suggest that face-like expertise can extend into other domains and the timing of these effects place constraints on the locus of the neural substrates. We propose a model in which expertise stimuli are processed via different modes and are less affected by the addition of external noise.

Attention: Tracking and Shifting

Monday, May 14, 2:30 - 4:15 pm, Hyatt Ballroom North
Moderator: Steven Franconeri

2:30 676 Spatial attention remains in retinotopic coordinates following saccades

Julie D. Golomb[1] (julie.golomb@yale.edu), Marvin M. Chun[1], James A. Mazer[1]; [1]Yale University

A remarkable function of human vision is our ability to maintain stable percepts of the world despite retinal inputs that change dramatically with each eye movement. Although previous studies have demonstrated that neurons in parietal cortex can update or "remap" visual inputs following saccadic eye movements (e.g., Duhamel et al., 1992), relatively little is known about how saccades and remapping interact with spatial attention. In the current study, we examined the behavioral effects of saccades on spatial attention in human observers. Trials began with a fixation dot presented at a pseudorandom location on the computer screen. While participants maintained fixation, a cue briefly appeared at a peripheral location; participants were instructed to hold this location in memory. On "saccade" trials, the fixation dot then moved to a new location, and participants made a corresponding saccade. On "no saccade" trials, subjects simply maintained fixation. After a variable delay, an oriented bar appeared, and participants made a speeded response indicating its orientation. Spatial working memory for the cued location was then queried with a challenging same/different location task. Reaction time (RT) on the orientation task was analyzed on trials in which participants correctly responded in both tasks. On "no saccade" trials, there were significant RT benefits when the oriented bar appeared at the cued location compared to other locations. However, on "saccade" trials, participants exhibited RT benefits when the target appeared at the cue's retinotopic location, now shifted in world coordinates. In fact, at some delays, RT benefits for the retinotopic locations were stronger than those for world coordinate locations, suggesting that the locus of spatial attention is encoded in retinotopic coordinates and shifts in space following saccades. Thus, even when spatial working memory maintains locations in world coordinates, spatial attention appears to operate in a retinotopic frame of reference.

Acknowledgement: Supported by NIH EY014193 (MC), NSF GRF (JG)

2:45 677 Can we maintain multiple attentional control sets over distinct regions of space?

Maha Adamo[1] (maha@psych.utoronto.ca), Carson Pun[1], Jay Pratt[1], Susanne Ferber[1]; [1]Department of Psychology, University of Toronto

It has been well established that attentional control sets occur when observers search the visual field for targets defined by a specific feature. When uninformative peripheral cues precede the target, cues that contain the specific target feature will capture attention while cues that do not will be effectively ignored. We tested whether different attentional control sets can be simultaneously maintained over distinct regions of space. On each trial, either a blue or a green target was presented within one of two placeholders located to the left and to the right of a central fixation cross. Observers were instructed to respond to only specific colored targets at specific locations (i.e., blue target at left placeholder, green target at right placeholder, or vice versa). On most trials, 150 ms before the target was presented, either a blue or a green cue appeared around the left or the right placeholder. These cues varied on two dimensions in relation to the impending targets: they were presented either in the same location (valid) or the opposite location (invalid), and they were either the same color (matching) or the other color (nonmatching). On other trials, no cue was presented. All trial types occurred with equal probability, and response time (RT) to the target was recorded. As expected, trials in which the cue was congruent with the target (valid-matching) elicited the fastest RTs relative to no-cue trials, while fully incongruent trails (invalid-nonmatching) elicited the longest RTs. Importantly, the partially incongruent trials (valid-nonmatching and invalid-matching) elicited RTs that did not differ from no-cue trials. This is the first demonstration that two separate attentional control sets can be simultaneously maintained at distinct spatial locations.

3:00 678 Neural evidence for persistent representation of tracked objects during occlusion

Trafton Drew[1] (tdrew@uoregon.edu), Todd S. Horowitz[2], Edward K. Vogel[1]; [1]University of Oregon, [2]Brigham & Women's Hospital, Harvard Medical School

In a typical multiple object tracking experiment, observers are asked to track 4 of 8 identical objects as they move independently and unpredictably for several seconds. The striking and robust finding of these experiments is that observers can successfully track 3-5 objects under these conditions. Moreover, tracking is not disrupted when the objects move behind occluders. How is this accomplished? One possibility is that the visual system actively tracks invisible occluded targets. An alternative explanation is that the system is able to rapidly recover the missing targets when they reappear in plain view. Behavioral studies have addressed this question by measuring RT to transient luminance probes. However, this method changes the attentional state of the observer. In the current study, we tried to distinguish between these two explanations by looking at the patterns of neural activity revealed by ERPs. Last year, we demonstrated that the amplitude of sustained contralateral ERP activity is highly sensitive to the number of objects that an observer is currently tracking (Drew & Vogel, VSS 2006). This amplitude provides a convenient online measure of the number of object representations that are currently active on a given trial. Here, we found that the amplitude of this contralateral tracking activity is not disrupted for objects that are occluded during the trial. These results suggest that object representations do indeed remain active for tracked items that fall from view as they pass behind other occluding objects.

3:15 679 Moons in orbit: How are targets distinguished from distractors in multiple-object tracking?

Michael N Tombu[1] (mike.tombu@vanderbilt.edu), Adriane E Seiffert[1]; [1]Vanderbilt University

People can track a subset of moving objects amongst distractors; a skill believed to be mediated by attentional processes. Multiple-object tracking (MOT) studies have provided insights into how objects are attended and represented. However, with most MOT tasks several factors presumably important to tracking performance such as eccentricity, target-target and target-distractor proximity vary unpredictably across time, making it difficult to pinpoint the specific causes of tracking failures. The goal of this study was to investigate the extent to which manipulations of speed, target-distractor proximity and the number of distractors affect common stages of processing. In order to do so, we designed a MOT display consisting of several groups of dots rotating about two axes: one at the center of each group, another at the center of the display. The display is similar to a solar system, such that the dots look like moon and planets rotating about each other in orbit about a star. The main benefit of this design is that speed, proximity and the number of distractors can be manipulated independent of one another and largely free of confounds, thus allowing for a more systematic investigation. We were particularly interested in determining whether target designation, presumably modulated by proximity and speed, was independent of distractor suppression, presumably affected by the number of distractors in the display. According to additive factors logic, if two manipulations affect independent stages of processing their effects should be additive, whereas if they affect a common processing stage, their effects should interact. Our results showed that, whereas proximity and number of distractors were additive, speed and proximity interacted. Performance was sharply impaired by speed increases when the dots were grouped closer than when they were far apart. These results suggest that distractors suppression and target designation occur at different stages of processing in MOT.

Acknowledgement: NIH EY014984
URL: http://www.psy.vanderbilt.edu/faculty/seiffert/

3:30 680 **Attentive tracking involves a demand-based dynamic redistribution of attention.**

Marcia Grabowecky[1] (grabowecky@northwestern.edu), Lucica Iordanescu[1], Satoru Suzuki[1]; [1]Department of Psychology, Northwestern University

People can attentively track multiple targets randomly moving among identical distractors. We analyzed target-localization errors to elucidate the mechanisms underlying this ability. We sought to determine (1) whether the underlying mechanisms track position, velocity, or both, and (2) whether they assign a discrete "attention index" to each target, or rather flexibly allocate more resources to targets when they are temporarily crowded by distractors. Testing these hypotheses required measurements of how accurately observers tracked each target's location and velocity. METHOD. On each trial, observers (N = 20) tracked 3 targets moving among 7 distractors. The targets were red, green, and yellow, and the distractors were assigned the same colors. This permitted color-based post-cueing. After 6 seconds of tracking, the display disappeared coincident with an aural cue of a color name. The observer mouse-clicked the last-seen location of the target of the post-cued color. Central eye fixation was enforced using an unpredictable digit-identification task. RESULTS. The direction of localization error (the vector from the true position to the mouse-clicked position) was correlated with the target's motion direction, indicating that observers tracked the motion direction of each target. The lack of correlation between the angular error (the angular difference between the direction of the localization error and the target's motion vector) and the absolute localization error (the distance between the mouse-clicked position and the true position) suggested that relatively independent mechanisms tracked velocity and position. Finally, tracking became increasingly precise as targets were surrounded by more distractors (within 3.37° diameter), indicating that greater attentional resources were dynamically allocated to crowded targets and away from less-crowded targets. These results show that during attentive tracking of multiple targets, (1) spatial distribution of attentional resources is continuously adjusted in a demand-based manner, and (2) the underlying tracking mechanisms monitor both position and velocity.

Acknowledgement: Supported by NIH Grant EY14110 to SS.

3:45 681 **Maintaining multiple attentional foci: spatial separation affects behavior but not posterior parietal activity**

Won Mok Shim[1] (wshim@fas.harvard.edu), George A. Alvarez[2], Yuhong V. Jiang[1]; [1]Psychology, Harvard University, [2]Brain and Cognitive Sciences, MIT

Humans are severely limited in their ability to maintain multiple attentional foci. In attentive tracking of moving objects, for instance, performance reduces as the number of tracked targets increases. Previous studies have interpreted such reduction in terms of a limit on the number of attentional foci. However, increasing the target number often correlates with reduced spatial separation between different targets. In this study, we isolate the role of target spatial separation from that of target number on attentive tracking. Participants view 16 bouncy balls, 4 in each visual quadrant, where the balls move randomly within their respective quadrant. Attentive tracking for a subset is required, where the subset may be a single ball (track 1), two balls within a single quadrant (track 2 near), or two balls, one in each adjacent quadrant (track 2 far). Results showed that tracking accuracy was determined primarily by spatial separation between tracked targets. Tracking two near targets was worse than tracking two far targets, despite the fact that the number of relevant distractors was fewer in the former condition. Tracking two far targets was equivalent to tracking a single target, showing little cost of splitting attention to two distant foci. In stark contrast to behavioral performance, activity in the posterior parietal cortex (as measured by fMRI) was sensitive to the number of attentional foci but not to the spatial separation between them. Parietal activity was lower in track 1 than in track 2 conditions, but it did not differ between track 2 near and track 2 far. Our results suggest that the posterior parietal cortex represents "attentional pointers" whose operation is independent of the spatial separation between the pointers. We propose that the resolution of attention is reduced by suppressive interaction between two adjacent attentional foci.

Acknowledgement: Supported by NIH 071788, ARO 46926-LS, and NSF 0345525

4:00 682 **Rapid shifts of attention between two objects during spatial relationship judgments**

Steven Franconeri[1] (franconeri@northwestern.edu), Todd Handy[2]; [1]Northwestern University, [2]University of British Columbia

The ability to judge spatial relationships among objects in the world is a fundamental part of visual processing. Despite the frequency of these judgments, they are attentionally demanding, as demonstrated by inefficient visual search for a targets defined by a spatial relationship. However, there is little evidence of *why* these judgments are difficult. We show that reporting a spatial relationship may require rapid shifts of spatial attention between two objects being judged.

Participants reported whether displays contained a red square on the left and a green square on the right, or the opposite arrangement. Using ERP, we measured a high temporal resolution trace of horizontal shifts of attention, by examining the difference over time between left and right electrode sites over visual cortex. A shift of attention to one side of the visual field is accompanied by greater negativity in the electrode sites on the contralateral side.

Five participants performed the task over two 2-hour sessions. Each participant's results suggest that shifts of attention (lasting 50-100ms) began 100ms after display onset. Individuals showed preferences for initial shifts toward an object on one side (e.g. on the left, as measured by the difference between the left and right electrodes), and/or for a given color (e.g. the green object, as measured by the difference between electrodes contralateral to green and those contralateral to red). These strategies varied among subjects and may reflect differences in the way that people implement visual routines.

Despite the feeling that we apprehend the relationship between two objects by attending to both at once, these results suggest that spatial relationship judgments require a serial shift of attention. We speculate that this shift may actually be the mechanism that produces the spatial relation judgment, perhaps through a form of efference copy of the direction of the shift.

Poster Session F

Monday, May 14, 8:00 am - 12:30 pm, Municipal Auditorium

Spatial Vision: Mechanisms and Orientation (683-701)
Perceptual Organization: Contours II (702-715)
Face Perception: Neural Mechanisms (716-731)
Eye Movements: Attention and Search (732-738)
Attention: Divided Attention, Inattention, and Inhibition (739-754)
Visual Working and Short-Memory Memory (755-769)

Spatial Vision: Mechanisms and Orientation

Author Presents: 8:00 - 9:45 am

F1 683 **S cone input to the chromatic Hermann grid illusion**

James Comerford[1] (comerfordj@neco.edu), Frank Thorn[1], Elizabeth Garland[1]; [1]The New England College of Optometry

Purpose: Isoluminant Hermann grids (HG) are typically not effective inducers of chromatic Hermann grid illusions (HGI). Oehler and Spillmann (1981) devised an isoluminant HG that resulted in strong chromatic HGIs that appeared to be induced by L and M cones but not S cones. We wished to determine the influence of the S cones on the chromatic HGI.

Method: 63 Isoluminant Hermann grids varied systematically in stimulation of the L, M and S cones. They were defined by three components: continuous neutral-colored vertical bars, horizontal line segments (21 varieties), and background squares (purple, neutral or yellow-green). The background squares differed from each other only in S cone excitation. 6 subjects rated the magnitude of the illusion. As a control, a series of achromatic grids were interspersed with the chromatic grids.

Results: For the purple background, there was a significant ($P<.0001$) increase in the strength of the illusion with a decrease in S cone stimulation of the horizontal line segments. This effect was greatest when the L/M cone ratio for the horizontal line segment was largest. For the yellow-green background, there was a significant ($P<.0001$) increase in the strength of the illusion with an increase in S cone stimulation of the horizontal line segments. This effect was smallest when the L/M cone excitation ratio for the horizontal line segment was largest. There was little or no illusion seen with a neutral background.

Conclusion: S cones participate in producing the chromatic Hermann grid illusion. The illusion varied for the different background squares, even though they were identical in L/M cone excitation and differed only in S cone stimulation. Under some conditions, increasing the cone excitation difference between horizontal line segments and the background resulted in weaker illusions, suggesting a suppressive effect of color noted in our previous work (Comerford et al VSS2005).

F2 684 **Temporal properties of monocular perisaccadic spatial distortion**

Zhi-Lei Zhang[1] (zhilei_z@berkeley.edu), Clifton Schor[1]; [1]School of Optometry, UC Berkeley

It has been shown that eye movement can distort space percept before and during saccade. We have demonstrated in previous study that stereopsis can be evoked by head-centric disparity due to the eye movement even though there was no retinal disparity. In this study we tested how the perceived visual direction changed with time immediately before the saccade that causes the visual direction of a stationary target to appear to be displaced in the direction of the saccade (Ross et al., 1997). Two flashes with an inter-stimulus interval of 50ms were presented briefly (3ms) to the same eye before saccade onset. We compared the perceived positional displacement of the two briefly flashed zero-horizontal offset targets as a function of the TSO. The TSO (Time to Saccade Onset) is defined as the time difference between the onset of the saccade and the onset of the second flash. The bigger the TSO, the earlier the flash was presented before the saccade onset. We found that even though the retinal horizontal position is the same for the two flashes they appear to be displaced with TSO up to 20ms, in which, the first flash displaced more than the second toward the saccade target. We didn't find the reverse of the temporal order (Morrone et al 2005) of the two flashes with TSO range from 0 to 60ms. This result demonstrated that the perceived visual direction varies before the saccade onset due to the dynamic of the eye position signal component. The result supported the theory of the head-centric disparity.

F3 685 **Orientation discrimination in the periphery depends on the context**

Laura Renninger[1] (laura@ski.org), Preeti Verghese[1]; [1]Smith-Kettlewell Eye Research Institute

PURPOSE How the visual system processes complex contours in a scene is still largely unknown. We seek to better understand the interaction of discrete orientations in the periphery during contour processing. As a first step, we examine how the orientation of a target line element is perceived as a function of surrounding orientation information. METHODS A target line was presented briefly in the periphery and observers were asked to judge its orientation from one of eight possible orientations, in steps of 22.5deg. The target element was surrounded by a half circle of oriented lines with different organizations: randomly oriented (random), tangent to the half circle (co-circular) and normal to the half circle (sun ray). The distance between the target and surround was varied. In the control condition, no surround was present. RESULTS The influence of the surround on target judgment depended on the distance between target and surround and began to affect performance at a distance of 1/10 the eccentricity. Orientation labeling of the target was impeded most when the surround was disorganized (random) and improved when the surround was organized (co-circular and sun ray). Errors in the organized conditions were restricted to neighboring orientations (22.5deg) while errors in the random condition were distributed to non-neighboring orientations. CONCLU-

SIONS The judgment of an orientation target is easiest if the surround is organized. When the surround is disorganized, the target orientation is more difficult to label and observers are more prone to guessing. The crowding literature demonstrates that the content of the surround is important for target perception. In this work, we've shown that the organization of that content is also important.

F4 686 An objective paradigm for the discrimination of visual uncertainty

Simon Barthelmé[1] (simon.barthelme@gmail.com), Pascal Mamassian[1]; [1]Laboratoire Psychologie de la Perception. CNRS/Université Paris V

Knowing which of two actions implies a higher risk is a basic prerequisite of rational action. We tested this ability in the visual domain by having observers perform a forced choice between uncertainties. Observers were presented with two stimuli in the context of a left/right orientation discrimination task. The stimuli were two Gabor patches to which Gaussian pixel noise was added, such as to generate high visual uncertainty. Observers were instructed to categorise only the stimulus for which they felt the least uncertain.

Unbeknown to the observers, trials could belong to one of two conditions: True Choice and False Choice. In True Choice trials, the stimuli had equal noise levels but differed in uncertainty. In False Choice trials, the stimuli were rotated so as to look different but to imply equal levels of uncertainty. This allowed us to assess the observers' ability to discriminate effectively between levels of visual uncertainty. Being able to choose the less "risky" of two stimuli implies that performance (in this case, probability of correct discrimination of orientation) will be higher on average than when that ability is not present. When the two options are equally risky, there is no gain to be had, thus providing a performance baseline.

We found that performance across a range of signal/noise ratios was indeed higher when the two stimuli differed effectively in uncertainty, demonstrating that observers are able to compare levels of visual uncertainty usefully.

Acknowledgement: Chaire d'Excellence to Pascal Mamassian from the French Ministry of Research

F5 687 Human Orientation Sensitivity During Object Perception

Henry Galperin[1] (hgalp@brandeis.edu), Peter Bex[2], Jozsef Fiser[3]; [1]Department of Psychology, Brandeis University,, [2]Institute of Opthalmology, University College of London, [3]Volen Center for Complex Systems and Department of Psychology, Brandeis University

Humans' sensitivity to orientation information has been typically measured in highly artificial tasks using very simple stimuli e. g. by quantifying orientation discrimination with small Gabor patches. How well do such measures capture the efficiency of coding orientation information during object perception? We used a 2-AFC match-to-sample paradigm to determine the level of internal noise and sampling efficiency with which orientation information is represented in the visual system while subjects looked at images of objects. Natural grayscale images of everyday objects were analyzed with a bank of multi-scale Gabor-wavelets. Stimuli were created using a small subset of the coefficients of the Gabor filters so that the resulting synthetic images retained the properties of the original image. A noiseless synthetic source image was presented for 1 sec, followed by a reference image that contained a fixed amount of orientation noise (s), and a target image containing an additional amount of orientation noise (s+D) under control of a staircase procedure. There were six levels of fixed noise from 1 to 32 degrees in logarithmic steps. Subjects were asked to identify which of the simultaneously presented images were more similar to the source image. Results were analyzed by bootstrapping and 95% confidence intervals were estimated. With increased pedestal noise (s) subjects' performance strongly increased up to 16 degrees and then steeply deteriorated independently of the groups of images used. These results are in sharp contrast to orientation sensitivity results obtained with standard discrimination tasks. They also suggest that the visual system is surprisingly robust to orientation noise when processing information of structured inputs rather than simple sine wave stimuli.

F6 688 Representing the orientation of objects: Evidence from adults' error patterns

Emma Gregory[1] (gregory@cogsci.jhu.edu), Michael McCloskey[1]; [1]Department of Cognitive Science, Johns Hopkins University

Representing the orientation of objects in the visual field is important for a variety of reasons. Perceiving the direction in which predators are facing is a life-or-death matter for many creatures, and a person reaching for an object must apprehend how that object is oriented in order to position her hand appropriately. Orientation is also important in processing visual symbols, such as arrows on street signs, or alphabetic letters (e.g., b, d). Despite the significance of orientation information, little attention has been directed toward questions concerning how the orientation of objects is represented in the visual system. We present a theoretical perspective that conceives of orientation as a relationship between reference frames. According to this theory, orientation representations relate an object-centered reference frame to a frame of reference external to the object, and this external reference frame may in turn be related to additional external frames. The theory also offers specific assumptions about how relationships between reference frames are represented, proposing that these representations consist of several components that together specify a mapping between coordinate systems. Given these assumptions, the theory makes predictions about the types of errors that should occur in tasks involving perception and memory for object orientation. For example, the assumption that object-centered frames are implicated in orientation representation predicts errors in the form of reflections across an object axis. We report two experiments designed to test the theory's predictions. Pictures of objects and artificial shapes were presented briefly, and participants reported the orientation of the stimuli. We argue that the observed error patterns support the theory's assumptions about the componential structure of orientation representations, as well as the assumption that object-centered reference frames play a critical role in orientation representation. We also consider alternative hypotheses, suggesting that these hypotheses cannot readily account for our results.

F7 689 Bilateral and Unilateral Orientation Dynamics

Nestor Matthews[1] (matthewsn@denison.edu), Kristin Cox[1]; [1]Department of Psychology, Denison Univeristy

Introduction: Previous studies have suggested that additional neural processing time may be needed for comparisons across the vertical midline than for comparisons restricted to either lateral hemi-field (Wilson, Blake & Lee, 2001; Ringo, Doty, Demeter & Simard, 1994) Here, we compared bilateral and unilateral orientation discrimination to determine the extent to which orientation judgments exhibit an inter-hemispheric cost. Method: Nine participants completed a 2x2 within subject experiment in which the independent variables were laterality and stimulus duration. On each trial, one of 15 randomly generated letters was presented foveally for 192 msec while two diagonally oriented gabor patches were flashed either unilaterally or bilaterally for either 83 or 183 msec. Randomly across trials, the gabor patches were either identically or orthoganlly oriented. The letter stimuli and the gabor patches were followed by visual masks to limit neural persistence. If the foveally presented letter was correctly identified, the participant judged the orientation of the peripherally presented gabor patches as either the 'same' or 'different'. Results: A 2x2 within-subject ANOVA revealed a significant main effect of stimulus duration. Specifically, orientation sensitivity was significantly greater at 183 msec than at 83 msec ($p < 0.01$). Neither the main effect of laterality nor the laterality-by-duration interaction was significant. Discussion: The present orientation-discrimination data are consistent with the previous finding that there is no cost associated with inter-hemispheric comparisons on a distal misalignment task (Pillow & Rubin, 2002). It may be that an inter-hemispheric cost was not present here because the orientation task did not require low-level grouping. Other studies requiring low-level grouping have shown a within-hemi-field advantage (Pillow & Rubin, 2002; Butcher & Cavanagh, 2004). Finally, the present data on peripheral orientation discrimination extend previous work that similarly demonstrated duration-related improvements in foveal orientation discrimination for masked stimuli (Strong, Kurosawa & Matthews, 2006).

URL: http://personal.denison.edu/~matthewsn/vss2007poster.html

F8 690 A blind subject can discriminate the orientation of a grating using electrical stimulation from an implanted retinal prosthesis

Avi Caspi[1] (avi.caspi@2-sight.com), Matthew J. McMahon[1]; [1]Second Sight Medical Products, Inc., Sylmar, CA

Although electrical stimulation of the retina can produce localized spots of light in patients blinded from retinal degeneration, it has been unclear if synchronized stimulation of different retinal locations using an array of electrodes can result in the percept of a meaningful image with spatial modulation.

We measured square-wave grating acuity of a totally blind subject who was implanted with a first generation Second Sight retinal prosthesis. The implanted system utilized an array of 4x4 stimulating electrodes tacked to the inner surface of the retina. Each of the 16 electrodes stimulates a different location on the retina corresponding to a different area in the visual field of a video camera mounted on the subject's glasses. Visual performance was evaluated using a four alternative forced-choice orientation discrimination task with gratings of varying spatial frequency (scaled relative to the width of the array). In addition, we examined the relationship between the number of active electrodes and visual performance. Performance levels greater than chance (i.e. 25% correct) of gratings finer than one cycle/array indicate the use of spatial information from individual electrodes within the array.

Results show that for spatial frequencies up to the 2 cycles/array (the Nyquist limit), the subject performed significantly above chance. Further, we found a significant decrease in performance when only a subset of the electrodes in the array were stimulated. Performance levels of 93±2%, 73±4% and 47±6% were measured for arrays with 4x4, 3x3 and 2x2 pixels respectively, for a grating with 0.9 cycles/array.

Our results clearly show that the blind subject can spatially resolve individual electrodes within the array of the implanted retinal prosthesis. Moreover, visual performance improves with the number of stimulated electrodes. This motivates the development of retinal prosthesis systems with larger numbers of electrodes to provide higher spatial resolution vision to blind subjects.

Acknowledgement: NIH Grant number EY012893

F9 691 Visual Discrimination During Controlled Retinal Image Motion

Ramon Iovin[1,2] (riovin@bu.edu), Martina Poletti[1], Fabrizio Santini[1], Michele Rucci[1]; [1]Department of Cognitive and Neural Systems, Boston University, [2]Program in Neuroscience, Boston University

Our eyes are constantly in motion, even during visual fixation. In a previous study, we found that fixational eye movements improve the discrimination of high spatial frequency stimuli. Here, we describe the results of two experiments which further support the hypothesis that fixational eye movements constitute an effective sampling strategy by which the visual system enhances the processing of fine spatial detail. In a forced-choice discrimination task, subjects reported the orientation (±45°) of an 11 cycles/deg grating embedded in low-frequency noise. To guarantee normal fixational instability, stimuli were displayed for 1s following an initial saccade. Stimuli were modified in real time by EyeRIS, a custom-developed system which processes the eye movements measured by a DPI eyetracker to enable precise and flexible control of the spatio-temporal stimulus on the retina. In the first experiment, we examined the effect of selectively stabilizing the stimulus along only one axis. We found that performance was impaired, as under complete retinal stabilization, when retinal image motion was restricted to the axis parallel to the grating, but remained unchanged when motion was allowed on the orthogonal axis. In the second experiment, we reconstructed the retinal image motion experienced during the normal occurrence of fixational eye movements by superimposing recorded eye movement on an otherwise stabilized stimulus. We found that passive exposure to retinal image motion was sufficient to reestablish performance. These results provide further evidence for the causal relationship between fixational modulations of luminance and performance. Discrimination is impaired when fixational input modulations do not convey information about the grating. Conversely, performance is normal when these input modulations contain information about the grating's orientation, regardless of whether the subject actively produced retinal image motion by means of fixational eye movements, or was passively exposed to it under conditions of retinal stabilization.

Acknowledgement: Supported by NIH-EY015732

F10 692 Anisotropic Contrast Sensitivity During Viewing of Broadband Stimuli: Timing and Tuning

Yeon Jin Kim[1] (y0kim009@netmail.louisville.edu), Andrew M. Haun[1], Edward A. Essock[1]; [1]Department of Psychological and Brain Sciences, University of Louisville

When viewing a pattern of broadband spatial content (e.g., a natural scene), visual performance for oriented content is best for oblique orientations and worse for horizontal than vertical (Essock et al., 2003; Hansen et al., 2003; Hansen and Essock 2004; 2005; 2006). When narrowband content such as a resolution-acuity target is viewed, most observers show an oblique effect (worst performance at oblique orientations) and if more content is added to the image, the anisotropy is a horizontal effect (Hansen and Essock, 2006). We've suggested that the change in the visual anisotropy results from anisotropic orientation-tuned gain-control (strongest at horizontal), whose effect is pronounced when viewing broad-band stimuli (creating more activity in units contributing to the gain control pool) and insignificant with narrowband stimuli. Such anisotropic suppression could be a direct consequence of a corresponding bias of cortical neurophysiology (e.g., Li et al., 2003) indicating more neurons tuned to horizontal than other orientations. Here we measure (1) the timing of the transition of the oblique effect to the horizontal effect as the mask-test SOA is varied, and (2) measure the orientation tuning of the threshold elevation at four test orientations (0°, 45°, 90° and 135°). When SOA between a 1/f broadband noise mask (15° orientation bandwidth) and a test (8 cpd Gabor) is varied, an oblique effect is seen at large SOAs but becomes a horizontal effect when the broadband content is present at about the same time as the test probe (SOAs around 50 msec). When orientation tuning is probed by a mask (flanking 5½ broadband wedges at varied test-mask orientation differences), elevation falloff is Gaussian (40° half-height) equally at all four test orientations, but with differential strength (peak thresholds at horizontal). Together, these results further support and extend the suggestion that the horizontal effect stems from orientation-tuned gain-control.

Acknowledgement: Grant from ONR and KSGC

F11 693 Internal and External Crowding in Recognition of Chinese Characters

Lei Liu[1] (lliu@icare.opt.uab.edu), Jun-Yun Zhang[2], Cong Yu[2]; [1]School of Optometry, University of Alabama at Birmingham, [2]Institute of Cognitive Neuroscience and Learning, Beijing Normal University

Crowding refers to the deteriorated target identification in the presence of nearby flankers. We studied crowding in recognition of Chinese characters (CCs) in normal and anisometropic amblyopic observers. The stimuli were four groups of CCs with various spatial complexities and English Sloan letters presented at 0°, 5°, and 10° retinal eccentricities. (1) Under no-flanker conditions, acuity sizes of more complex CCs increased faster with retinal eccentricity than that of simpler CCs and Sloan letters, suggesting possible internal crowding among components of complex CCs in peripheral vision. (2) When the target was flanked by same-sized characters from the same stimulus group at a 1-character size gap, strong external crowd-

Monday Posters

ing was evident in peripheral vision, but internal crowding for complex CCs was not carried over to external crowding. (3) Crowding was reduced by 30-45% when the spatial complexities of the flankers and the target were different. More complex flankers reduced more crowding to a simpler target than did simpler flankers to a more complex target. (4) Acuity sizes for all stimuli were larger in anisometropic amblyopic eyes than in non-amblyopic and normal eyes up to 10° retinal eccentricity. However, internal crowding of more complex CCs observed in normal eyes was not shown in amblyopic eyes. External crowding that prevailed in normal and non-amblyopic eyes was very weak in amblyopic eyes. Our results indicated that both internal and external crowding affected the recognition of CCs in the visual periphery, which should be considered when Chinese reading using peripheral vision is evaluated. Both low level lateral masking and high level attention deployment may be responsible for the observed crowding reduction when target and flankers had different spatial complexities. Unlike normal or non-amblyopic eyes, anisometropic amblyopic eyes seemed to be immune to crowding across the visual field.

F12 694 **Crowding is directed to the fovea and preserves only feature contrast**

Yury Petrov[1] (y.petrov@neu.edu), Ariella Popple[2], Suzanne McKee[3]; [1]Psychology Department, Northeastern University, [2]School of Optometry, UC Berkeley, [3]Smith-Kettlewell Eye Research Institute

The abundant literature on crowding offers fairly simple explanations for the phenomenon, such as position uncertainty or feature pooling, but convincing evidence to support these explanations is lacking. In part, this is because the stimuli traditionally used for crowding studies are characters or other complex shapes, which makes it hard to determine exactly what kind of information is lost. In our first experiment a 45% contrast Gabor target presented at 9 deg eccentricity was flanked by a plaid made of two replicas of the target (one was rotated by 90 deg). The scale of the whole stimulus was varied in an adaptive fashion. Observers had to identify the target's slant (45 deg left or right). In agreement with early crowding studies (e.g. Bouma, 1973) we observed a strong crowding effect, when the mask was positioned outward with respect to the target, but not when positioned inward, above, or below it. This demonstrates that crowding has a pronounced foveal directionality, which rules out explanations based on simple pooling or surround suppression (which does not show such directionality). In our second experiment, we asked observers to identify simultaneously the slants (left or right) of three horizontally aligned Gabor targets. The targets were presented at 6 deg in the periphery, and their size and separation was chosen to incur strong crowding. In agreement with the first experiment we observed that the outmost target was crowded much less than the other targets. The specific pattern of confusion shown by all the observers indicates that the only reliable information available to them was orientation contrast, i.e. the number (and, to a lesser degree, the location) of sites where slant changed. Thus, crowding appears to spare only the most salient peripheral information, which supports the hypothesis that crowding is caused by limitations of attentional resolution.

Acknowledgement: This work was supported by National Institutes of Health (NIH) National Eye Institute Grants RO1EY017071, R01EY01728, and by Smith-Kettlewell Eye Research Institute.

F13 695 **Abstract withdrawn**

F14 696 **Modulation of V1 response to a target by adjacent distractors in attended and non-attended conditions**

Fang Fang[1] (fang0057@umn.edu), Sheng He[1]; [1]Department of Psychology, University of Minnesota

When a peripheral target is flanked by distractors, especially in a radial orientation, its visibility is significantly reduced. This phenomenon is known as crowding or surround suppression, which has been an active research topic for more than four decades. However, little is known about its underlying neural mechanism. It is known that crowding has a "radial > tangential" asymmetry as well as an "outward > inward" asymmetry. We conducted two fMRI experiments to study the modulation of V1 response to a target by spatially adjacent distractors when subjects performed a fixation task (non-attended condition) or a contrast-discrimination task on the target (attended condition). The target was always positioned on the right horizontal meridian. In the first experiment, the target was presented either alone, or with two flanking distractors positioned either tangentially (above and underneath the target) or radially (left and right of the target). In the second experiment, the target was presented either alone or with an inward distractor (left of the target) or an outward distractor (right of the target). The stimuli in the attended and non-attended conditions were exactly the same. We found that, in both attended and non-attended conditions, the pattern of V1 responses to the target were radial>tangential>single in the first experiment, and outward>inward>single in the second experiment. Attending to the target enhanced V1 responses, but attentional enhancement was larger when a distractor(s) was presented. Interestingly, attentional enhancements were stronger in the radial condition than in the tangential condition at the flanking locations where no physical stimuli were presented. These results suggest that crowding effects result from a combination of bottom-up lateral interaction and top-down attentional modulation, and reveal a neural correlate of unfocussed spatial attention in the crowding effect (Strasburger, 2005).

Acknowledgement: This work is supported by the James S. McDonnell Foundation and NIH grant R01 EY02934. The 3T scanner at the University of Minnesota, Center for Magnetic Resonance Research is supported by NCRR P41 008079 and by the MIND Institute.

F15 697 **Anisotropic representation of oriented bars in human visual cortex is revealed by fMRI projective and receptive field mapping techniques**

Kuwook Cha[1] (kuwook@snu.ac.kr), Sang-Hun Lee[1]; [1]Department of Psychology, Seoul National University

Optical imaging studies in primates demonstrated that neural responses to an oriented stimulus are distributed over a substantial region in early visual cortex (Grinvald et al., 1994), with the spreading pattern being elongated along the axis of the orientation of the stimulus (Bosking et al., 1997). Here we report that this anisotropy exists also in human visual cortex using two converging paradigms of fMRI, 'projective field mapping (PFM)' and 'receptive field mapping (RFM)' techniques.

In the PFM experiment, observers fixated the center of a screen, where a punctual (800ms), small (s=.33°) Gabor patch (sf=1.1~4.4 cyc/°) appeared repeatedly every 13.2 secs, with its orientation alternating randomly between 45° and 135° across trials. We estimated the spatial extension of cortical activity by measuring fMRI responses from cortical subregions which represent 1.16°-width annuli at different eccentricities (0.58°~5.22°). In the RFM experiment, observers viewed an 8 x 8 array of grids inside each of which a Gobor patch intermittently appeared according to m-sequence. For each voxel of early visual cortex, we derived a field map of stimuli that evoked activity of that voxel using the spectral reverse correlation technique (Nishimoto et al., 2006).

In the PFM experiment, cortical activity spread farther to the periphery along the collinear than orthogonal axis of the foveal Gabor stimulus, resulting in an elliptical 'projective field' map whose major axis matched the orientation of the Gabor patch. An analogous 'receptive field' map was obtained from the RFM experiment: a set of Gabor elements that activated a given voxel were distributed anisotropically, such that the elongated axis of the distribution matched the orientation of stimuli composing the array. These two maps, taken together, lend converging supports to the presence of anisotropic representations of oriented stimuli in human visual cortex, which may contribute to contour integration in form perception.

Acknowledgement: Supported by a grant(#M103KV010017-06K2201-01710) from Brain Research Center of the 21st Century Frontier Research Program

F16 698 **Multi-component correlate for lateral collinear interaction in the human visual cortex as revealed by Visual Evoked Potentials.**

Anna Sterkin[1] (anna.sterkin@gmail.com), Oren Yehezkel[1], Yoram Bonneh[2], Anthony Norcia[3], Uri Polat[1]; [1]Goldschleger Eye Research Institute, Tel Aviv University, Tel Hashomer, [2]Department of Neurobiology, Brain Research, Weizmann Institute of Science, [3]Smith Kettelwell Eye Research Institute, San Francisco

The perceptual effect of facilitation during lateral masking, measured as a decrease in detection thresholds for low-contrast Gabor patches (GP) when flanked by collinearly oriented high-contrast patches was previously reported. However, earlier studies of long-range spatial interactions in human visual cortex either performed spectrum analysis or focused on the waveforms for perifoveal target stimuli with contrast pedestals.

Here, visual evoked potentials (VEPs) elicited by a foveal near-threshold target GP presented in isolation (T), T in the presence of two flanking collinear high-contrast GPs (lateral masking, LM), or the flankers alone (F) were measured. The paradigm was compatible with the behavioral facilitation of T detection. Both waveform and spectrum in the 1 to 10 Hz frequency band for the midline occipital site were analyzed.

When LM was compared to linearly summed waveforms elicited by T and F, significant attenuation of peak amplitudes was found for each of five components, ranging between 64-290 ms after stimulus onset. In order to assess the effect of lateral interactions, the ratio between the spectrum amplitude of the linear prediction and LM was calculated. Suppression peaked at 1Hz (0.5 log units) and dropped to zero at 4Hz, followed by facilitation at higher frequencies (5-8Hz, peak at 6 Hz, 0.4 log units).

Despite the fact that the waveform elicited by LM was largely dominated by the high-contrast flankers with no differences in the latencies of any component, lateral interactions were reflected by nonlinear waveform modulations of multiple components and frequencies, including early onsets. Moreover, the spectrum analysis suggests that the perceptual outcome reflects a combination of shifting modulation distributed at different frequencies, either suppression or facilitation. Thus, the physiological correlates of lateral interactions may originate at multiple sources, while their impact on the perceptual decision is imbalanced.

Acknowledgement: This research was supported by grants from the The National Institute for Psychobiology in Israel founded by The Charles E. Smith Family (UP and AS).

F17 699 **Spatio-temporal tradeoff in neural processing of backward masking as revealed by visual evoked potentials.**

Oren Yehezkel[1] (yehez@post.tau.ac.il), Anna Sterkin[1], Yoram Bonneh[2], Anthony Norcia[3], Uri Polat[1]; [1]Goldschleger Eye Research Institute, Tel Aviv University, Tel Hashomer, [2]Department of Neurobiology, Brain Research, Weizmann Institute of Science, [3]Smith Kettelwell Eye Research Institute, San Francisco

We developed a new VEP paradigm for exploring backward masking (BM) in the human visual cortex. Low-contrast, foveal target Gabor patches (T) were masked by two collinear high-contrast Gabor patches, spatially separated from the target. The mask was presented at different ISIs after (1) target alone (BM-on-T) or 2) the target plus simultaneous collinear flankers (lateral masking (LM), BM-on-LM) placed at the location of the mask. The elicited responses for various BM combinations were compared within time-windows defined by the separate waveforms evoked by the target alone, mask alone and the LM combination at different ISIs. The amount of correlation between the waveforms and/or the amplitude modulation of different components was regarded as indicative of a BM effect. There was no evidence for BM of the response to the target in either condition (1) or (2) at ISI=50, due to the temporal integration of the responses elicited by target and mask. This is compatible with the behavioral finding of no suppression of target detection in BM-on-T and a lack of lateral facilitation in BM-on-LM. However, while the response to the mask in the BM-on-T condition remained unchanged, the mask response was suppressed in BM-on-LM but recovered at longer ISIs. Moreover, the waveform produced by subtracting the response to LM from the response evoked by BM-on-LM is highly similar to the response to target, but with the peak latency of mask. This suggests a mechanism of extended persistence of the target representation that could underlie behavioral facilitation in LM. In both conditions, while the peak latency could be predicted by linear summation of the separate responses at all ISIs, the amplitude did not follow the linear prediction. Thus, the results suggest that BM reflects complex neural processing of temporal order and saliency of each component.

Acknowledgement: This research was supported by grants from the The National Institute for Psychobiology in Israel founded by The Charles E. Smith Family (UP and AS) and Israel Science Foundation (UP)

F18 700 **Computing the mean size is based on perceived size**

Hee Yeon Im[1] (na772882@hotmail.com), Sang Chul Chong[1, 2]; [1]Department of Cognitive Science, Yonsei University, [2]Department of Psychology, Yonsei University

Recent studies reported that one can accurately extract the mean size of similar objects. However, few studies tested that calculation of the mean size was based on either perceived size or physical size. To investigate this, we used Ebbinghaus illusion. We either simultaneously (Experiment 1) or sequentially (Experiment 2) presented four Ebbinghaus illusion figures per each visual field. Participants' task was to decide which visual field had the larger mean size. They had to calculate the mean size based only on center circles and ignore illusion-inducers. The center circles and the inducers had a different color to help participants to focus on the center circles. In both experiments, participants consistently chose the visual field that contained inducers smaller than center circles, although the sizes of center circles were always same across two visual fields. In Experiment 3, we investigated how much calculation of the mean size was influenced by Ebbinghaus illusion. We measured PSE using the staircase method. We found that the average difference between PSE and the actual mean size was about 13 min. These results suggest that participants' calculation of the mean size was based on perceived size. Moreover, they imply that judgment of mean size is achieved in a later stage of visual processing, at least after resolving size constancy.

Acknowledgement: This research is supported by Korea Research Foundation Grant # H00039.

F19 701 **Processing of the Müller-Lyer Illusion by a Grey Parrot (*Psittacus erithacus*)**

Irene Pepperberg[1,2] (impepper@media.mit.edu), Jennifer Vicinay[3], Patrick Cavanagh[1]; [1]Psychology, Harvard University, [2]Psychology, Brandeis University, [3]Biology, Brandeis University

Alex, a Grey parrot (Psittacus erithacus) who identifies the bigger or smaller of two objects by reporting its color or matter using a vocal English label and who states "none" if they do not differ in size, was presented with two-dimensional Müller-Lyer figures (Brentano form) in which the central lines were of contrasting colors. His responses to "What color bigger/smaller?" demonstrated that he saw the standard length illusion in the Müller-Lyer figures in 32 of 50 tests where human observers would also see the illusion and reported the reverse direction only twice. He did not report the illusion when (a) arrows on the shafts were perpendicular to the shafts or closely approached perpendicularity, (b) shafts were 6 times thicker than the arrows, or (c) after being tested with multiple exposures, conditions that also lessen or eliminate the illusion for human observers. These data suggest that parrot and human visual systems process the Müller-Lyer figure in analogous ways despite a 175 fold difference in the respective sizes of their brain volumes, and that parrots are viable candidates for further testing on visual illusions.

Acknowledgement: Research was supported by donors to The Alex Foundation

Perceptual Organization: Contours II

Author Presents: 10:00 - 11:45 am

F20 702 **Abstract withdrawn**

F21 703 **Classification images reveal differences between spatial and spatiotemporal contour interpolation**

Brian P. Keane[1] (keane@ucla.edu), Philip J. Kellman[1], Cassandra M. Elwell[1]; [1]University of California, Los Angeles

Contour interpolation, the process whereby object fragments (inducers) are connected based on the geometrical relation of their contours, is relatively well-explored for static displays, but not much is known about how interpolation spans gaps in space and time. Here, we investigate characteristics of spatiotemporal interpolation with a classification image paradigm. For each condition, one naïve and one non-naive observer each judged on 4000 trials whether a vertical illusory contour of a gray rectangle appeared concave or straight. In the static condition, both inducers appeared simultaneously and motionless. In the "spatiotemporal" condition, inducers moved at 3 deg/s, and appeared in alternation from frame to frame. In both conditions, interpolation regions were embedded in a new noise field every motion frame (30 hz) and inducers were always shown noise-free at high contrast. By averaging the noise fields for each stimulus-response category, a classification image (CI) was derived for each frame of each condition. The CI effectively revealed the degree to which noise regions influenced responses. CIs from both observers showed that regions along interpolation boundaries are employed in more frames and to a greater degree in the spatiotemporal condition. To test whether the result arose solely from the difference in speed, the non-naïve observer engaged in a third "spatial-moving" condition, wherein inducers appeared simultaneously and moved at 3 deg/s. The resulting CI showed that interpolation regions were employed more than the static condition, but significantly less than the spatiotemporal condition. These results, taken together, suggest that interpolation regions are employed to a greater degree in spatiotemporal interpolation and that motion may also contribute towards interpolation strength. Finally, if interpolation strength peaks at the frame on which interpolation regions are most influential, it also appears that spatiotemporal interpolation may be faster than the alternative forms of contour interpolation.

Acknowledgement: Supported by NEI EY13518 and NSF ROLE 0231826.

F22 704 **The effect of aging on contour integration**

Eugenie Roudaia[1] (roudaia@mcmaster.ca), Patrick J. Bennett[1,2], Allison B. Sekuler[1,2]; [1]Department of Psychology, Neuroscience, and Behaviour, McMaster University, [2]Centre for Vision Research, York University

Form perception requires the integration of local contour information (Hess et al, 2003). For example, Saarinen & Levi (2001) measured contrast thresholds for identifying the location of the gap in a C-shaped contour comprising Gabor patches. Observers required less contrast to perform the task for Gabors oriented tangentially to the contour than those oriented orthogonally or in mixed orientations, suggesting that young observers integrate information across local orientation elements. Despite our vast knowledge about the contour integration process in young observers, we know virtually nothing about contour integration in older observers. Previous research (Govenlock et al., VSS 2006) showed that the basic mechanisms underlying orientation discrimination are intact in older age, but older observers are impaired at curvature discrimination (Legault et al., VSS 2006). Does this age-related deficit stem from an inability to integrate local orientation information across space? We compared performance of 8 older (~ 68 years) and 8 younger (~ 21 years) adults on a variant of Saarinen & Levi's task. Observers viewed C shapes comprising 16 Gabor patches, with the gap in the C facing one of four directions. The orientation of the Gabors varied across blocks: all tangential to the C, all orthogonal, or mixed; stimuli in those conditions were always presented in positive cosine phase. In a fourth condition, Gabors were oriented tangentially, but alternated positive and negative cosine phase. Two interleaved staircases manipulated Gabor contrast to estimate contrast thresholds for correct gap localization. As in Saarienen & Levi, younger observers required significantly less contrast to perceive the contour in the tangential condition than in other conditions. As a group, older observers' thresholds were higher than those of the younger group. However, older observers showed no advantage for tangentially oriented contours. These results support the idea that contour integration processes are impaired in older observers.

Acknowledgement: This research was supported by CIHR (ABS, ER, & PJB) and the Canada Research Chair programme (ABS & PJB).

F23 705 **Orientation tuning of contour integration**

Bruce C. Hansen[1] (bruce.hansen@mcgill.ca), Robert F. Hess[1]; [1]McGill Vision Research, Department of Ophthalmology, McGill University

There currently exists an extensive body of literature devoted to understanding how the visual system integrates spatially segmented elements into contours, either artificially generated, or modeled after the contour statistics of natural scene imagery. However, little is known about the orientation tuning of the integration mechanism and whether such tuning changes as a function of contour curvature. To address those issues, we employed stimuli consisting of texture fields made up of pseudo-randomly distributed band-pass filtered noise elements (band-pass in spatial frequency and orientation), some of which, by virtue of their orientation alignment, formed a contour path. The orientation bandwidth of all filtered noise elements was varied, and the local spatial orientation misalignment (element-to-path angle) between the local element orientation and the contour path itself was systematically manipulated. The task consisted of a standard psychophysical 2AFC paradigm where observers were required to indicate which stimulus interval contained a contour. The results indicated that the local element orientation bandwidth needed to integrate low curvature contours was quite broad (ranging between 40° to 60°). For contours possessing a high degree of curvature, this bandwidth was significantly narrower (ranging between 20° to 30). However, the element-to-path angle varied very little as a function of contour curvature, ranging between 15° to 25° for all curvatures. The results indicate that the local element orientation tuning of the human visual contour integration mechanism is dependent on contour curvature.

Acknowledgement: Acknowledgement: Canadian Institutes of Health Research (CIHR) grant: MT 108-18 to RFH

F24 706 **Element grouping with semicircular contours.**

Melanie L. Hamel[1] (melanie@rice.edu), James L. Dannemiller[1]; [1]Rice University

Human perception appears to incorporate the statistics of natural contours as they appear in images (Geisler et al., 2001). Neighboring line segments are constrained in direction, distance and orientation if they are part of the same contour. Last year we showed that observers primarily used segments near the axis of symmetry in discriminating a parabolic contour from a stimulus in which the line segments were individually rotated by 90 degrees forming a radially oriented pattern with the same distance and direction but differing orientation statistics. We have now conducted additional experiments a) controlling for factors that could have caused reduced orientation discriminability for more eccentric segments and b) using a circular contour with equal curvature at all points. The patterns were composed of 13 oriented segments, 0.17 deg in length with a center-to-center distance of 0.42 deg. On each trial uniformly distributed random orientation noise in a range of ± 90 deg was added to the stimulus, and the pattern was presented randomly within a range of distances around fixation at one of four possible orientations. Observers classified the pattern presented on each trial as a variant of the semicircular contour or its radial counterpart. After 5120 trials for each participant, logistic regression of the observers' responses on the orientation noise added to each segment of the pattern continued to show higher weightings near the axis of symmetry. Based on the data in Geisler et al. (2001), we computed the likelihood of neighboring segments on each trial belonging to the same physical contour. These likelihoods predict the responses for observers, although there

Monday Posters

are large individual differences. The higher weighting of segments near the axis of symmetry could reflect flanking facilitation from more eccentric segments on the grouping of center segments or possible attentional effects.

F25 707 Competition between real and illusory contours in early visual cortex revealed by a novel illusory contour stimulus (pure IC)

Barbara Dillenburger[1] (barbara.dillenburger@vanderbilt.edu), Peter Kaskan[1], Haidong D. Lu[1], Anna W. Roe[1]; [1]Psychology Dept., Vanderbilt University, Nashville, TN

Visual scenes contain local (real) and global (illusory) contour cues which may signal conflicting and competing orientation signals. We previously suggested that these potential conflicts may be resolved by a competitive interaction between real and illusory contour processing in early visual cortex. By using subthreshold RCs superimposed on ICs, we demonstrated clear interference of IC perception by subthreshold RCs, thereby supporting a previous study suggesting suppression of RC signals in V1 by V2 feedback (Ramsden 2001). We now examine this hypothesis further using a novel IC stimulus.

We measured single-unit neural responses in anaesthetized macaque V1 and V2 to moving RCs embedded in four different contexts: RCalone, pureIC (Gu et al VSS 2006), KanizsaIC, and rotated pacmen (KanizsaControl). To examine orientation dependence, low contrast RCs were embedded parallel (superimposed upon) and orthogonal (abutting) to the IC. IC inducing cues were 2*RFwidths away from the RF.

We found opposite effects of pureIC and KanizsaIC contexts on RC response in V2. Whereas the pureIC context had a suppressive effect on parallel RC-responses in V2, the KanizsaIC resulted in facilitation of these V2 responses. Effects on parallel vs orthogonally oriented RCs also differed. Parallel RCs were suppressed (enhanced) by pureIC (KanizsaIC) contexts and enhanced (suppressed) by KanizsaIC (pureIC) contexts. In V1, effects were insignificant or reduced relative to V2 effects. Responses to the KanizsaControl were reduced or unchanged in V1 and V2.

Our results underscore a strong difference between illusory contour effects induced by pureICs vs KanizsaICs. We suggest that high contrast and collinearity cues present in Kanizsa figures confound the illusory contour contribution and result in misinterpretation of RC-IC interactions. In contrast to Dresp & Bonnet, our results are not consistent with IC-RC-summation. Importantly, our findings support roles for suppressive influences between parallel ICs and RCs, consistent with a competitive interaction.

Acknowledgement: Supported by EY11744, Vanderbilt Vision Research Center, Center for Integrative and Cognitive Neuroscience.

F26 708 Shape and meaning in the perception of occlusion

Barbara Gillam[1] (b.gillam@unsw.edu.au); [1]School of Psychology University of New South Wales

Perceived occlusion is here taken to be indicated by an illusory contour at an alignment. Most research on occlusion and shape has concerned the nature of amodal completion behind an occluder (are completions local, global or fuzzy?) Our question is not how or if shapes are completed but how shape determines whether an occluder is seen at all. In the first set of experiments there were different sets of 5 black identical shapes aligned at one edge. Width of the configuration at the aligned edge and the support ration were constant. Method. Subjective contour strength was measured by the method of paired comparison allowing a z score scale of contour strength to be calculated from choice probabilities. Results. Subjective contour strength was much greater for quadrilateral shapes which if continued beyond the edge could be symmetric than for those whose explicit visible shape was symmetric. It was much greater for shapes that could be rectangles if continued beyond the edge than for those explicitly rectangular. It was also found that a set of 5 half circles produced a significantly weaker subjective contour than either quarter or three quarter circles with the same support ratio. Implications for extant theories of occlusion perception will be discussed. In a second set of experiments we explored the role of familiarity and meaning on the strength of subjective contours along truncated letters using only those where truncation did not violate closure. Using paired comparisons we showed that truncation produced a strong subjective contour not only for truncated letters forming a phrase but also for reversed/jumbled letters and carefully controlled non-letters. The critical factor was found to be the presence of a junction of some kind in the centre (as for most letters) which truncation moved to a lower position. Thus letter recognition was not implicated.

Acknowledgement: ARC grant DP0211698

F27 709 The Influence of Stored Representations in Working Memory on Amodal Completion

Hyunkyu Lee[1] (hyunkyu-lee@uiowa.edu), Shaun P. Vecera[1]; [1]The University of Iowa

A recent study showed that amodal completion, which is typically viewed as bottom-up process, can be influenced by high-level visual processes such as visual short-term memory (VSTM; Lee & Vecera, 2005). In the present study, we investigated whether the VSTM influence on amodal completion is caused by a general working memory load or by a memory of the to-be-completed object in VSTM. We used squared c-shaped objects that could be completed as two rectangles when an occluder was present. Experiments 1, 2 and 3 replicated the previous findings of an object-based attentional benefit based on a unitary object, on a completed object and on a completed image with preview display. In Experiment 4, participants remembered one of the c-shaped objects for a later memory-probe task. The results showed that when the remembered object was cued, there was an object-based benefit based on the object's remembered shape, not the completed shapes. However when the other, unremembered object was cued, there was an object-based benefit based on completed image. These results suggest that both VSTM and bottom-up images cues influence amodal completion on a trial-by-trial basis.

Acknowledgement: This research was supported by grant from the National Science Foundation (BCS 03-39171)

F28 710 Spatiotemporal interpolation behind moving occluder

Hideyuki Unuma[1] (hide.unuma@kgwu.ac.jp), Hisa Hasegawa[2], Philip Kellman[3]; [1]Kawamura Gakuen Women's University, [2]Aoyama Gakuin University, [3]University of California, Los Angeles

Numerous studies indicate that the visual system ultimately represents partly occluded objects as completed forms, and that interpolated contours and surfaces play a great role in these situations. We explore how visual interpolation process depends on spatial and temporal stimulus attribute: movement of occluder. In order to overcome spatially and temporally fragmentary inputs, we hypothesized that visual interpolation process could encode the briefly-viewed fragments in a buffer and integrate them with later-appearing fragments. Kellaman, Guttman and Wickens (2001) called this "the persistence hypothesis".

We examined the temporal limits of visual persistence with shape discrimination task used in previous studies (Unuma, Hasegawa, & Kellman, 2006; Ringach & Shapley, 1996). Specifically, we conjectured that if fragmentary elements are integrated and produce a shape, the performance of shape discrimination task should be better than those with fragmental elements. Illusory-contour squares and large occluder with small window were presented to observers. The occluder rotated on the illusory square and the speed of rotary motion was manipulated. The method of constant stimuli was used. The psychometric functions for the discrimination of the shape was measured as a function of presentation cycle of inducing figures.

Monday Posters

Results showed that with increasing presentation cycle, percentage of correct response increased. These results support the notion that visual edges can be encoded in a temporally limited buffer, and that interpolation process can integrate spatially and temporally fragmentary elements behind moving occluder.

URL: http://www.kgwu.ac.jp/sinri/unuma/index.htm

F29 711 Memory for holes: Intrinsic vs. accidental shapes

Rolf Nelson[1] (rnelson@wheatonma.edu), Jessica Thierman[2], Stephen Palmer[2]; [1]Wheaton College, [2]University of California, Berkeley

The case of holes presents a unique problem for shape perception and figure-ground organization. Normally in bipartite figure-ground displays, the figural side is remembered while the ground is not, even though they share the same contour. When a surrounded region is perceived as a hole through another surface, however, the shape of the hole itself is remembered. This presents a case in which two factors which are normally coupled in figure-ground perception -- depth assignment and contour ownership -- become decoupled. In the present experiments, a distinction is made between holes which are an intrinsic part of the surface to which they belong and holes which only arise from an accidental relationship to their bounding surfaces. In the first experiment, it is demonstrated that memory for intrinsic holes is superior to that for both accidental holes and accidental objects, whose boundaries and shape change according to viewing perspective. A second control experiment revealed a confound in the structure of these stimuli, however, indicating that larger shapes are remembered better than their constituent parts. A third experiment using stereo viewing with shutter glasses and a different set of stimuli without this problem, however, validated the original conclusion that intrinsic holes are remembered, whereas accidental holes are not. It is concluded that certain types of holes in surfaces are perceived as having shape (in the way that figures have shape), whereas others are not.

F30 712 Inverse Zoellner illusiondue to implicit orientations

Pietronilla Penna[1] (maria.pietronilla@unica.it), Baingio Pinna[2]; [1]University of Sassari, Dept. of Sciences of Languages, Italy, [2]University of Cagliari, Dept. of Psychology, Italy

Two types of orientation cues can instill "polarity" to a basic square element made up of two contiguous white and two black edges on a grey background. (i) Cues of explicitly oriented forms (explicit orientation), i.e. the orientation of the checks themselves. (ii) Cues rendered solely by the internal organization of luminance – such as the diagonal organization of the light and dark sides in the square element (implicit orientation), i.e. the orientation of the invisible base of the vertex. Under these conditions, the dominant orientation is along its internal diagonals of asymmetry. The role of implicit polarity is basic to elicit apparent motion (Pinna, 1990; see also Pinna & Brelstaff, 2000; Gurnsey et al., 2002; Morgan 2002), providing the directional cues for biasing the motion vectors that affect the perceived motion direction. Given parallel columns made up of square elements with opposite implicit orientations but with the same width, length, and orientation, because of the reversal of the vertex orientation, the implicit diagonals at the base of the vertices along each column have opposite inclinations. Under these conditions, the parallel columns of checks appear to be tilted in the same direction as the intersecting oblique implicit orientations. This result is opposite to what happens in the Zoellner illusion, where parallel lines are perceived as being tilted in a direction perpendicular to the intersecting oblique segments. The roles of explicit and implicit orientations were studied through psychophysical experiments. The results suggest the opposite role played by implicit and explicit orientations in affecting the direction of the tilt. The most invoked explanation of the Zoellner illusion, based on the principle of perceptual enlargement of acute angles of intersection between the oblique segments and parallel lines, cannot be applied in our conditions. A unitary explanation for both illusions is suggested.

Acknowledgement: Fondazione Banco di Sardegna, Alexander von Humboldt Foundation, PRIN ex 40% Cofin. es. 2005 (prot. 2005112805_002) and Fondo d'Ateneo (ex 60%).

F31 713 Comparisons of features within and between objects

Sarah Hawley[1] (shawley@ruccs.rutgers.edu), Jacob Feldman[1]; [1]Center for Cognitive Science, Department of Psychology, Rutgers University

The integration of spatially separated elements into coherent objects is a process that the visual system performs continuously in order to make sense of the world around us. Yet notwithstanding an enormous literature on perceptual grouping, we still lack a clear understanding of the specific representational consequences of grouping disparate visual locations. Our experiment investigated this issue using a stimulus that could induce amodal completion of four elements into two objects behind a central occluding disk. The strength of the amodal completion percept was manipulated by varying the support ratio of the objects. The stimulus was backward-masked at a variable SOA, allowing us to examine changes in the perceptual organization of the visual elements over time. The four elements were curved solid bars, terminating distal to the central occluder in several possible end-shapes, and subjects were asked to indicate the other end matching the one at a pre-cued location (3 alternative forced choice). We compared performance when the matching element belonged to the same apparent object (within-object condition) to when the matching element was at the equidistant location on the other object (between-objects condition). Intriguingly, we generally found superior performance for between-object matches. In a second study where the same stimulus configuration was rotated 45° so that feature comparisons crossed the central vertical or horizontal axes (thus amounting to a symmetry detection task) the effect sometimes reversed, but less consistently. We discuss possible reasons for the differences between the two conditions, the time course of the observed effects, and their significance with respect to object perception. We also relate our findings to the more prevalent finding in the literature of superior performance for within-object comparisons. In conclusion, we suggest that formation of a visual object tends to suppress representation of distinct features at disparate locations within the object.

F32 714 Perceptual decisions under risk in a motion-extrapolation paradigm

Shalin Shah[1] (shalins@eden.rutgers.edu), Manish Singh[1]; [1]Department of Psychology and Center for Cognitive Science, Rutgers - New Brunswick

Classical work on decision-making has demonstrated systematic deviations from normative behavior. Recent experiments on movement planning, however, have shown that subjects can be indistinguishable from optimality in their visuo-motor decisions (e.g., Trommershaeuser et al., Spatial Vision 2003). Unlike the classical case, the uncertainty in the visuomotor case is internal to the subjects; it arises from their motor variability—variability in executing a motor action.

We asked whether observers can also combine the instrinsic variability in their perceptual representation with externally-specified reward-and-penalty structure to make optimal decisions. We extended a paradigm used to study the visual extrapolation of static contour geometry (Singh & Fulvio, PNAS 2005), to examine observers' decisions under risk in extrapolating curved motion trajectories.

Methods: Observers viewed a dot moving along a parabolic trajectory disappear behind the straight-edge of a half-disk occluder. Their task was to "catch" the dot from the opposite curved side, by adjusting the angular position of an arc or "mit" (length = 20½). In the risky conditions, a double-mit was used, comprising a green reward region and a red penalty region, with partial overlap. Observers' gains/losses were determined by the part of the double-mit that "caught" the dot. Variables manipulated were: trajectory curvature (0.1185, 0,237 deg-1), penalty value (-200, -500), and mit overlap (-0.5, -0.25, +0.25, +0.5).

Results: Observers' performance in the baseline condition was used to estimate individual bias and variability. Based on these, predictions of optimal shift and optimal score were computed, using maximization of expected gain. We found that observed shifts were well predicted by optimal shifts. Moreover, observer efficiency (observed/optimal score) was high (80% - 114%). The results indicate that observers are implicitly aware of the instrinsic variability in their perceptual representation, and can combine it with externally-specified reward-and-penalty structure to make near-optimal decisions.

Acknowledgement: NSF BCS-0216944

F33 715 Bayesian Contour Detection

Jacob Feldman[1] (jacob@ruccs.rutgers.edu); [1]Dept. of Psychology, Center for Cognitive Science, Rutgers University - New Brunswick

The detection of a curvilinear contour embedded in a field of random oriented visual elements---that is, the discovery of a set of elements that form a relatively coherent smooth group---has been extensively studied, but computational models of the process are still lacking. In a series of studies, subjects were asked to detect (two-interval forced choice) a curvilinear group of oriented elements (short line segments) that had been intermixed with a background set of 150 elements of random position and orientation. Unlike most similar studies, background elements were drawn freely from a uniform density over the display area. Inter-element distances along the contour were chosen to exactly match the distribution of inter-neighbor distances in the Delaunay triangulation of the background set, so that only orientation cues could be used to identify the virtual contour. A Bayesian model for detection of a contour in this situation was developed, based on a "subjective" prior that assigns probability to successive turning angles along the contour via a normal density centered on collinear. The key idea in the model is that detectability of a contour should depend on the likelihood ratio (Bayes factor) between the hypothesis that the elements in question were generated by a contour process and the "null hypothesis" that they were generated at random as part of the background set. This likelihood ratio (i) increases linearly with the number of elements in the contour, and (ii) decreases with the aggregated turning angle along the contour. Subjects' performance closely followed these predictions, with the detectability of each target contour depending on its Bayes factor. These results provide a very natural and detailed quantitative account of contour detection processes, and suggest that the visual system is very close to optimal in detecting non-random patterns in the environment.

Acknowledgement: Supported by NIH R01 EY15888.

Face Perception: Neural Mechanisms

Author Presents: 10:00 - 11:45 am

F34 716 Methodological issues in using spatial filters in ERP studies of face processing

Anastasia Flevaris[1,2] (ani@berkeley.edu), Lynn Robertson[1,2], Shlomo Bentin[3]; [1]Department of Psychology, University of California, Berkeley, [2]VA Northern California Health Care Systems, Martinez, CA, [3]Department of Psychology and the Center of Neural Computation, Hebrew University of Jerusalem, Jerusalem, Israel

Research exploring the influence of spatial filtering on the face-sensitive N170 ERP has yielded mixed results. Goffaux and colleagues (2003) found that the N170-effect (increased amplitude elicited by faces compared to non-face objects) was absent when low spatial frequencies were filtered out of the stimuli. Using MEG, however, Hsiao et al. (2005) found the opposite result: a decrease in the M170 when mid and high spatial frequencies were removed from the stimuli. One difference between these two studies is that the stimuli used by Goffaux et al. were hybrids of low- or high-pass filtered foreground images with conversely filtered background textures, whereas Hsiao et al. did not use such hybrids. Hybrid stimuli have the advantage of equating spectral content across all conditions. However, the addition of a reciprocally filtered texture may add noise that is not equal across filtering conditions. We compared the N170 effects elicited by hybrid vs. non-hybrid stimuli, and found asymmetrical influences of the background texture. Participants viewed face stimuli and non-face objects that were either high-pass (>5 cycles/degree) or low-pass (<0.9 cycles/degree) filtered, and performed an unrelated detection task. Half of the blocks contained hybrid stimuli and half of the blocks contained non-hybrid stimuli. Adding a high spatial frequency background to a low spatial frequency stimulus did not have much influence. In contrast, adding a low spatial frequency background to a high spatial frequency stimulus diminished the N170 component. For non-hybrid faces, the N170 was greater for high than low spatial frequency stimuli. This effect was diminished in hybrid stimuli, presumably due to the asymmetrical effect of the background textures. Thus, when designing such studies, it is important to consider not only the benefit of equating spectral content across conditions but the cost of introducing a new source of noise in the background texture.

F35 717 High Band Pass Filters of Face Images and their Effect on the N170 Event Related Potential

Lucy J. Troup[1] (Lucy.Troup@colostate.edu), Michael A. Pitts[1], Bruce Draper[2], Erin K. Catellier[1]; [1]Department of Psychology, College of Natural Sciences, Colorado State University, [2]Department of Computer Science, College of Natural Sciences, Colorado State University

An event related potential (ERP) study was conducted to evaluate the effects of Gabor filtered face images on the N170 Event Related Potential (ERP) component. Gabor filtered images are of interest for two reasons. First, Gabor filtering has proven to be an effective first step in several face recognition algorithms developed by the computer vision community; it is therefore interesting to see how the human vision system responds to Gabor-filtered images. Second, previous research has indicated that face images filtered with low band pass filters are preferred to face images filtered with high pass filters. We were interested in the effect these filtered images had on the well define N170 component that is associated with face recognition with "normal" face stimuli in humans. Comparisons were made to achromatic "normal" photographs of faces, in a rapid presentation task. ERP's were recorded using a high density net in a passive viewing task. Participants viewed random presentations of either "normal" faces or Gabor filtered faces. Our results showed that for the "Gabor face" condition N170 was delayed in latency, and was reduced in amplitude, this difference was statistically significant. This is contrary to previous research indicating that low band pass filters in face recognition yield better speed and accuracy performance compared to high bands pass filters.

Acknowledgement: National Science Foundation Grant, The National Defense Agency, & Colorado State University - Research Experience for Undergraduates In Mind Brain and Behavior.

F36 718 Are inverted faces processed at a later stage?

Tom Busey[1] (busey@indiana.edu), Bethany Schneider[1], Dean Wyatte[1], Jordan DeLong[1], Alex Burkhardt[1], Bosco Tjan[2]; [1]Psychological and Brain Sciences, Indiana University, Bloomington, [2]Department of Psychology, University of Southern California, Los Angeles

Previous work by Tjan, Lestou, and Kourtzi (2006) suggests that the relation between brain activity of a cortical area and stimulus signal-to-noise ratio is a signature of the degree of feature invariance and feature complexity processed by the cortical area. In a cascade of decision stages, activity associated with later stages will produce a steeper response function for a given range of signal-to-noise ratios. We extend this work into the electrophysiological domain by recording EEG responses to upright and inverted faces presented in various levels of amplitude-matched noise. We plot the activity of N170 component against the signal-to-noise ratio for upright and inverted faces and find that the slope of the function corresponding to inverted faces is steeper than that of upright faces. This suggests that the N170 that corresponds to inverted faces represents activity in later processing stages. This is consistent with a model in which upright faces are processed by an earlier stage, perhaps corresponding to configural or holistic processing, which may explain why inverted faces have a larger and later N170 than upright faces. We explore earlier time points and additional channels to characterize the development of this set of relations.

Tjan, B. S., Lestou, V., and Kourtzi Z (2006). Uncertainty and invariance in the human visual cortex.. Journal of Neurophysiology. 96, 1556-1568.

F37 719 The time course of the face inversion effect

Corentin Jacques[1] (corentin.jacques@psp.ucl.ac.be), Bruno Rossion[1]; [1]Université Catholique de Louvain

Human faces look more similar to each other when they are presented upside-down, leading to an increase of error rate and response time during individual face discrimination tasks. This inversion effect is one of the most robust finding in the face processing literature. Recent neuroimaging studies using adaptation to face identity have shown that the 'fusiform face area' was the primary neural source of the behavioral face inversion effect (FIE). However, the time course of the FIE – i.e. when inversion affects the coding of facial identity in the human brain - remains unclear. Here we addressed this question by recording event-related potentials (ERPs) on the scalp during an adaptation paradigm with upright and inverted faces. Subjects were presented with a first (adapting) face stimulus for about 3000 ms, followed by a second face of either the same identity or a different identity. The ERP response to the second face stimulus was markedly reduced over occipito-temporal electrode sites when it was identical to the adapting face, starting at about 160 ms. When the exact same stimuli were presented upside-down, the reduction of signal was smaller, and took place about 30 ms later, in line with the behavioral effect of inversion. This result shows that the effect of face inversion on individual face discrimination takes place during early face perceptual processes in the occipito-temporal cortex. It also strongly suggests that individual face configuration is extracted as early as 160 ms following stimulus onset.

Acknowledgement: Authors are supported by the Belgian National Foundation for Scientific Research (FNRS)

F38 720 Face discrimination performance is not reflected in the N170

Jesse Husk[1] (huskjs@mcmaster.ca), Melissa Sergi[2], Tania Gora[1], Guillaume Rousselet[3], Patrick Bennett[1,4], Allison Sekuler[1,4]; [1]Dept. of Psychology, Neuroscience, & Behaviour, McMaster University, Canada, [2]School of Medicine, Queens University, Canada, [3]Dept. of Psychology, University of Glasgow, Scotland UK, [4]Centre for Vision Research, York University, Canada

The N170 is a negative-going visually evoked potential that is particularly robust for faces. However, it is unclear whether this component reflects the detection of a face or the discrimination of individual faces. Most studies that directly compared N170s across individual faces have failed to find differences (e.g., Bentin & Deouell, 2000; Eimer, 2000), yet one recent study reported a larger N170 for morphed faces perceived as distinct from one another (Jacques & Rossion, 2006). Furthermore, although eyes seem particularly important for identity discrimination (e.g., Gold et al., 1999, 2004; Gosselin & Schyns 2001; Sekuler et al., 2004), studies examining the importance of the eye-region in driving the N170 have yielded conflicting results (e.g., Bentin et al., 1996; Eimer et al., 1998; Schyns et al., 2003; Itier et al., 2006).

The current study examined whether the N170 is linked to performance in a 2-face discrimination task. Across conditions, faces were degraded to include different regions of the face, while equating the total information available for discrimination. Faces containing the most informative pixels consisted of pixels primarily from the eye region; faces containing moderately- and least-informative pixels contained pixels distributed widely throughout the face, but not near the eyes. Consistent with earlier behavioural results (Gaspar et al., VSS 2003), discrimination accuracy was lowest in the least-informative pixel condition, even though stimuli in that condition had the greatest resemblance to normal faces. However, the N170 for full faces most closely resembled that for the least-informative pixel condition. Thus, our results show a clear dissociation between the N170 and discrimination performance.

Acknowledgement: This research was supported by NSERC operating grants 105494 & 42133 and the Canada Research Chairs Programme (ABS & PJB), a CIHR Fellowship (GAR), and an NSERC PGS-D Fellowship (JSH).
URL: http://www.science.mcmaster.ca/psychology/husk/index.html

F39 721 Neural correlates of visual discrimination expertise: Chinese face versus Chinese character processing

Joseph McCleery[1] (jmccleery@psy.ucsd.edu), Liezhong Ge[2], Zhe Wang[2], Jie Tian[3], Leslie Carver[1], Kang Lee[4]; [1]University of California, San Diego, [2]Zhejiang Sci-Tech University, [3]Chinese Academy of Sciences, [4]University of Toronto

The N170 event-related potential (ERP) component has several face-specific response properties, including larger amplitude and shorter latency responses to faces than to non-faces and larger amplitude responses to inverted faces than to upright faces. Recent evidence suggests that several of these response properties are also modulated by degree of visual discrimination expertise. Simultaneously, visual discrimination expertise has been shown to be associated with increased sensitivity to configural information, which is believed to be a critical component of face processing. However, little is known about the direct relationships of visual discrimination expertise, configural processing, and the face-specific response properties of the N170. Therefore, the focus of the present study was to compare and contrast N170 responses associated with long-term high-level visual discrimination expertise that involves both featural and configural sensitivity (face processing) with long-term high-level visual discrimination expertise that involves primarily featural sensitivity (Chinese character processing). High-density event-related potentials were recorded while Chinese adults discriminated upright and inverted Chinese faces and Chinese characters in a within-subjects design. Statistical analyses revealed that upright faces and characters elicited similar amplitude N170 responses, but that faces elicited shorter latency N170 responses than characters. Additionally, faces and characters elicited differential inversion effects whereby inverted faces elicited larger amplitude responses than upright faces but inverted characters elicited smaller amplitude responses than upright characters. These results suggest that N170 amplitude effects may be associated with visual discrimination expertise more generally, but that N170 latency and inversion effects may be specifically associated with configural processing.

Acknowledgement: This research was supported by National Institute of Health and Human Development Grant R01 HD046526 to K. Lee. J.P. McCleery was supported by an Integrative Graduate Education and Research Training traineeship from the National Science Foundation (Grant DGE-0333451 to G.W. Cottrell).

F40 722 Critical spatial frequencies in the perception of letters, faces, and novel stimuli.

Ipek Oruc[1,2,3] (ipek@psych.ubc.ca), Jason Barton[1,2,3]; [1]Department of Ophthalmology and Visual Sciences, University of British Columbia, [2]Division of Neurology, University of British Columbia, [3]Department of Psychology, University of British Columbia

Critical-band masking paradigm is a method that reveals the band of spatial frequencies used by human observers to identify a stimulus. Previous studies of letter recognition have shown that a) the critical band of frequencies is relatively narrow and b) the peak frequency in object frequency units changes with letter size, indicating scale-dependence and suggesting the existence of channels specialized for processing letters of various sizes (Majaj, Pelli, Kurshan, & Palomares, 2002; Oruc & Landy 2006). In this study, we investigated whether similar results are found for other types of visual stimuli. We characterized stimuli along two main dimensions: evolutionary relevance and amount of training. Letters are arbitrary shapes from an evolutionary perspective, but for which most observers are highly trained. Faces are not only well trained but may have long-standing evolutionary relevance in the human visual system. As arbitrary and untrained stimuli we used, first, a set of novel shapes, and second, mirror-image letters. We found, first, that all four types of patterns are recognized using a narrow band of frequencies, despite the fact that these are all broadband stimuli. Second, the critical frequency band shifted with changes in stimulus size in a similar manner for letters, reversed letters, and novel shapes. Faces on the other hand differed, in that there was a greater degree of scale invariance for larger stimuli. These results show that the critical frequencies found for letter processing are not unique to these linguistic symbols; face processing, however, may differ from other stimuli.

Acknowledgement: supported by CIHR grant MOP-77615 (JB)

F41 723 Face Perception: Importance of Phase Alignments

Reza Farivar[2] (reza.farivar@mail.mcgill.ca), Bruce Hansen[1], Robert Hess[1]; [1]McGill Vision Research, McGill University, Montreal, Canada, [2]Psychology, McGill University, Montreal, Canada

Complex patterns, such as faces, can be described by the combination of their Fourier frequency and phase components. Whereas the role of frequency information has received the majority of research attention, the importance of phase information in face perception has been largely neglected. In the experiments reported here, we sought to investigate the role of phase information on face perception using a discrimination task on arrays of face morphs. In the first experiment, we varied the amount of aligned Fourier phase in different regions of the face frequency spectrum in order to determine whether the information in some regions was more important than others and whether the properties of the underlying neural processes are best understood in terms of frequency bandwidth or number of phase-alignments. In the second experiment, linear filtering was implemented to estimate the information content in different face frequency bands and to determine whether it is the number of phase-alignments or the signal-to-noise ratio of phase-alignments that matter. In the third experiment, we varied the distribution of phase-aligned frequencies to ascertain whether it is the number of contiguous phase-aligned frequencies or the global signal-to-noise ratio that matters. We conclude that there are underlying processes that depend on a certain signal-to-noise ratio of phase-alignments within a contiguous range of face frequencies (we termed these critical band of phase alignments) which operate with equal efficiency throughout the face frequency spectrum.

Acknowledgement: Canadian Institutes of Health Research (CIHR) grant: MT 108-18 to RFH, and an FRSQ Doctoral Fellowship to RF.

F42 724 Identifying faces in two-tone ('Mooney') images: A psychophysical and fMRI study.

Jay Hegdé[1] (hegde@umn.edu), Serena Thompson[1], Daniel Kersten[1]; [1]Department of Psychology, University of Minnesota, Minneapolis

Two-tone images, such as the Dalmatian Dog image by R. C. James, have edges whose source can be highly ambiguous. It is known that prior object knowledge can disambiguate these edges, and be critical to detecting an object in two-tone images. But can prior knowledge also influence how well the visual system can identify visual objects in these images?

Using a one-back task, we measured the ability of human subjects to identify faces in the same set of two-tone images before and after viewing a different set of full-color images of the same faces. Each image consisted of an unfamiliar face rendered against an outdoor background. The face identity, background, viewpoint and direction of illumination varied systematically across the images. No image was presented twice in two-tone and/or full-color form, so that the subjects had to generalize across the images in order to perform the task.

Prior to viewing the full-color images, the subjects were unable to reliably identify the faces in the two-tone images (mean correct one-back response, 5%). After viewing the full-color images, the subjects performed significantly better using the same set of two-tone images as before (71% correct; $p << 0.05$, binomial proportions test). When the faces in the full-color images were different from those in the two-tone images, the performance showed little change before vs. after viewing the full-color images (7% vs. 9% correct; $p > 0.05$). Thus, the improvement in the identification performance was attributable to gaining familiarity with specific faces.

Several brain regions near the superior temporal sulcus and in the frontal cortex showed significantly larger BOLD responses to two-tone images after viewing the corresponding full-color faces than before the viewing. No increased response was evident anywhere in the visual cortex using the same contrast upon viewing irrelevant full-color faces.

Acknowledgement: This work was supported by ONR grant N00014-05-1-0124 and NEI grant R01 EY015261 to DK and NIH grant T32 HD00715 to SKT. The 3T scanner at the University of Minnesota Center for Magnetic Resonance Research is supported by BTRR P41 008079 and by the MIND Institute. Office facilities were provided by the Center for Cognitive Sciences at the University of Minnesota.

F43 725 Investigation of featural versus configural processing of faces in the middle fusiform gyrus

Valerie Goffaux[1,2] (valerie.goffaux@psychology.unimaas.nl), Bettina Sorger[1], Christine Schiltz[2], Rainer Goebel[1], Bruno Rossion[2]; [1]Department of Neurocognition, University of Maastricht, The Netherlands, [2]Department of Cognitive Development, University of Louvain, Belgium.

Inverting a face affects the processing of the vertical relations between features (e.g. eye height) more than the processing of horizontal relations (e.g. interocular distance) and of local features (e.g. eye shape and surface) [1]. Inversion also decreases hemodynamic responses (HR) in face-sensitive regions in the middle fusiform gyrus (MFG), presumably because it reduces face distinctiveness and leads to larger adaptation [2]. Here we tested the hypothesis that inversion affects the perception of vertical metric distances between features in the MFG. In the present fMRI study, twelve subjects were presented with short blocks of upright and inverted pairs composed either of identical faces ('same' condition), or of faces that differed at the level of 'vertical' relations, 'horizontal' relations, the shape of all inner feature ('different'), or the shape of one single 'feature'. In rMFG, smaller HR were observed for 'same' as compared to 'different' condition when faces were presented upright; due to HR adaptation. 'Vertical', 'horizontal' and 'featural' conditions led to HR close to 'same' condition. Inversion decreased HR in all conditions except the 'same' condition, thus replicating previous findings [2]. The largest inversion-related decrements measured in rMFG were observed for vertical relations. In the left MFG, all conditions led to larger HR than the 'same' condition at upright. Inversion decreased HR in vertical and horizontal conditions only. These results suggest different roles of the MFG across hemispheres. rMFG may code ecological face differences, since release from adaptation was only observed for completely different faces in this region. Moreover, rMFG may be sensitive to face configuration as suggested by the generalised inversion-related HR decrease. In contrast, lMFG may code any kind of physical difference between faces irrespective of orientation, except for relational differences.

[1]Goffaux & Rossion, in press;[2] Mazard et al., 2006; [3] Yovel & Kanwisher, 2004.

F44 726 fMRI evidence for multiple face processing pathways in the human brain

Laurence Dricot[1] (laurence.dricot@nefy.ucl.ac.be), Christine Schiltz[1], Bettina Sorger[2], Rainer Goebel[2], Bruno Rossion[1,3]; [1]Department of Neurophysiology, University of Louvain, Belgium, [2]Department of Cognitive Neuroscience, Maastricht University, The Netherlands, [3]Department of Cognitive Development, University of Louvain, Belgium

Two regions in the occipito-temporal cortex respond more strongly to faces than to objects and are thought to be important for face perception: 'the fusiform face area' ('FFA') and the 'occipital face area' ('OFA'). Whether these areas responding preferentially to faces play a dominant or exclusive role in face processing or if sub-maximal responses in other areas of the ventral stream such as the lateral occipital complex (LOC) are also involved is currently debated. To clarify this issue, we tested a brain-dam-

Monday Posters

aged patient presenting a face-selective deficit, prosopagnosia, with functional magnetic resonance imaging (fMRI). Using fMRI-adaptation, we found a dissociation between the coding of identity in the structurally intact 'FFA', which was impaired for faces but preserved for objects. This observation complements recent fMRI findings that the 'FFA' reflects averaging of heterogeneous highly selective neural populations for faces and objects, by showing here that the responses of these populations can be functionally independent. Most importantly, a larger response to different faces than repeated faces was found in the ventral part of the LOC both for normals and the patient, next to the right hemisphere lesion. Following prosopagnosia, areas that do not respond preferentially to faces such as the ventral part of the LOC (vLOC) may still be recruited to subtend residual individual face discrimination. Overall, these observations indicate that faces are processed through a network of visual areas in the human brain, with a subset of these areas responding preferentially to faces being critical for efficient face recognition.

F45 727 Face-selective activation in the middle fusiform gyrus in a patient with acquired prosopagnosia: abnormal modulation for face identity

Jennifer Steeves[1] (steeves@yorku.ca), Herbert Goltz[1], Laurence Dricot[2], Bettina Sorger[3], Judith Peters[3], A. David Milner[4], Melvyn Goodale[5], Bruno Rossion[2,6]; [1]Centre for Vision Research, York University, Toronto, Canada, [2]Dept. of Neurophysiology, University of Louvain, Belgium, [3]Cognitive Neuroscience Dept., Faculty of Psychology, Maastricht University, The Netherlands, [4]Durham University, Durham, UK, [5]CIHR Group on Action and Perception, The University of Western Ontario, London, Canada, [6]Dept. of Cognitive Development, University of Louvain, Belgium

We recently reported bilateral face-preferential activation in the middle fusiform gyrus (mFG) and in the superior temporal sulcus (STS) of patient DF, who has severe acquired prosopagnosia and object agnosia but who is able to discriminate a face from an object (Steeves et al., 2006). Further, DF showed no face-preferential activation in the inferior occipital gyrus (IOG) in either hemisphere, which is near her lateral occipital lesions (LO). Identical face-preferential activation in the right mFG was also reported in the acquired prosopagnosic patient PS, who has lesions in the left mFG and right IOG (Rossion et al., 2003). However unlike neurologically-intact individuals, PS did not show release from adaptation to face identity in this area (Schiltz et al., 2006). Here, we tested DF for face identity-specific modulation using event-related fMR adaptation. In a passive design, DF viewed pairs of same and different faces and objects (1000 ms each, separated by 500 ms with 7500 ms ITI) and the task was to identify face-object trials. In an active 1-back matching design, DF viewed pairs of same and different faces. As before, DF showed face-preferential activation in both left and right mFG and STS. Contrary to healthy controls, in both designs the activation in these regions did not show the expected pattern of adaptation recovery with different face identities. Consistent with her behavioural performance, DF's cortical face networks do not appear to process face identity. Comparing patients PS and DF puts forth a solid case— they have different lesion patterns within the face-preferential cortical network but both have intact right mFG and a common lesion in the right IOG. In both cases, face-selectivity and face detection can operate with an intact right mFG but modulation for face identity within this region appears to be affected by the loss of the right IOG.

F46 728 Clarifying the nature of facial identity and facial expression representations with an acquired case of prosopagnosia

Roberto Caldara[1] (r.caldara@psy.gla.ac.uk), Daniel Fiset[2], Caroline Blais[3], Philippe Schyns[1], Christoph Scheepers[1], Eugene Mayer[4]; [1]Department of Psychology, University of Glasgow, UK, [2]Department of Psychology, University of Victoria, Canada, [3]Centre de Recherche en Neuropsychologie et Cognition, Département de psychologie, Université de Montréal, Canada, [4]Hopitaux Universitaires de Geneve, Geneva, Switzerland

The human face transmits a wealth of nonverbal signals that readily provide crucial information for social interactions. The brain, as a decoder, flexibly filters the information arriving at the sensory inputs to rapidly achieve complex perceptual categorizations, such as people identification and expression. Response classification techniques have revealed that the face system uses differential effective information to achieve face identification (Bubbles - Gosselin & Schyns, 2001) and expression (Smith et al., 2005). Yet, a fundamental question remains unresolved (Calder and Young, 2005): does facial information used for face identity and expression tap into a unique facial representation system, or does this processing occur in dedicated systems? To address this question we tested PS, a pure case of acquired prosopagnosia with lesions sparing the neural substrates dedicated to expression (STS, amygdala). In marked contrast to normal observers, PS does not use the eyes to identify faces but the mouth (Caldara et al., 2005), highlighting defective representations for identity. However, PS' expression categorization is extremely effective compared to face identification. Consequently, the PS case represents an exceptional opportunity to test whether the face system relies on a unique representation system or can instead flexibly adapt to face expression categorization by using dedicated representations. Patient PS and normal observers categorized neutral, happy and fearful faces by expressions while using Bubbles. Strikingly, patient PS consistently used only the mouth to categorize these expressions, even for fear in which the eyes are highly diagnostic for normal observers. Importantly, eye movement patterns showed that PS spontaneously attempted to extract information from the eye region, indicating a general, selective deficit impinging on the representations for the eye region. Critically, these results clearly demonstrate that a unique representation system is used to code face features, and support a single, flexible (in normal observers) coding system for face representations.

F47 729 Extraordinary face recognition

Richard Russell[1] (rrussell@fas.harvard.edu), Brad Duchaine[2], Ken Nakayama[1]; [1]Department of Psychology, Harvard University, [2]Institute of Cognitive Neuroscience, University College London

In recent years several laboratories have independently established the existence of individuals who are significantly worse than normal at recognizing faces, despite an absence of apparent neurological damage. However, it is not clear whether these "developmental prosopagnosics" have a pathological condition or simply represent the low end of a continuous distribution of face recognition abilities. Studying people with especially strong face recognition abilities may help to answer this question, as well as provide information regarding the natural range of abilities of this faculty. We are in contact with several individuals who self-identify as having face recognition that is significantly better than ordinary. These individuals describe their face recognition abilities in strong terms, for example "I have a photographic memory for faces. It has been my entire life, but it doesn't matter how many years pass, if I've seen your face before I will be able to recall it. It happens only with faces.", or "I often pick out the bit part actors, able to place them from brief roles in movies and television I have seen ten and fifteen years prior.", or "I often pretend not to recognize someone because it scares them if I say, 'Oh, I remember you, you were behind me in line at a supermarket in 1996 wearing a yellow soccer jersey!'" Preliminary investigations of one individual found unusually high performance on several tests of face recognition and face perception, as well as object recognition. We report results from several experiments with these individuals, including tests of recognition memory for familiar and unfamiliar faces, face perception (discrimination), facial expression recognition, and object recognition.

F48 730 Facial attraction: a study of the aesthetic dimension of face processing in prosopagnosia

Chris Waite[1,2] (asuna@interchange.ubc.ca), Rebecca Hefter[3], Itzhak Aharon[4], Chris Fox[1,2], Jason Barton[1,2]; [1]Department of Ophthalmology and Visual Sciences, University of British Columbia, [2]Division of Neurology, University of British Columbia, [3]Department of Psychology, University of Wisconsin, [4]Department of Psychology, Massachusetts Institute of Technology

Monday Posters

Background: Attractiveness is the perception of a facial property that has seldom been investigated in patient populations. On the one hand, it is a social signal, and thus may depend on processing in the superior temporal sulcus, but on the other it seems likely that attractiveness may depend on elements of facial structure that do not change with dynamic shifts in expression or gaze, and thus processed by the fusiform face area.

Objective: We investigated the status of facial attractiveness perception in prosopagnosia, an impairment in the recognition of another temporally invariant property of faces, their identity. We hypothesized that if attractiveness is processed by regions that encode the temporally invariant properties of faces, such as the fusiform face area, then these patients should be universally impaired on this function.

Method: We studied eight prosopagnosic subjects in two separate tasks: one testing their explicit rating of attractiveness and the other an attractiveness-motivated keypress behaviour.

Results: Both tasks showed that the prosopagnosics were impaired in processing facial attractiveness. Residual but impaired attractiveness perception was found only in subjects with unilateral right-sided occipitotemporal lesions or anterior temporal lesions. Measures of perception of facial attraction also correlated with measures of residual familiarity for famous faces.

Conclusion: The processing of facial attraction requires participation of the same neural structures that encode facial identity.

Acknowledgement: Supported by grants from the CIHR (MOP-77615), NIMH (R01 MH069898) and a Thomas A Dohm research award

F49 731 Transient pupil constrictions when viewing human and macaque faces.

Claire A Conway[1] (c.conway@abdn.ac.uk), Benedict C Jones[1], Anthony C Little[2], Lisa M DeBruine[1], Arash Sahraie[1]; [1]School of Psychology, University of Aberdeen, [2]School of Psychology, University of Stirling

While it is well established that there are rapid transient constrictions of the pupil in response to various low-level aspects of visual stimuli that are processed along the ventral and dorsal pathways (e.g. light flux, colour, gratings and motion), we know of no previous studies that have demonstrated rapid transient pupil constrictions to more complex visual stimuli. Since the neural mechanisms that underpin face perception occur further along the ventral pathway than those that underpin colour processing, one would expect the presence of a transient pupil constriction when viewing faces. The response latencies may also be expected to be similar or larger than those elicited by coloured targets, reflecting activity further along the visual pathways. Here we present evidence from three experiments of a transient pupil constriction elicited by the onset of face stimuli, with a typical latency of approximately 360ms. The response amplitudes are significantly smaller for scrambled or inverted face stimuli. This suggests that the pupil response is associated with configural processing that occurs to a greater extent when processing upright faces than when processing other types of visual stimuli. Furthermore, the effect of inversion on the transient pupil constriction was smaller when stimuli were macaque faces than when stimuli were human faces, suggesting that the pupil response is also influenced by familiarity with the category of face shown. These findings are consistent with the pupil response to faces being influenced by neural mechanisms along the ventral pathway that are important for face processing (e.g. the fusiform face area), and reveal a novel, objective and non-invasive method for studying face perception.

Eye Movements: Attention and Search

Author Presents: 8:00 - 9:45 am

F50 732 The Role of Bottom-Up and Top-Down Influences in Directing Primate Gaze Shifts

David Berg[1] (dberg@usc.edu), Susan Boehnke[2], Robert Marino[2], Pierre Baldi[3], Doug Munoz[2], Laurent Itti[4]; [1]Neuroscience Graduate Program, University of Southern California, [2]Centre for Neuroscience Studies and Department of Physiology, Queen's University, [3]Department of Computer Science, University of California, Irvine, [4]Departments of Computer Science, Psychology and Neuroscience Graduate Program, University of Southern California

We investigated differences in the propensity for human and monkey eye movements to be guided by bottom-up stimulus properties or cognitive factors. We recorded eye movements from 4 humans and 4 monkeys freely viewing 50 natural video clips (approximately 20,000 frames). To quantify species differences in attentional allocation we used a computational model of visual surprise (Itti, Baldi, 2005). We measured the amount of surprise at the endpoints of saccadic eye movements and compared it to the amount of surprise at randomly shuffled eye positions. We found that humans and monkeys are attracted to surprising locations significantly above chance (p<10-10) but with no significant species difference (p=0.5); however, interobserver agreement is significantly higher in humans than monkeys. When multiple monkeys simultaneously agreed on a common gaze target the location had significantly increased surprise (p=.0001), while humans showed slightly decreased surprise (p=0.6) for agreed gaze locations. This indicates that monkeys agree on gaze targets for bottom-up and humans for cognitive factors. This is further supported by the observation that those strong attractors of gaze corresponded to different locations for humans and monkeys. We found that over the course of a clip monkeys remain consistently surprise driven, while humans showed significant differences over time (p<10-10). We observed a similar trend in interobserver agreement. We conclude that humans and monkeys are in general equally driven by surprise, but humans tend to agree on locations containing scene specific semantic information while monkeys agree on locations containing visually surprising information. The time course of surprise and interobserver predictability for each species implies that top-down influences play a greater role in modulating the influence of bottom-up attention in humans than monkeys. This study indicates that monkeys serve as a good model for bottom-up attention in humans due to the limited effect of top-down influences.

Acknowledgement: National Science Foundation

F51 733 The impact of content-independent mechanisms on guiding attention

Po-He Tseng[1] (pohetsn@gmail.com), Ran Carmi[2], Ian G. M. Cameron[3], Doug Munoz[3], Laurent Itti[1,2]; [1]Department of Computer Science, University of Southern California, [2]Neuroscience Program, University of Southern California, [3]Centre for Neuroscience Studies and Department of Physiology, Queen's University

Several eye-tracking experiments have shown that human observers tend to look at the center of photographs and movies more than expected by chance. This so-called "center bias" in gaze distributions may be caused by centrally-biased content, such as objects of interest (top-down bias) and salient features (bottom-up bias), or by other content-independent factors, such as experimental setup. Here we quantify the relative contribution of these potential causes.

We shot videos of natural scenes that were either biased (camera following a main actor) or non-biased (camera panning at a fixed speed) in terms of top-down influences. These videos were further classified into bottom-up biased versus non-biased based on a computational model of bottom-up influences, resulting in four bias conditions. We then tracked the eyes of twelve young adults as they freely viewed the videos, and extracted their saccades (12132). The extent of center bias was quantified using a metric

Monday Posters

that measures the average distance of saccade targets from the center (0: saccade targets uniformly distributed over display; 100: all saccade targets at center).

We found highly significant center-bias remained in the eye-movement patterns in all the four conditions. (1) For both top-down and bottom-up center-bias condition, it scored 45.26±0.52 (mean±SE); (2) top-down and not bottom-up center-bias: 41.61±0.61; (3) bottom-up and not top-down center-bias: 38.26±0.64; (4) neither top-down nor bottom-up center-bias: 38.07±0.56.

Our data demonstrates for the first time that a bias exists which is due to neither cognitively interesting items nor bottom-up salient items being concentrated around the center. It also indicate that 84% of the maximal observed center-bias can be explained by factors that are content-independent, such as the methodological setup (chin rest, centralized gaze position of subjects when they look straight ahead), and a viewing strategy of looking at the center so as to minimize the amplitude of saccades.

F52 734 Attention and saccades during an active visual task

Brian Schnitzer[1] (schnitzb@rci.rutgers.edu), John Wilder[1], Timothy Gersch[1], Barbara Dosher[2], Eileen Kowler[1]; [1]Department of Psychology, Rutgers University, [2]Department of Cognitive Sciences, University of California at Irvine

Selective attention is crucial to natural vision, contributing both to the quality of perceptual experience and to the guidance of saccadic eye movements. A central question is how attention is distributed in real tasks, handling the requirements of both perception and saccades concurrently. We studied attention while counting, an active visual task that can be performed either with or without saccades. Subjects counted 10-19 randomly-distributed dots (16′ diam) in an 8 deg diam region while a probe stimulus (tilted Gabor patch, σ=.9 deg) was flashed (65 ms) at one of 4 locations during a randomly selected pause between saccades. During counting, identification of the orientation of even high-contrast Gabors was poor, regardless of whether counting was mediated by saccades or by shifts of attention during steady fixation. Errors in orientation identification were not due to failures to notice the Gabor, since detection and localization were accurate. Orientation identification was far better when comparable patterns of saccades were made without the concurrent counting task and without pre-defined saccadic targets. We also tested a pointing task in which the cognitive load was greater than that of simply looking, but less than that of counting. When subjects pointed to 7-15 randomly-distributed dots using a stylus on a graphics tablet, two showed a loss in Gabor orientation identification comparable to that during counting, two showed a modest loss, and one no loss at all. Taken together, these results show a strong attentional bottleneck at the level of perceptual identification. Active tasks, such as counting or pointing (but not necessarily the saccades themselves), place strict limits on what we can identify during any single fixation pause, but modest limits on the ability to detect, locate and move the eye to new or important objects.

Acknowledgement: NIH EY15522 NSF DGE0549115

F53 735 Optimal searcher, saccadic targeting model, and human eye movements during search: Effects of target visibility maps

Wade Schoonveld[1] (schoonveld@psych.ucsb.edu), Miguel Eckstein[1]; [1]University of California -- Santa Barbara

Many models of saccadic eye movements during search direct saccades toward the location that is most likely to contain the target (saccadic targeting models; Beutter et al., 2003; Torralba, 2003, JOSA-A). Alternatively, a recently proposed model of human eye movements during search, the optimal searcher uses knowledge of the differential detectability of the target across the retina (i.e., visibility map) to direct saccades to areas that maximize the probability of correctly localizing the target (Najemnik & Geisler, 2005, Nature). The optimal searcher occasionally executes “center-of-gravity” saccades between potential target locations. There has been little work comparing these models to human saccades across different target types. Here, we compare the ability of saccadic targeting and optimal search models to predict saccades during search for three different target types (a Gaussian blob and two Gabors, one with high and one with low contrast; spatial frequency=9.7 cycles/degree) that each had different associated visibility maps. Three observers each performed three search tasks localizing the high contrast target among four dimmer distractors within a 600 ms presentation time. The contrast of the target and distractors varied over time, every 25ms, by adding independent samples of random Gaussian contrast noise. Display elements were placed equidistant around the circumference of a circle with a radius of 5 degrees. The first two saccades were recorded from each trial and compared to the predictions made by the two models. “Center-of-gravity” saccades were predicted by the optimal search model for the Gaussian and high contrast Gabor, but are uncommon in the human data. The ideal saccadic targeting model accounts for human performance better than the optimal search model. For the low contrast Gabor, model predictions were essentially the same for both models with no “center-of–gravity” saccades and agreed with human behavior.

Acknowledgement: Grant Support: NSF 0135118

F54 736 Evidence for attention in the saccadic gap effect

Zhenlan Jin[1] (jin.z@neu.edu), Adam Reeves[1]; [1]Dept. of Psychology, Northeastern University

Removing the fixation spot some 200 ms before the onset of a target speeds saccades to the target (the 'gap effect' of Fisher,). Last year (Reeves & Jin, VSS 2006) we tested and rejected six (oculo-motor and other) accounts of the gap effect, and were left with a hypothetical default explanation based on disengaging attention from fixation. This year we tested the role of attention directly, by presenting a dim probe dot near fixation on a random 20% of trials. The fixation spot was manipulated 200 ms before target onset either by removing it altogether ('blank gap' condition) or by leaving it on but changing its color ('no-gap' condition). (Our no-gap condition is superior to the often-used 'overlap' condition, in which the fixation spot remains unchanged, in that it provides the same temporal cue as the gap condition.) The probe occurred 80 ms before, or 20, 80, 140, or 240 ms after the fixation spot was manipulated. Probes were always presented before the saccade occurred. Compared to the blank-gap condition, in which attention is hypothetically released from fixation, holding attention at fixation in the no-gap condition both slowed saccadic latencies to the target (the gap effect) and sped up reaction times to detect the probe. There were no speed-accuracy trade-offs. Thus, the latency data support the hypothesis that attention remains attached to the fixation area in no-gap, thus speeding processing of the probe, but is disengaged in the gap condition, thus delaying processing of the probe. Moreover, differences between the saccadic latencies in two gap conditions decreased with probe-dot onset up to 140 ms, while key-press reaction time differences increased, as if attentional disengagement requires 0.1 to 0.2s to complete.

F55 737 Exploring the distinction between semantic and spatial selective attention using eye movements

Christopher Masciocchi[1] (cmascioc@iastate.edu), Veronica Dark[1]; [1]Department of Psychology, College of Liberal Arts and Sciences, Iowa State University

Dark, Vochatzer and VanVoorhis (1996, Journal of Experimental Psychology: Human Perception and Performance) presented pair of words for 100 ms before masking them. A small abrupt onset peripheral arrow cued the location of one word 50 ms before pair onset. On some trials, one word in the pair was related to a context word presented before pair onset. Instructions were to report both words but typically only one word was reported. Both relatedness and spatial cuing independently influenced which word was reported, leading to the conclusion that semantic and visual selective attention are different mechanisms. The current study employed a similar procedure except there was always a related word in the pair. Subjects in all experiments were instructed to not move their eyes, but because eye movements are linked to visual selective attention, we monitored the direction of eye movements. In Experiment 1, subjects were instructed to report both words. Behavioral findings replicated the pattern found by Dark et al.: participants reported more related words and more cued words. Moreover, participants were more likely to move their eyes to a cued than an uncued word. In Experiment 2, two groups of subjects performed different tasks: report the cued word or report the related word. The behavioral data again replicated Dark et al.'s findings of a benefit for related and cued words. More eye movements were made on trials in the report cued (39%) than in report related condition (32%). Additionally, eye movements were more likely to be made to cued words regardless of whether instructions were to report the cued word or related word. Thus, while visual cues draw spatial attention, this does not interfere with the processing of primed words. Taken together, these results support Dark et al.'s conclusion that semantic selective attention and visual selective attention are distinct.

URL: http://www.psychology.iastate.edu/~vjdark/LAB%20WEBSITE/index.htm

F56 738 **Endogenous shifts of attention during smooth pursuit initiation**

David Souto[1] (david.souto@pse.unige.ch), Dirk Kerzel[1]; [1]Department of Psychology, University of Geneva

Several studies have shown that the execution of goal-directed saccadic eye movements needs the previous allocation of endogenous attention at the target location. Here, we investigated the presence and the temporal build-up of this coupling for the initiation of smooth pursuit eye movements (SPEM). Subjects had to report the orientation of a Gabor patch located 7° above or below a horizontally moving SPEM target. Endogenous cues indicated the location of the upcoming discrimination target and preceded the SPEM target onset by 550, 350, 250, 150 or 50 ms (SOA). Unlike in classic saccadic dual-task paradigms, no selection among competing SPEM targets was necessary. Cueing effects were therefore due to signal enhancement rather than to external noise reduction. On the one hand, the discrimination performance was improved with valid cues compared to neutral cues and this improvement was independent of SOA. On the other hand, the latency and gain of SPEM initiation was not perturbed when attention was shifted to a peripheral location. A tradeoff analysis indicated no modulation of cuing effects with SPEM latency. However, the presence of the 550 and 350 ms precues increased SPEM latency relatively to a no-precue condition, even when they had to be ignored. Altogether, the results suggest that although SPEM initiation can be influenced by attention-related factors like alertness or task load, it is not spatially coupled to attention. If there is no uncertainty with respect to the location or identity of the SPEM target (as in our experiment) attention may be shifted to other places without incurring a cost.

Acknowledgement: The two authors were supported by the Swiss National Foundation 10011-107768/1

Attention: Divided Attention, Inattention, and Inhibition

Author Presents: 8:00 - 9:45 am

F57 739 **High attentional load reduces neural classification of orientation in early visual cortex**

Christian Kaul[1,2] (c.kaul@ucl.ac.uk), Nilli Lavie[3], Geraint Rees[1,2]; [1]Institute of Cognitive Neuroscience, University College London, U.K., [2]Wellcome Trust Centre for Neuronimaging, University College London, U.K., [3]Department of Psychology, University College London, U.K.

The level of attentional load in a current task is known to determine the extent to which an irrelevant stimulus will evoke a BOLD neural response in sensory cortex (Rees et al, 1997; Schwartz et al., 2005). Here we examined whether the level of attentional load in a central task modulated feature-specific representations in early visual cortex for an irrelevant stimulus. We measured responses to a task-irrelevant peripheral grating with one of two orthogonal orientations while participants performed a central RSVP task of varying attentional load, using fMRI and multivariate pattern analysis applied to V1-V3. The orientation of the irrelevant grating was classified significantly better than chance in both high and low attentional load conditions from responses in V1-V3. However accuracy was significantly higher under low versus high attentional load. This suggests that high attentional demand for a task at fixation modifies feature-specific neural representations of irrelevant peripheral stimuli in early visual cortex.

F58 740 **Attentional capacity limitations on the identification of alphanumeric characters, English words, and American Sign Language signs**

Heather P. Knapp[1] (hknapp@u.washington.edu); [1]University of Washington

Our primary research goal is to determine whether alphanumeric characters and higher-level linguistic stimuli can be processed in parallel, without capacity limitation. There is an abundance of evidence for simultaneous processing of multiple alphanumeric characters (Erkison & Spencer, 1969; Shiffrin & Gardner, 1972; Pashler & Badgio, 1987). Whether the identification of higher-level linguistic stimuli benefits from covert shifts of attention is more controversial. In the current set of experiments we replicate Pashler and Badgio's (1987) highest-digit identification task and extend it to semantically-equated number words and American Sign Language number signs. This allows us to hold constant the underlying semantic content of targets and distractors (numerosity), the relationship between target and distractors, and the target selection criterion (highest number) while varying only the external surface structure (digit vs. word vs. sign) of the stimulus. Moreover, it allows us to assess digit, word, and sign processing in an understudied population of users with expertise in distributing visual attention over a variety of high-level linguistic stimuli. In hearing non-signers (n = 4) we find no processing advantage for successive vs. simultaneous identification of digits, but significant improvements in accuracy for successively-presented words. In Deaf signers (n = 5) we find identical patterns to the hearing non-signers, and additionally find that sign identification parallels that of word identification. These data are inconsistent with unlimited-capacity parallel processing models, and speak to the importance of the surface form of objects during multiple-object identification tasks. These results represent critical first steps in our goals to explore attentional capacity limitations at play during the perception of a wider range of real-world images and objects.

F59 741 **Distinguishing models of multifocal attention: It's a matter of time**

Thomas Carlson[1,2] (tom@wjh.harvard.edu), Rufin VanRullen[1,3], Hinze Hogendoorn[1,2], Frans Verstraten[2], Patrick Cavanagh[1,4]; [1]Department of Psychology, Harvard University, [2]Helmholtz Institute, Experimental Psychology Division, Universiteit Utrecht, Utrecht, The Netherlands, [3]Centre de Recherche Cerveau et Cognition, CNRS, Université Paul Sabatier Toulouse 3, [4]Laboratoire de Psychologie de la Perception, Université Paris V

In recent years, there has been increasing evidence indicating that humans can selectively process information from multiple locations. While the defining characteristic of multifocal attention is spatial, what distinguishes models that account for this ability is a question of the timing of access to the locations. The temporal properties of multifocal attention were studied to evaluate three models: 1) a serial mechanism that rapidly switches between locations, 2) a parallel process that independently and simultaneously extracts information from multiple locations, and 3) a capacity-limited parallel process. In an adaptation of the method used by Carlson, Hogendoorn & Verstraten (JOV, in press), observers monitored two running analog clocks and reported the "time" on both clocks at the presentation of a cue. Our first experiment found that reporting the "time" from two locations as opposed to one required an additional 100ms of processing time, thus providing evidence against independent, parallel access to multiple locations. In a second experiment, we found that this additional time was not a consequence of switching attention between locations (as would be predicted by a serial model), but instead could be attributed to an increase in processing time at both locations. The results of our experiments therefore indicate that multifocal attention is a capacity-limited parallel process.

F60 742 **Dividing attention between multiple targets: simultaneous or sequential allocation?**

Rufin VanRullen[1,2] (rufin@klab.caltech.edu), Thomas Carlson[2], Patrick Cavanagh[2,3]; [1]CerCo, CNRS, Université Paul Sabatier Toulouse 3, [2]Department of Psychology, Harvard University, [3]Laboratoire de Psychologie de la Perception, Université Paris V

Increasing evidence suggests that attention can concurrently select multiple locations; yet it is not clear whether this ability relies on continuous allocation of attention to the different targets (a "parallel" strategy), or whether attention switches rapidly between the targets (a temporal "sampling" strategy). Indeed, both strategies can explain the occurrence of classic "set size effects" (i.e. decreases of performance with increasing number of attended items), either because attention is a limited resource ("parallel" strategy), or because the effective time that attention samples each object decreases when several objects must be attended ("sampling" strategy). However, the psychometric function for detection of a single target as a function of its duration can be used to predict the expected psychometric function for multiple targets, and the predicted shape is quite different for parallel and sequential strategies. We find that the model that best predicts our observed data is a "sampling" model when the task involves a challenging contrast decrement detection (with the sampling period around 140ms, ranging from 100ms to 180ms across our 8 subjects), whereas the optimal model is a "parallel" one for an easy version of the same task (with a performance loss of 16% for each additional item to be attended). This distinction was observed for all subjects tested. The two versions of the task give rise, respectively, to serial (40ms/item) and parallel (0ms/item) slopes in a visual search situation. The results suggest that, at least for attentionally demanding tasks, it may not be possible to simultaneously attend to multiple locations; instead, the multiple items of interest are processed in series at a rate of about 7 items per second.

F61 743 **Incompatibility of the object-judgment reference frames has costs in dual-object report deficits**

Shiau-Hua Liu[1] (shliu@uci.edu), Barbara Anne Dosher[1,2], Zhong-Lin Lu[3], Pamela Jeter[1]; [1]Memory, Attention, and Perception (MAP) Laboratory, Department of Cognitive Sciences,University of California, Irvine, [2]Institute of Mathematical Behavioral Sciences,University of California, [3]Laboratory of Brain Processes (LOBES), Department of Psychology, Neuroscience Graduate Program,University of Southern California, Los Angeles

Attributes of different visual objects are often less accurately reported than separate attributes of the same object, a behavioral pattern theoretically associated with the limitations of object attention. Object attention has evolved as an organizing principle for cortical mechanisms of visual object attention (Desimone, 1998). However, Han, Dosher, & Lu (Psych. Science, 2003) showed that large dual-object report deficits in discrimination thresholds occurred only when different judgments (i.e., orientation and phase of Gabors) but not same judgments (orientations or phases) were made for two spatially separated objects. Given this and previous literature, we predicted that different judgment frames, as well as different features, could impose dual object costs. The current study tests this prediction of dual-object report deficit using distinct frames to report the same simple feature dimension. Subjects judged the orientation (+/- 18 deg) in two spatially separated (5 dva) Gabors oriented around the same (or / /) or different (? orÅ¤) diagonal base angles or frames. In dual report (DR) conditions, orientation was judged for both objects in a cued order. For single report (SR) conditions, only one cued object was reported. Contrast psychometric functions showed significant DR deficits (SR-DR) for different frame but not for same frame conditions for four subjects – especially in the presence of high external (white) Gaussian noise. A similar small effect occurred in noiseless conditions. A fifth subject was also affected by frame consistency, but showed DR deficits in all conditions. These results, then, support the influence of judgment frames in dual-object attention paradigms. The nature of the attention effect is more robust in high external noise, identifying external noise exclusion as an important function of dual-object attention. These judgment frame effects may have implications for human performance in complex visual displays.

Acknowledgement: Supported by: NEI and NIMH

F62 744 **Contribution of location uncertainty and feature similarity to illusory conjunction of basic visual features under limited attention**

Li Jingling[1] (giny_li@yahoo.com.tw), Li Zhaoping[1]; [1]Department of Psychology, University College London

We explore contributing factors to illusory conjunction (IC) of basic features under limited attention. Subjects were briefly shown two bars, horizontally next to each other, of different colors, different orientations and moving in different directions. These bars were horizontally flanked by two stationary, colorless, 'S' symbols, and presented at 5.76½ eccentricity at randomly one of four possible corners of the display. Subjects had to (1) name a currently presented digit at fixation, and (2), report the feature value of a target bar (among the two bars) in a given feature dimension, which was either color, or orientation, or motion direction, and is termed the reporting feature dimension. The target bar was defined as the one having the color, or orientation, or motion direction (called the target defining feature) indicated by a subsequently presented central stimulus. In each experimental session, the reporting feature dimension was fixed and had four possible feature values; the defining feature dimension randomly varied between the two other feature dimensions. Each defining feature dimension had two feature values, one for each bar. Subjects reported the features either correctly, or erroneously reporting the feature of the non-target bar (conjunction error, CE) or an absent feature value (feature error, FE). Using FE rates to remove the contribution of guessing to CE rates, we calculated the IC rates. We found that, given a defining feature, regardless of its feature dimension, IC rates increased with the error rates of reporting the target position (left or right of the two bars), probed in another experiment (using the same stimuli, digit naming task, and the target defining procedure, for the same subjects). Since target position errors were found to increase with feature similarities in the defining feature dimension, different previous explanations to IC could be reconciled (Donk 1999, Ashby et al 1996).

Acknowledgement: Supported by the Gatsby Charitable Foundation

F63 745 **The effects of unattended congruency on attended targets.**

Jennifer L Boyer[1] (boyer004@rice.edu), James L Dannemiller[1]; [1]Rice University

A persisting question in attention research is how much processing unattended items receive. Priming studies have shown that semantically related items can improve reaction times to a subsequent target without awareness of the prime, while picture-word interference studies have shown that semantically related items can interfere with responding. In the current study we employed the method of Rees et al. (1999) using superimposed pictures and words (Experiment 1) or superimposed large and small pictures (Experiment 2) to examine the effect of semantic congruency (e.g., picture of a ball and the word "ball") in an unattended channel on reaction times to detect a repeated item in an attended channel. This method additionally allowed us to examine whether repetition redundancy and repetition blindness can occur in the unattended channel. Observers were asked to attend either to one channel of an RSVP stream (pictures or words; large or small pictures) and to ignore the information in the other channel. Task structure and timing were chosen to make attending to the non-target stream highly disadvantageous for doing the primary task well. We show that semantic congruency from the unattended channel exerts differential effects on reaction times to the repeated item depending on the temporal proximity between the two items and on which type of information is in the attended channel (words or pictures). This indicates that under some circumstances unattended items are processed to a level at which they can influence behavior.

F64 746 **Chromatic Pattern-Onset VEPs are Robust to Inattention.**

Jennifer Highsmith[1] (highsmit@unr.nevada.edu), Zenaida Santiago[2], Michael A. Crognale[1]; [1]University of Nevada, Reno, Departement of Psychology ,Cognitive and Brain Sciences, [2]University of Nevada, Reno

Introduction: Attention has been shown to affect both behavioral and electrophysiological measures of visual processing. In addition, it is often difficult to determine whether or not a subject is attentive to the stimulus. Electrophysiological effects are often evident when attention is divided across space. In other studies where VEP and distracter stimuli remain spatially coextensive, changes in waveforms are not always seen. In this study we measured the effects of divided attention with spatially separated distracters on the chromatic pattern on-set VEP as might occur when a subject is looking at but not attending to the stimulus.

Methods: Stimuli were 1 cycle/degree horizontal sine-wave gratings modulated along the L-M and S-(L+M) axis in color space and presented in a pattern-onset mode. Subjects centrally fixated the VEP stimuli on one monitor while attending to an adjacent monitor and performing a judgment task on the distracter stimuli displayed thereon. Subject gaze and performance was monitored to ensure fixation and attention were directed to the proper monitors.

Results: No change in waveform amplitude and latency, as compared to typical VEP viewing conditions, was found when fixation remained on the VEP stimuli and attention was diverted to an adjacent monitor. Attention to the stimulus is not necessary for a robust chromatic pattern on-set VEP response. These results reinforce the clinical utility of the chromatic onset VEP in populations that may have difficulty maintaining an attentive state or following verbal instructions.

F65 747 **Auditory cues facilitate both low-level and high-level unattended visual processing**

Hao-Hsiang You[1] (jgallery@gmail.com), Su-Ling Yeh[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

Previous studies have shown visual-auditory integration effects when the visual events are attended. For example, in the "sound-induced-flash illusion", a single fully attended flash accompanied with two auditory beeps is perceived as two flashes (Shams, Kamitani, & Shimojo, 2002). The current study demonstrates that auditory cues can facilitate visual processing even when stimuli are unattended, and this facilitation can occur for both texture segregation (low-level) and the Simon effect (high-level). We adopted the inattentional blindness (IB) paradigm of Moore and Egeth (1997). In the texture segregation task, the unattended background pattern was formed by texture segregation of different oriented Gabors to render the railroad track as in the Ponzo illusion. The participants were asked to judge the length of the two horizontal lines. In the Simon task, the unattended background pattern was presented on the left or right side of the fixated target and the response to the target (left/right) is compatible or incompatible to the background pattern. In both tasks, a set of inquires was conducted to make sure that the background patterns were indeed unattended. Half of the trials were accompanied with a beep sound, and the other half were not. Results show that in trials with beep sounds, compared to those without, both the Ponzo illusion and the Simon effect are obtained, even when the participants are blind (i.e., IB) to the background pattern. These results suggest that unattended visual-auditory integration can occur at different locus through the processing stream.

Acknowledgement: Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020

F66 748 **Electrophysiological evidence for different qualities of change detection and change blindness**

Niko A. Busch[1] (niko.busch@nat.uni-magdeburg.de), Ingo Fruend[1], Christoph S. Herrmann[1]; [1]Department of Biological Psychology, Institute of Psychology, University of Magdeburg

Studies on change blindness, the failure to detect large changes in a visual display, have provided new insights on perception, attention, and visual experience. It is currently debated whether changes can be detected ("sensed") preattentively without a corresponding visual experience. While some authors have claimed that sensing and visual experience are separate processes, others hold that there is merely a quantitative difference, with sensing having a more liberal response criterion. While electrophysiological (EEG) experiments can potentially dissociate the neurophysiological processes involved, most previous EEG studies have used only simple, abstract stimuli and did not differentiate between different types of change detection. The present study investigated qualitative and quantitative electrophysiological differences between sensing and visual experience. On each trial an array of 4x4 colored drawings of everyday objects was presented for 615 ms, replaced by a blank screen for 80 ms, and presented again for 615 ms. The identity of one object was changed in the second display on half of the trials. Participants reported whether or not they detected any change, irrespective of whether or not they could report the object's identity. On detected change trials, participants were additionally asked to identify the object. While detection can be performed on the basis of sensing, identification requires a visual experience of the change. A negative deflection of the event-related potential (ERP) at posterior sites around 200 ms after the change was found for identification and, with smaller amplitude, as well for detection. Identification was associated with several ERP components contralateral to the side of a change, such as the N2PC. This component was completely absent for changes that were only detected and for change blindness. This qualitative electrophysiological difference between change detection and identification supports the claim that sensing and visual experience of a change are indeed separate qualities of perception.

F67 749 **Attentional Filtering of Repetitive Transients Reduces Change Blindness**

Mark W. Becker[1] (mbecker@lclark.edu), Sara Vera[1]; [1]Department of Psychology, Lewis & Clark College, Portland, OR

From a practical standpoint, change blindness may seldom occur in the real world. For instance, the odds of an object changing in perfect synchrony with a person's eye blinks or saccades seem fairly slim. Thus, in the real world, people's transient detection system may allow for excellent change detection. However, O'Regan, Rensink, and Clark (1999) reported that distracting transients that co-occur with a change produce change blindness. This finding may have real-world implications because there are often multiple objects that produce continuous transients. For instance, while sitting in your living room the VCR clock may be blinking and the ceiling fan may be rotating. These objects produce visual transients, but they are also repetitive, localized, and to some degree predictable. The question we ask is whether these types of repetitive transients produce change blindness. In four experiments we find that repeatedly presenting distracting transients prior to a change produces a recovery from change blindness. This recovery is not due solely to low-level neural adaptation of transient detectors, but instead seems to be based on attentional filtering of the distracting transient signals. Finally, this attentional filtering can be object- rather than location-based.

F68 750 **Change blindness as a result of a single mudsplash.**

Makoto Ichikawa[1] (ichikawa@l.chiba-u.ac.jp); [1]Dept. of Psychology, Chiba University

Observers would fail to detect the sudden image change when multiple distracters are presented in the scene (change blindness as a result of mudsplashes). We found that a single small flash may induce the blindness for the shape change of a moving stimulus (19.1 x 19.0 arc min). The moving stimulus went upward or downward with a constant velocity (9.8 arc deg/s) along a linear course at 2.6 arc deg right or left of the fixation point. A flash stimulus (1.6 x 0.3 arc deg) was presented at 5.5, 11.6, or 17.6 arc deg from the fixation point in the same visual field with the moving stimulus. In the half of 120 trials, the moving stimulus changed its horizontal length to 57.3 arc min at the moment of the flash. Observer's task was to detect the shape change of the moving stimulus. In 37% of the trials for the nearest flash to the fixation point, observers could not detect the shape change. Such a frequent fail in change detection was not obtained for the stationary stimulus. In the other experiment, we examined how the ipsilateral and contralateral presentation of the flash and moving stimulus affect the blindness by the use of nine time lag conditions between the shape change and flash, which ranged from –133.3 to 133.3 ms (negative and positive values indicate that the flash preceded or followed the shape change, respectively). Only when the flash and moving stimulus were presented in the ipsilateral visual field, observers missed the shape change in at least 30% of the trials with the time lag conditions from –66.7 to 33.3 ms. These results indicate that the visual system has limitation to notice events within a specific period, in particular for the moving object in the same visual field with the flash.

F69 751 Processing of the ignored object during eye gaze cueing

Alexandra Frischen[1] (alex.frischen@maccs.mq.edu.au), Daniel Loach[1]; [1]MACCS, Macquarie University

Observing another person's actions activates a similar motor program in the observer, via a system of mirror neurons that match observation and execution of actions. In a somewhat similar manner, observing another person shift their gaze in a certain direction results in a shift of attention in the corresponding direction. This facilitates processing of objects at the gazed-at location. However, little is known about what happens to objects or locations that are gazed away from. If you are watching another person select an object via their gaze shift, do you activate a similar selection mechanism? If so, you should effectively ignore an object that has been ignored (i.e., gazed away from) by another individual. Here, we examine object- and location-based negative priming effects resulting from observing shifts of eye gaze direction.

F70 752 Congruent features of the target presented as distractors impair target detection

Chaturi Jayasuriya[1] (c.jayasuriya@abdn.ac.uk), Maarten Milders[1], Arash Sahraie[1]; [1]Vision Research Laboratories, School of Psychology, University of Aberdeen

Ability to ignore irrelevant information is vital for effective cognitive functioning. Research in attention-induced motion blindness (AMB) suggest detection of a brief episode of coherent motion, embedded in a global stream of incoherent motion, can fail if it occurs shortly after a local color cue which is the signal to switch attention to the global stream. Essential for this effect to occur is the presence of irrelevant coherent motion episodes (distractors) prior to the cue (Sahraie et al 2001; Milders et al 2004). Earlier we proposed this motion blindness to result from inhibition of the distractors and a delay in releasing inhibition on appearance of the cue (Sahraie et al 2001). In addition, indirect evidence suggests AMB may be influenced by higher cognitive processes (Milders et al 2004). Thus, in the current study, we examined the role of expectation on distracter inhibition in AMB by presenting participants with congruent distracters (that shared properties of the target) and incongruent (distinct from the target). Recent studies in visual marking (Watson and Humphreys 1997) and attention-induced motion blindness (Milders et al 2004) have shown that behaviourally irrelevant stimuli (distractors) are ignored in order to prioritise relevant stimuli (target). Other studies have shown targets were more likely to be detected if they shared features with distractors. The findings of current study suggest those congruent distractors result in greater impairment in detection of the target than incongruent distractors. To rule out the possibility of a pop-out in the incongruent condition, the number of distractors of congruent and incongruent was varied. Findings strengthen the notion that distractors that share properties with the future target impair target detection to a greater extent than incongruent distractors.

Acknowledgement: Jim Urquhart for technical assistance

F71 753 Motor selection bias in a no-target, response choice version of the attentional cueing paradigm

Daryl Wilson[1] (daryl.wilson@queensu.ca), Jay Pratt[2]; [1]Psychology, Queen's University, [2]Psychology, University of Toronto

In a typical attentional cueing paradigm, irrelevant peripheral cues produce early facilitation (fast responses) followed by later inhibition (slow responses) to cued locations. Here we examine whether cues not only influence the speed with which responses are produced, but impact or bias which location is ultimately selected as requiring a response. Specifically, can cues influence not only the speed with which we respond but also influence the behavior produced? To examine this question, a choice localization task was used in which no targets were presented, and subjects were asked to choose which effector (left hand, right hand) to use in response to a centrally presented tone. Thus, following either a left or right peripheral cue, and then a central tone, subjects were free to respond with either their left or right hand. Early facilitation and later inhibition with this choice procedure were found in both response times and the proportion of responses to the cued and uncued locations. These results suggest that there are processes which initially bias response selection toward cued locations and then subsequently bias response selection away from cued locations.

Acknowledgement: This research was supported by a Vision Science Research Program Fellowship to Daryl Wilson and a Natural Sciences and Engineering Research Council grant to Jay Pratt.

F72 754 Dissociation between eye-movements and right perceptual biases in chimeric face processing in right hemisphere lesioned patients

Monika Harvey[1] (M.Harvey@psy.gla.ac.uk), Stephen Butler[1], Keith Muir[2], Ian Reeves[2]; [1]Department of Psychology, University of Glasgow, Glasgow, Scotland, UK, [2]Department of Neurology and Care of the Elderly, Southern General Hospital, Glasgow, Scotland, UK.

Using blended chimeric facial stimuli, where the left and the right sides of the face are different, we have previously shown that both young and older observers tend to bias their responses significantly toward the information on the left, supposedly reflecting a right-hemisphere advantage in this task (Butler, Gilchrist, Burt, Perrett, Jones & Harvey, 2005, Neuropsychologia, 43, 52-59; Harvey & Butler, 2004, Perception, 33, 106). Analyses of the eye movement patterns further indicated a tendency for both groups to initially scan to the left side of the chimeric image, presumably reflecting the tendency to first inspect the side of the face better suited to face analysis (left side of face/right hemisphere). As expected, patients with right hemisphere lesions based their gender decisions mainly on the right side of the chimeric face and this was not only the case for patients who suffered from spatial neglect (Mattingley, Bradshaw, Phillips, Bradshaw, 1993, Brain and Cognition, 23, 145-165). More interestingly though, there was no clear relationship between perceptual and eye-movements biases to chimeric stimuli. Although most patients showed more right-sided saccades and longer rightward fixations this was not necessarily reflected in the rightward perceptual bias. One patient in particular showed rightward saccades only, yet based his gender decision on the left hemi-face half the time when he should have shown 100% rightward hemi-face judgements. We would argue that although in healthy subjects face biases and eye-movement biases are tightly coupled, this relationship breaks down with brain damage and that for such patients eye-movement patterns are not a good indicator of perceptual processing (see also Ferber, Danckert, Joanisse, Goltz, Goodale, 2003, Neurology, 60 1826-1829 and Harvey, Olk, Muir, K, 2003, Neuropsychologia, 41, 1114-1121 for supporting evidence).

Acknowledgement: This work was supported by the Royal Society of Edinburgh/Lloyds TSB Foundation.

Visual Working and Short-Memory Memory

Author Presents: 10:00 - 11:45 am

F73 755 Infants' visual working memory for shape, luminance and color tested with equally salient objects.

Zsuzsa Kaldy[1] (zsuzsa.kaldy@umb.edu), Erik Blaser[1]; [1]Dept. of Psychology, University of Massachusetts Boston

BACKGROUND:

The question of whether infants can use one visual feature developmentally before another can only be studied legitimately if manipulations to those features are equally salient (Kaldy, Blaser, & Leslie, 2006). Our 'Interdimensional Salience Mapping' method allowed us to generate three comparison objects whose salience difference from a common baseline object was equal along one of three feature dimensions: shape, luminance or color. We then compared infants' visual working memory (VWM) for these features.

METHODS:

General: Age range: 8;15 - 9;15 (Exp. 1: n=14, Exp. 2: n=22). All stimuli were presented on a 21" LCD monitor.

Experiment 1: Salience differences were calibrated by pitting a baseline object (a yellow geometric figure) against another object that differed from the baseline either in shape, luminance or color (red saturation) in a preferential looking paradigm. (For shape, we varied perimeter, while keeping area constant.) Gaze direction (left/right) was coded. Data from 14 subjects yielded monotonically increasing psychometric functions of feature 'intensity' versus preference. Values at the 67% preference level were chosen; objects with these values have iso-salient differences from baseline along their respective feature dimensions.

Experiment 2: We used the violation-of-expectation method. Infants saw one of the objects in the baseline-comparison object pair, which was occluded for 2 seconds, and then either the same object or the other object in the pair was revealed. Looking times were measured.

RESULTS:

Using the iso-salient stimuli from Experiment 1, we found that 9-month-olds were able to maintain shape information in VWM. The luminance and the color tests are currently ongoing, but preliminary results show that infants note color changes, but not luminance.

DISCUSSION:

'Interdimensional Salience Mapping' can generate psychophysically comparable stimuli. VWM results so far are consistent with our "Ecological Memory" hypothesis, which predicts that reliable features of objects are better remembered.

F74 756 Preserved visual representations despite change blindness in 11-month-old infants

Stephen Mitroff[1] (mitroff@duke.edu), Su-hua Wang[2]; [1]Center for Cognitive Neuroscience, Department of Psychology & Neuroscience, Duke University, [2]Department of Psychology, University of California, Santa Cruz

The nature of visual representations remains an unanswered question. Whereas some change detection research might suggest that visual representations are fleeting and sparse, recent findings demonstrate that change blindness can result from a failure to compare available representations rather than from a failure to form representations. Observers can miss a change but still have access to the pre- and post-change information, suggesting representations can be robust, even if they are not compared to one another (Mitroff, Simons, & Levin, 2004). Here we find comparable results with infants – when they fail to notice a physical change, they nonetheless remember both the pre- and post-change information. Wang and Baillargeon (2006) showed 11-month-old infants an event in which an opaque tall cover was lowered over a short block. When the cover was lifted to reveal that the block had become much taller, the infants did not look longer than if the block were uncovered as the same height, suggesting they failed to detect the change. (When the block was hidden behind the cover through occlusion, however, the infants nevertheless detected the change.) Here we presented 11-month-old infants with a change from a short to a tall block through covering, but then administered to them a preferential-looking task: On alternating trials they were shown the short and a medium block, or the tall and a medium block. All blocks were identical except in height. Consistent with the view of maintained representations despite change blindness, the infants looked longer at the medium block than at either of the previously seen ones (a classic novelty preference revealing memory for the short and tall blocks). These results are developmentally significant, demonstrating an infant-adult parallel, and are also informative for the nature of visual representations, showing limited performance in infants does not necessarily reveal a representational failure.

F75 757 Pre-cuing the number of objects modulates visual short-term memory performance

Michael Ambinder[1] (ambinder@casper.beckman.uiuc.edu), Daniel Simons[1]; [1]University of Illinois

Research into the capacity of visual short-term memory (VSTM) using change detection tasks has revealed an estimated limit of around 4 objects which may decrease with increasing information load in the display. We used a cueing technique to examine whether instantiating a response-irrelevant attention set could contribute to greater memory capacity or improved performance. Specifically, we tested whether providing information in advance about the number of objects in the display would enhance performance in a standard VSTM change detection task.

Across several experiments, cueing the number of objects in the display significantly increased change detection performance, even for set sizes within the estimated capacity of VSTM. None of the existing theories of VSTM capacity — either those setting an object-based limit or those setting an information-based limit — predict increased memory capacity due to foreknowledge of the number of objects that will appear in the display. Performance was enhanced by cueing the number of objects at all set sizes. Strikingly, a visual cue enhanced performance more than a numerical or verbal cue, suggesting that visual cues allow more effective tuning of visual attention. Control studies eliminated the possibility that the cueing benefits resulted from general alerting of the participant to the trial start. Our results imply that VSTM capacity — or performance in tasks which measure VSTM capacity — can be improved when participants are able to tune their attention set to the nature of the display, suggesting that VSTM capacity might be more malleable than previously thought. Further studies examine whether cueing a feature dimension similarly affects VSTM task performance.

F76 758 Implicit Colour Memory Mediated by Explicit Memory

Pauline Pearson[1] (p.pearson@uwinnipeg.ca), Sherri Smart[1]; [1]Department of Psychology, University of Winnipeg, Winnipeg, Canada

Purpose: To assess the role of task-relevance and explicit memory in implicit colour memory. Methods: At study, participants (N=112) reported either the colour or the category of 26 coloured line drawings. At test, black-and-white versions of objects (26 old, 26 new) were shown and participants reported the colour of the line drawing seen at study (explicit memory). Subsequently on each trial, participants were shown coloured versions of the same objects (half the same colour as during study and half colour transformed) and reported colour, category or identity (implicit memory). Results: When the colour and category of the items were correlated at study, those participants who reported category at study (N=48) evidenced reaction times for colour transformed items that were longer than those for non-transformed objects in all test conditions. Participants who reported colour at study (N=32) evidenced no influence of colour transformation on implicit memory. Furthermore, when colour and category were not correlated at study, participants who reported category at study (N=32) evidenced no influence of colour transformation on implicit

Monday Posters

memory. However, in all conditions, repetition priming was absent when explicit recall was incorrect. Conclusions: Colour appears to be encoded even when colour is irrelevant to the task at study (i.e. report category). Repetition priming occurred regardless of whether colour was relevant (i.e. report category or colour) or irrelevant to the decision at test (i.e. report identity). However, implicit recall was not independent of explicit recall in any of the conditions in these experiments.

F77 759 Predicting Human Action from Gaze Cues

Nancy Carlisle[1] (nancy.carlisle@vanderbilt.edu), Daniel Levin[1]; [1]Department of Psychology and Human Development, Peabody College, Vanderbilt University

From about one year of age humans are able to reliably follow gaze cues from others. These cues have been shown to covertly direct attention in adults (Langton & Bruce, Visual Cognition, 1999). Additionally, action towards an object is often preceded by gaze toward that object (Land & Hayhoe, Vision Research, 2001). Because gaze cues can direct attention and reliably precede future action, we conjectured that they might be used in the prediction of human action. To investigate this hypothesis we examined whether the amount of representational momentum caused by brief videos of reaching actions depended on gaze cues. Participants watched videos that contained an initial grasping action, but that stopped just prior to the start of a second grasp. Three different kinds of gaze cue preceded the stopping point: a shift in gaze from looking down to looking at a to-be-grasped object (Object Gaze Cue), a shift in gaze from looking at the camera to looking at the object (Communicative Gaze Cue), or no gaze cue (Control). Subjects indicated whether a probe image was the same as the last frame in the video. Critically, the examination of representational momentum was based on gaze cue alone, before any action of the hand and arm was visible. We found that communicative gaze cues produced the most representational momentum, as revealed by a relative predominance of false alarms in recognition of frames advanced in time relative to the stopping point (that is, frames depicting the beginning of the second reach), relative to recognition of the stopping-point frame. Both the object gaze cue and the control conditions produced less representational momentum, and were not different from each other. This finding suggests that communicative gaze invokes perceptual predictions about the short term course of upcoming actions.

Acknowledgement: Michael Mack, Stephen Killingsworth

F78 760 Increasing Visual Short-Term Memory Load Impairs Object Processing in the Left Visual Field

Stephen M. Emrich[1] (steve.emrich@utoronto.ca), Susanne Ferber[1]; [1]Department of Psychology, University of Toronto

After lesions to temporo-parietal regions, patients with visuospatial neglect demonstrate a profound deficit in awareness for contents in the contralateral visual field. Likewise, individuals suffering form extinction demonstrate an impaired awareness for stimuli in one visual field under the presence of bilaterally presented stimuli. While neglect and extinction have traditionally been associated with impaired attentional processing, current models of neglect suggest that it is also associated with a profound deficit in visuo-spatial memory. Interestingly, recent experiments have demonstrated that increases in visual short-term memory (VSTM) load produce decreases in neural activity in the right temporo-parietal junction (TPJ), the same region associated with neglect. These experiments also demonstrate that this decrease may be associated with inattentional blindness. Here, we tested whether increases in VSTM load could produce deficits in awareness for objects presented on the left visual field. Under a low or high VSTM load, participants had to indicate the number and identities of objects that were briefly presented to the left and/or right visual fields during the memory delay. Results demonstrate that under the high memory-load condition individuals were equally accurate in reporting the number of objects regardless of visual field, or whether objects were presented unilaterally or bilaterally. However, accuracy in reporting the objects' identities was impaired under bilateral presentation relative to unilateral conditions. Interestingly, we also demonstrate that this impairment in object processing was significantly worse in the left visual field compared to the right under high memory load. The results demonstrate that high VSTM load can produce an extinction-like deficit for the recognition of objects in the left visual field.

F79 761 Prioritization of New Objects During Visual Search is Limited by the Capacity of Visual Short-Term Memory

Naseem Al-Aidroos[1] (naseem.al.aidroos@utoronto.ca), Stephen M. Emrich[1], Jay Pratt[1], Susanne Ferber[1]; [1]Department of Psychology, University of Toronto

When new items are presented in a visual scene, these items are typically given attentional priority over old ones. While some theories posit that this prioritization of new items is related only to the automatic capture of attention by luminance changes, other evidence suggests that the visual system may mark or inhibit the old items, thereby giving these old items less priority. If the visual system can in fact inhibit old items, the ability to do so may be limited by visual memory capacity (about 4 items). Accordingly, we tested whether the number of old items in a visual scene that could be given reduced priority was limited by the capacity of visual short-term memory (VSTM). We presented participants with a visual-search task in which 0-7 distractors were previewed for one second prior to the presentation of the target. The results demonstrate that the search time is not affected by the number of old items when the old items can be held in VSTM (i.e., when there are fewer than 4 old items). Furthermore, this prioritization occurs even in the absence of luminance changes. We also demonstrate that when the number of old items is greater than memory capacity, performance is benefited by the preview of old items, as search times are equivalent to the removal of roughly 4 distractors. These results provide compelling evidence that the number of old items that can be given reduced attentional priority relative to new items is limited by the capacity of visual short-term memory, suggesting a role for VSTM in the prioritization of new items in a visual scene.

F80 762 The effects of spatial and object working memory on change detection using the flicker paradigm.

Bonnie Angelone[1] (angelone@rowan.edu), Melissa Beck[2], Kariann Amante[1], Kimberly Sikorski[1], Diana Klimas[1]; [1]Psychology, Liberal Arts and Sciences, Rowan University, [2]Psychology, Arts and Sciences, Louisana State University

Observers often have difficulty detecting visual changes when they are presented during a disruption, an experience known as change blindness. Successful change detection requires not only focused attention and encoding, but also a comparison process to detect the difference between pre and post presentations of the stimulus. As such, working memory may be an important component in this process. Previous research suggests different systems within working memory may differentially affect visual search for a target. Visual search performance is detrimentally affected by filling spatial working memory. However, performance remains successful when an object based working memory task is used. The current research investigated the effect of object and spatial working memory on change detection performance using a flicker paradigm. Previous work from our lab suggests that filling object based working memory has little effect on change detection performance for color changes. The present experiments examined object and spatial working memory and change detection using a dual task design. In Experiment 1, observers complete an object based working memory task and a change detection task both in isolation and concurrently. In Experiment 2 observers complete a spatial working memory task and a change detection task both in isolation and concurrently. In the working memory task observers first see an array of 4 squares (all different colors in the object working memory experiment and all black in the spatial working memory experiment). Then they see a square in isolation and have to determine whether that color or spatial location was in the original display. The flicker change detection task used naturalistic scenes that contained either a change to the color or location of one object in the scene. If similar processes underlie visual search and change detection, we expect object based and spatial working memory to differentially affect change detection performance.

F81 763 **Do change detection measures underestimate the capacity of visual short-term memory?**

Jean-François Delvenne[1,2] (j.delvenne@bham.ac.uk), Axel Cleeremans[3], Cédric Laloyaux[3]; [1]Behavioural Brain Sciences Centre, University of Birmingham, UK, [2]Cognitive Neuroscience Unit, UCL, Belgium, [3]Cognitive Science Research Unit, Université Libre de Bruxelles, Belgium

Change detection performance is habitually assumed to reflect the capacity of visual short-term memory (VSTM). Accordingly, it has been suggested that only four or fewer items can be simultaneously encoded into VSTM. Recent indirect measures of change detection, however, suggest that explicit reports – typically requested in the change detection paradigm – may underestimate the capacity of VSTM. Studies on implicit change detection, for example, showed that observers remain able to detect a change better than chance would predict even when claiming they failed to perceive it (e.g., Fernandez-Duque & Thornton, 2000). Likewise, studies on eyes movements revealed that when observers fail to explicitly report a change, fixation durations on changed objects are significantly longer (e.g., Hollingworth & Henderson, 2002). Here, we used a cueing paradigm, similar to that used by Becker et al. (2000), to directly investigate whether the capacity of VSTM is underestimated in change detection tasks. The memory array consisted of 6 colored shapes and was presented for 500 ms, with accurate retention required over a subsequent 1500-ms delay. The test array consisted of one colored shape, and participants were instructed to decide whether the shape and the color of that object came from the same object or from two different objects in the memory array. Change detection improved when the location of the two objects that could potentially swap their features was cued during the interval, namely 700 ms after the offset of the memory array. Given that participants must first encode the objects and the associations of features in VSTM in order to make proper use of the cue, these results indicate that we may have a larger storage capacity in VSTM than that indicated by the change detection paradigm. This clearly challenges the hypothesis that explicit change detection provides an exhaustive measure of VSTM.

F82 764 **Proactive interference from items previously stored in visual short term memory**

Tal Makovski[1] (tal.makovski@gmail.com), Yuhong V. Jiang[1]; [1]Department of Psychology, Harvard University

This study investigates the release of information from visual short-term memory (VSTM) when it is no longer needed. Previous studies have found inconsistent results, with some studies showing effective release of irrelevant information (Olivers, Meijer & Theeuwes, 2006), and other studies showing proactive interference effects from previously remembered items (Jonides & Nee, 2006). Here we investigate whether visual information retained on trial N-1 continues to interfere with performance on trial N, whether this interference is spatially specific, and whether it relies on active memory from trial N-1. Using change detection tasks of colors or shapes, we show that participants tended to falsely classify a changed item as “no-change” if the item matched one of the memory items on trial N-1, suggesting that memory for trial N-1 was not effectively released. The interference is spatially specific: memory for trial N-1 items interfered more if the test item match the feature value and the location of a trial N-1 item, than if it did not matched the location. Yet, the interference is not retinal-based and is seen when the display on trial N-1 was expanded or contracted compared with trial N. A four-alternative-forced-choice task revealed that intrusion from trial N-1’s item was similar in magnitude to intrusion from trial N’s adjacent items, suggesting that temporal interference is comparable to spatial interference. Finally, interference from items on N-1 is a direct consequence of retaining information in VSTM. If participants passively viewed items on trial N-1, no intrusion was found. We conclude that humans are not efficient at releasing unwanted information from memory, even though intuitively its better to delete previously remembered items to make room for new input.

Acknowledgement: NSF 0345525

F83 765 **Identifying a target during visual search affects the contents of working memory**

Jason Wong[1] (wongjasonh@gmail.com), Matthew Peterson[1]; [1]Department of Psychology, George Mason University

Object identification is important for visual search, yet search remains paradoxically efficient when visual object working memory (VOWM) is full (Woodman, Vogel & Luck, 2001). However, the previous study used stimuli that were visually dissimilar, such as colored blocks for the memory task and Landolt-C's for the search task. The present study uses similar or dissimilar stimuli (complex faces and houses) across all tasks. Participants held two objects in memory while searching for the presence of a single target in a search display consisting of four or eight objects. The memory and search task could either involve the same stimuli class (similar condition) or different stimuli classes (dissimilar condition). For example, in the similar condition, if the memory set consisted of faces, then the search set would also consist of faces, whereas in the dissimilar condition, if the memory set consisted of houses, then the search task would consist of faces. Results mirror Woodman, et al. and show that search efficiency is not affected by a working memory load and is not dependent on stimuli similarity. However, memory accuracy was affected when a target was correctly detected in the similar condition versus the dissimilar condition. This demonstrates that target identification during search will interfere with memory for objects that are similar with the search task. This effect suggests that VOWM is involved in identifying search targets, but is not involved in rejecting distractors.

F84 766 **An ERP study of visual change detection.**

Helene Gauchou[1] (helene.gauchou@univ-paris5.fr), Agnieszka Wykowska[2], Anna Schubö[2], Kevin O'Regan[1]; [1]Perception Psychology Laboratory, CNRS, Paris 5 University, Paris, France., [2]Department of Psychology, Ludwig-Maximillian University, Munich, Germany.

Numerous studies employed event-related brain potential (ERP) in order to understand the time course of neural events underlying the change detection of a visual stimulus. It has been reported that change detection would be related with an increase of negativity at posterior sites peaking around 200ms after stimulus onset (Kaernbach, Schröger, Jacobsen & Roeber, 1999; Koivisto & Revonsuo, 2003) and with an enhanced positivity in the P3 time range (Niedeggen, Wichmann & Stoerig, 2001; Turatto, Angrilli, Mazza, Umilta & Driver, 2002). The posterior negativity is described as an electrophysiological correlate of phenomenal visual change awareness and the enhanced positivity as a later postperceptual processing stage involved in response-related decision processes.

In the present ERP study participants were presented for 100ms with a sample screen composed of four colored squares and after a 1s delay appeared a test screen. The task was to detect the color change of one of the items that was cued on the test screen by the use of a frame. The use of this cue allowed us to assess if the N2 increased amplitude is correlated with the change detection mechanism or with the attentional processes related with target detection.

Moreover in a second time the participants had to rate the level of confidence of their change/non-change detection answer. This scale allowed us to study separately three kinds of trials: 1) High level of confidence trials corresponding to the situation where participants saw the change/no-change; 2) Medium level trials where they had no visual experience but a feeling of change/no-change; 3) Low level trials where participants were guessing. This categorization allowed us to investigate the ERP difference between correct and non correct answers as a function of the different levels of visual experience.

F85 767 **Updating feature information about objects in visual short-term memory**

Philip C. Ko[1] (philip.c.ko@vanderbilt.edu), Adriane E. Seiffert[1]; [1]Department of Psychology, College of Arts and Sciences, Vanderbilt University

Updating memorized information is important for cognition, for example when mentally resorting a list. Is this process object-specific in visual short-term memory (VSTM)? Kessler and Meiran (2006, JEP:HPP, 32(3):570-585) suggested that updating an element in verbal short-term memory refreshes all elements in memory. The current study investigated whether this finding could be replicated in VSTM. If updating the memory of one object refreshes all of VSTM, performance across conditions with the same number of updates should be equal, regardless of how updates are distributed across objects. Conversely, if updating objects in VSTM requires attention that would otherwise be allocated to the maintenance of non-updated objects, performance should be better when updates are distributed equally across all objects, compared to when they are restricted to one. Participants (n=14) memorized colors and locations of three briefly presented dots. Participants then either maintained this information, or updated VSTM to match recurrences of the dots. During recurrences, one dot briefly re-appeared at its original location in a new color. Each dot recurred either zero, one, two or three times. At test, all dots were presented in their most recent colors either at the correct locations, or with the locations of two dots swapped. Participants reported whether or not the test matched their updated memory representation. Accuracy did not differ with the number of recurring objects when the number of total recurrences per trial was equal (e.g., one object with three recurrences versus three objects with one recurrence each). Results are consistent with the theory that all information in VSTM is refreshed when a subset is updated. These preliminary findings suggest that the process of updating objects in VSTM operates under similar principles as in verbal STM. This provides an initial step in understanding updating processes in multi-element VSTM.

Acknowledgement: NIH EY014984
URL: http://www.psy.vanderbilt.edu/faculty/seiffert/

F86 768 Single-probe advantage in standard change detection task does not reflect memory for feature binding

Aki Kondo[1] (kondo@cv.jinkan.kyoto-u.ac.jp), Jun Saiki[1,2]; [1]Graduate School of Human and Environmental Studies, Kyoto University, [2]PRESTO, Japan Science and Technollogy Agency

Although it has been reported that visual short-term memory could hold representations of 3-5 feature-bound objects, Wheeler and Treisman (2002) showed that change detection performance in retaining binding information was significantly worse than the performance in retaining visual feature information. They attributed this binding memory deficit to retrieval processes based on the significant improvement of performance by using a single probe display. However, change detection tasks may be insufficient to evaluate feature-binding because participants can use other types of memory representations. This study examined whether binding memory deficit reflects memory retrieval or maintenance, using tasks to evaluate binding memory more strictly; type identification task and relevant-feature switch detection task. As in typical change detection tasks, sample and test displays were presented with a blank period in between. The stimuli were objects defined by shape and color and during delay period, properties of two objects, either both shape and color, shape alone, or color alone, could switch. To investigate the effect of retrieval, single- and whole-probe trials were randomly mixed within experimental blocks. First experiment with the standard change detection showed significant performance improvement in the single probe condition, replicating Wheeler and Treisman. In the type identification task, participants identified the switch type (shape, color, shape-and-color, and no-switch), and in the relevant-feature switch detection task, participants were asked to detect switches involving shape, and switches involving color in different sessions. Both tasks need discrimination of different switch types, not only detecting the presence of any change. If the binding memory deficit reflects retrieval processes, then these tasks should also show the single-probe advantage. Results showed no single-probe advantage in these two tasks, suggesting that binding memory deficit reflects maintenance, not retrieval. Previous findings using change detection tasks may reflect memory system unrelated to feature binding.

Acknowledgement: Support from 21st Century COE (D-10 to Kyoto Univ.), and PRESTO from JST.

F87 769 Direction specific impairments of spatial working memory as a consequence of saccadic remapping.

Brandon Vasquez[1] (bvasquez@watarts.uwaterloo.ca), Jonathan Carriere[1], James Danckert[1]; [1]Department of Psychology, University of Waterloo

One of the most common impairments resulting from right parietal stroke is a disorder called visuospatial neglect, in which patients behave as if half their world has ceased to exist. Current theoretical attempts to explain neglect have suggested that, in addition to attentional biases, these patients also demonstrate impairments of spatial working memory and/or spatial remapping. These two mechanisms are closely related in that they are critically important for maintaining and updating spatial representations in our environment. We examined the influence of saccadic remapping processes on spatial working memory in a group of healthy individuals. Participants first had to determine the presence or absence of a target (a circle with a small segment removed) presented amongst distractor stimuli (full circles). On trials in which a target was detected, a probe stimulus then appeared, following a brief delay (1 sec). Participants had to indicate whether or not the probe occupied the location of the previously detected target stimulus. Critically, we manipulated fixation during the delay condition such that fixation could remain static or could move to the left, right, up or down. These four shift conditions required the participant to remap the target display in order to make accurate decisions concerning the spatial location of the probe. Performance for judging the spatial location of the probe was best when central fixation was maintained. Interestingly, decrements in SWM (i.e. accurately matching the target location with the probe) were only observed when saccadic remapping was executed into right or lower visual space. This suggests that saccadic remapping processes interact with SWM processes in specific ways that may be related to both hemispheric biases in attention for changes induced by lateral remapping, and differences in personal versus extrapersonal space for changes induced by vertical remapping.

Acknowledgement: NSERC

Poster Session G

Monday, May 14, 2:00 - 6:30 pm, Municipal Auditorium

Color Vision Mechanisms

Author Presents: 2:00 - 3:45 pm

G1 770 **Compensation for light loss due to filtering by the macular pigment: Specificity of the mechanism.**

Max Snodderly[1] (max.snodderly@mail.utexas.edu), Randy Hammond[2], James Stringham[2], Bill Wooten[3]; [1]Human Ecology/Institute for Neuroscience, Univ of Texas at Austin, [2]Department of Psychology, University of Georgia, Athens, [3]Department of Psychology, Brown University

Our past data have shown that the visual system compensates for filtering of short-wave light by macular pigment (MP). Compensation is evident from the fact that S-cone sensitivity and yellow-blue color perception are unaltered when comparing foveal responses, where MP is dense, to parafoveal responses where MP density (MPOD)is unmeasureable.

Yellow (575 nm)-blue (440 nm) and red (600 nm) –green (501 nm) cancellation functions, as well as increment thresholds (using conditions that were designed to isolate the S-cone pathway) were obtained at 0,1, 1.75, 3 and 7°. MPOD was measured using heterochromatic flicker photometry. Ten young subjects were studied.

When using conditions that isolate the S-cone pathway, the S-cone system behaved univariantly and scaled sensitivity to offset differences in MPOD across the retina. Since the spectral shapes of these components differ, the effects of compensation were a function of wavelength. Adjustment of the S-cone pathway predicts overcompensation at 520 nm, and undercompensation at 460 nm for foveal (FOV) compared to parafoveal (PF) sites, respectively. We tested these predictions at multiple wavelengths based on a theoretical compensation mechanism specific to the S-cone pathway. S-cone sensitivity changed with eccentricity consistent with our predictions based on a gain mechanism. The PF S-cone curve (based on classic p-1 curves or Stockman's fundamentals) is different from the broader FOV curve, which includes MP absorbance. The shapes of subjects' PF functions were very similar across subjects, but shapes of the FOV S-cone functions differed depending on individual differences in MPOD. Hue cancellation values for the Y-B system did not change significantly across the retina. R-G sensitivity, in contrast, changed as a function of MPOD. These results are consistent with the idea that the visual system increases gain of the S-cone system, but not other systems, to compensate for light absorption by MP.

Acknowledgement: Pfeiffer Research Foundation

G2 771 **How does the third red-green photopigment of color-defect carriers contribute to color vision?**

Yang Sun[1] (berber.sun@gmail.com), Steven Shevell[1]; [1]Visual Science Laboratories, University of Chicago

PURPOSE: The mother or female child of a male with X-chromosome-linked color-vision deficiency is a heterozygous carrier of the defective gene. A female carrier's defective gene is posited to be expressed, so carriers may have more than one type of M or L cone. An open question is how the carrier's extra cone pigment affects the neural signals encoding color. Here, alternative models considered how the signal from an extra red-green pigment combines with signals originating from the standard L and M cones. The models predicted individual differences in color matching among carriers, which were tested for carriers whose defective gene was assessed by examining the color vision of the color-defective father or son.

METHODS: The usual Rayleigh match using an anomaloscope as well as high-intensity Rayleigh matches using a 5-channel Maxwellian-view optical system were measured. The matches were compared to model predictions based on three different assumptions about the signal from the extra cone pigment: it is combined with the signal from (1) the standard L pigment, (2) the standard M pigment or (3) both pigments. Both spectral-sensitivity peak and optical density of the pigments were considered in the model.

RESULTS AND CONCLUSIONS: The male protans and their female obligate carriers exhibited various extents of shift from the normal Rayleigh match. The model successfully predicted the protan carriers' shifts under the assumption that the signal from their extra red-green pigment is combined with only the signal from the standard L pigment.

Acknowledgement: Supported by PHS grant EY-04802

G3 772 **Asymmetric pedestal masking of S-cone increments and decrements: Does sawtooth polarity matter?**

Scott H. Gabree[1] (gabree.s@neu.edu), Rhea T. Eskew, Jr.[1]; [1]Department of Psychology, Northeastern University

There is substantial evidence to indicate that the mechanisms detecting S-cone increments (S+) and decrements (S-) differ in more than just the polarities of their S, M and L cone inputs. Our lab has investigated the S-cone increment and decrement pathways using a pedestal method. We used S+ and S- pedestals as well as an equal combination of L and M-cone increments or decrements that had a color appearance similar to S-cone stimuli. Both S and LM pedestals produced masking at high pedestal contrasts; however, "bluish" (S+ or LM-) pedestals masked more than "yellowish" (S- or LM+) ones. Consistent with other results (Vingrys & Mahon, 1998), these results indicate that these detection mechanisms are asymmetric (McLellan & Eskew, 2000; Shinomori, Spillman & Werner, 1999), and suggest that perhaps there is a greater contrast gain control in the S-ON than the S-OFF pathway (Solomon & Lennie, 2005).

All stimuli (pedestals and tests) in these experiments used a "rapid-start" temporal waveform, one that rapidly increased (or decreased) in contrast and then linearly ramped back to the mean field. The incremental or decremental stimulus contrasts, coupled with "rapid-start" temporal waveforms, should differentially stimulate S-ON and S-OFF pathways. The question we ask here is whether the temporal sawtooth polarity is important in creating the asymmetry we found. We repeated the pedestal masking experiment, but with a "rapid-stop" temporal waveform that linearly ramped to a peak and then abruptly returned to the mean field. Tests were again S+ or S-; pedestals were S+, S-, LM+, or LM- as before. Even with high contrast pedestals, the sawtooth polarity had little effect. One possible interpretation is that the contrast polarity difference produces clear separation of ON and OFF pathways, and changing the sawtooth polarity of single flashes has little further effect.

G4 773 Chromatic discrimination of textured stimuli

Martin Giesel[1] (Martin.Giesel@psychol.uni-giessen.de), Thorsten Hansen[1], Karl R. Gegenfurtner[1]; [1]Experimental Psychology, Justus-Liebig University, Giessen, Germany

We have previously investigated chromatic discrimination for chromatic distributions (Hansen & Gegenfurtner, 2005) and observed that discrimination contours are shaped in a manner that matches the chromatic distributions of the input. Interestingly, this is only the case for conditions when discrimination is measured at the adaptation point. At the same time, overall thresholds for color discrimination are lowest at the adaptation point and increase linearly with increasing distance of the test color from the adaptation point. Here we investigate the interplay between the effects of chromatic distributions and adaptation systematically. Discrimination thresholds were measured at various distances from the adaptation point for stimuli whose chromaticities were modulated around a test color symmetrically on a line in the DKL color space. These stimuli had a spatial frequency characteristic with an amplitude spectrum of 1/f. A spatial four-alternative forced-choice procedure was employed to measure discrimination thresholds along eight comparison directions. The four stimuli were presented against an equal-energy white background. Three of the stimuli were identical while the chromaticity of the fourth one (comparison stimulus) was varied by shifting its normalized chromatic distribution into one of the eight comparison directions. Thresholds were defined as just-noticeable shifts of the chromatic distribution. Discrimination ellipses were fitted to the thresholds. Thresholds were measured in this way at the adaptation point and at different distances from the adaptation point for eight test directions. We found that the shape of the discrimination ellipses is determined by the amplitude and direction of both the chromatic distribution and the shift away from the adaptation point. Increasing the distance between the adaptation point and the test color, induces an additional modulation of chromaticities causing an increase in thresholds. Depending on the amplitude of the shift, these elevated thresholds outweigh the effect of the chromatic distribution.

Acknowledgement: Supported by German Science Foundation GE 879

G5 774 Evaluating chromatic contrast sensitivity functions during saccades

Wei-Chung Cheng[1] (waynecheng@mail.nctu.edu.tw); [1]National Chiao Tung University, Taiwan

Purpose: The Color Breakup phenomenon is the most challenging problem for today's field sequential liquid crystal displays, in which the temporally synthesized white appears as separated red, green, and blue in different regions of retina during saccades. Since only the M–pathway is selectively suppressed, the color breakup phenomenon remains perceivable during saccades. For the display industry, measuring, modeling, and predicting color breakup is essential to derive any feasible solution. Although Daly and Kelly have offered models of spatio-velocity contrast sensitivity functions during smooth pursuit, they are not sufficient to predict high-speed saccade-induced color breakup.

The color breakup of a white patch can be considered as a series of red, green, and blue flashes across retina. Therefore, degree of color breakup depends on the temporal frequency (field rate), spatial frequency (Gabor), retinal velocity (saccade length), luminance (Block law), size (Franit-Harper law), duty cycle (Broca-Sulzer law), wavelength (Hecht-Shlaer law), eccentric position (Hecht-Verrijp), and so on. Our goals are to measure the threshold of detecting color breakup by using behavioral approaches and to derive prediction models.

Method: We have built a display platform which was capable of producing arbitrary color sequences to synthesize white. Two-interval forced choice experiments were used to induce saccades and to determine the color breakup threshold. In the mean time, a head-mount eye-tracker was used to record the saccade trajectories. The experiments swept different contrasts and Gabor patterns as independent variables.

Results: The resulting data and models resemble the previous ones for smooth pursuit with minor modification. Since the detectability varies with wavelength, it is possible to derive the optimal mix of red, green, and blue that generates the least color breakup with given luminance. It also suggests the possibility of novel interactive display systems that minimize color breakup by substituting chromaticity dynamically when saccades initiate.

URL: color.di.nctu.edu.tw

G6 775 Abstract withdrawn

G7 776 Functional evidence for the maintenance of chromatic opponency across visual space

Jonathan Peirce[1] (jon@peirce.org.uk), Paul McGraw[1]; [1]Nottingham Visual Neuroscience, University of Nottingham

P-cells in the lateral geniculate nucleus (LGN) with foveal or para-foveal receptive fields (RFs) typically have chromatically-opponent centre-surround organisation. How this opponency arises is a matter of considerable debate. It might arise from a wiring whereby the cone inputs are selected in a principled fashion to allow for opponency. Alternatively, since the RF centre at these eccentricities is thought to receive input from a single cone, and the surround from very few, the chromatic opponency might arise simply from random wiring of the cone outputs to retinal ganglion cells. Therefore, the random wiring hypothesis predicts reduced chromatic opponency in the periphery versus central foveal vision. Electrophysiological studies have provided conflicting evidence for that hypothesis (e.g. see Dacey, 1996; 2000 versus Martin et al, 2001; Solomon et al, 2005).

The theories might also be distinguished psychophysically. We quantified chromatic opponency in central and peripheral regions by measuring the effect of retinal after-images for chromatic stimuli equated in detection thresholds. Subjects adapted a patch of retina at either 7.5° or 30° from fixation on the vertical meridian. Two probes were then presented, one falling in the same location as the preceding adapter and the other falling in the corresponding location in the other hemifield. We measured the point of subjective equality (PSE) between the two fields for a full range of chromatic probes. A reduction in opponency at eccentric locations would predict that the after-image would be weaker or less tightly tuned than in the more central location. We found no evidence to suggest a weakened chromatic opponency across the visual field, in agreement with Solomon et al (2005).

Acknowledgement: JWP is supported by the BBSRC. PVM is supported by the Wellcome Trust

G8 777 The spatiotemporal properties of the achromatic and chromatic Craik-O'Brien-Cornsweet effect

Frédéric Devinck[1] (Frederic.Devinck@psychol.uni-giessen.de), Thorsten Hansen[1], Karl Gegenfurtner[1]; [1]Justus-Liebig-Universität Giessen

Monday Posters

The Craik-O'Brien-Cornsweet effect (COCE) is a visual phenomenon in which a difference in brightness is observed between two equal luminance regions separated by a luminance defined edge consisting of both sharp and gradual discontinuity. This effect is also shown with isoluminant colors. It has been hypothesized that the COCE is mediated by a cortical filling-in process. According to this hypothesis, filling-in needs some finite amount of time for the brightness or color to spread from the locations corresponding to both edges of a COCE grating into the space between them. Consequently, if the COCE relies on a neural spreading effect it should proceed at finite speed, and exhibit some temporal tuning as a function of the width of the area enclosed by the contours. In the present study, temporal frequency thresholds were determined at three spatial frequencies ranged from 0.05 to 2 cpd. Observers varied the temporal frequency of a COCE grating to determine the maximum temporal frequency at which temporal brightness or color modulation is perceived. In the achromatic COCE, contours were determined along the luminance axis of the DKL color space; in the chromatic COCE, contours were modulated along the L-M- or S-cone axis. Two contrasts were used (0.1 and 1). For the achromatic condition at low contrast, the data showed that the temporal frequency for an induction effect increased with an increasing spatial frequency, while it was constant for the high contrast condition. For both chromatic COCE, the modulation in chromaticity at low contrast decreased when the spatial frequency increased, while it was constant in the high contrast condition. Our results are consistent with the spatial filtering properties of the luminance and chromatic systems, but they suggest that temporal filling-in may not operate under all conditions.

Acknowledgement: supported by DFG grant Ge-879/5 and the Alexander von Humboldt foundation

G9 778 Chromatic VEP points to two systems for processing colour

David P Crewther[1] (dcrewther@swin.edu.au), Sheila G Crewther[2]; [1]Brain Sciences Institute, Swinburne University of Technology, [2]Psychological Science, La Trobe University

Recent optical imaging experiments have demonstrated a complicated arrangement of colour and luminance processing that is carried out in Area V2 (Wang et al. 2006). While imaging can give some idea of function, electrical activation measured with the cortical visual evoked potential (VEP) may add to this picture. We aimed to study surface versus contour based colour processing through diffuse heterochromatic exchange compared with that generated by the appearance/disappearance of a heterochromatic pattern. Six participants with normal colour vision volunteered for the study. The VERIS mfVEP system was used. Diffuse stimulation corresponded to the hexagons (subtence 4 deg) alternating between the colour and background grey either at the same luminance (36 cd/m2) or with a constant luminance contrast of 30%. Patterned coloured stimuli comprised line patterns presented in appearance-disappearance mode with the same colour and luminance contrasts as for the diffuse exchange. For red stimulation, a positivity (140 ms, recorded Oz to Fz with ear ground) demonstrated an amplitude which increased with saturation of red. Blue diffuse stimulation resulted in a negativity (130 ms) in the first order response. Patterned stimulation though producing a larger signal than diffuse stimulation was almost independent of the level of saturation. Spectral dependance of the diffuse chromatic VEP showed a null point at yellow (570 nm). However, the response to yellow pattern appearance was still considerable, with a manifestly different waveform from the diffuse chromatic VEP. Thus, there are separate neural processes for serving surface and contour colour signalling. The diffuse response shows a separation between luminance and colour while the pattern response shows no such separation. The contribution of the blobs of (V1) and thin stripes (V2) to these processes are yet to be established.

Ref. Wang, Xiao, Felleman, Cerebral Cortex (2006)

G10 779 Chromatic Processing in Hemianopia

Nicola Ridgway[1] (n.ridgway@abdn.ac.uk), Mary-Joan MacLeod[2], Arash Sahraie[1]; [1]Vision Research Laboratories, University of Aberdeen, [2]School of Medicine and Therapeutics, University of Aberdeen

When observers have to respond to two simultaneously presented targets, their reactions times are significantly faster than responses to single targets. This is termed the Redundant Target Effect (RTE). In experiment one, we demonstrated the presence of RTE in ten normal observers using, luminance-defined, colour-defined and combined luminance-colour defined stimuli, even when targets were presented in different hemifields. For colour-defined targets, Random Luminance Modulation (RLM) technique was used to mask any luminance cues.

In experiment two, we applied the same technique to investigate the extent of chromatic processing within the field defect of a group of cortically blind patients. Previously, RTE had only been consistently reported in 1 out of 20 cortically blind patients tested, using combined luminance-colour targets (Marzi, Tassinari, Aglioti & Lutzemberger, 1986). Here we show evidence for chromatic processing within the field defect in all 5 cortically blind patients tested, by showing that the reaction times to sighted field presentations are affected if a similar target is presented within the field defect. More specifically, depending on the stimulus conditions all five patients illustrated either facilitation (RTE, i.e. shorter reaction times) or inhibition (i.e. slower reaction times) of chromatic processing. Overall the pattern of facilitation and inhibition for luminance and colour defined targets are complex. However, s-cone sensitive stimuli consistently led to an inhibitory effect in all five patients. This finding is significant as s-cone afferent signals reportedly, do not project to midbrain structures such as superior colliculus, often implicated in blindsight.

Acknowledgement: Dr. James A Mearns Charitable Trust

G11 780 The bandwidth of chromatic mechanisms mediating visual search

Patrick Monnier[1] (patrick.monnier@colostate.edu); [1]Dept. of Psychology, College of Natural Sciences, Colorado State University

BACKGROUND: The nature of suprathreshold color representation still is unclear. In addition to determining the number of mechanisms, measuring the mechanisms' bandwidth is important in characterizing color vision. Broad (narrow) bandwidths indicate linear (non-linear) combinations of cone signals. In this study, the bandwidth of chromatic mechanisms was assessed by systematically varying distractor color heterogeneity in a latency visual search task.

METHODS: Reaction time was measured for chromatic targets presented with 48 distractors. The chromatic composition of the distractors was determined by selecting colors on an equal-performance sector in color space. E.g., a 360 deg sector would consist of colors from an equal-performance circle centered at the target chromaticity. A 0 deg sector would consist of distractors of a single chromaticity (homogeneous) complementary from that of the target chromaticity. Reaction time was measured for the same chromatic target presented with distractors of various color heterogeneity (the sector angle was systematically varied).

RESULTS: Distractor color heterogeneity had a profound effect on search performance, often increasing reaction time by a factor of five. The ratio of reaction time for the heterogeneous and homogeneous conditions was taken as an indicator of the effect of color heterogeneity. Ratios smaller than one indicated worse search performance for the heterogeneous compared to the homogeneous condition. Plotting these ratios as a function of the size of the chromatic sector was used to estimate the bandwidth of chromatic mechanisms mediating search. Across three observers and two different target chromaticities, the bandwidths were generally broad showing a doubling of reaction time between sector sizes of 90-135 deg.

CONCLUSIONS: Distractor color heterogeneity, selected from equal-performance sectors in color space, is a viable approach to estimate the bandwidth of chromatic mechanisms mediating search. Bandwidth estimates were similarly broad across observers and target chromaticities.

G12 781 **The role of categorical boundaries in visual search for colour**

Ester Reijnen[1] (ester.reijnen@unibas.ch), Anina N. Rich[2], Michael J. Van Wert[2], Jeremy M. Wolfe[2]; [1]Department of Psychology, University of Basel, Switzerland, [2]Brigham & Women's Hospital/Harvard Medical School

Colour is critically important in our complex visual world. Here, we studied the impact of colour categories on guidance of attention in visual search. In our first experiment, we compared search for a target among distractors drawn from different colour categories (across-category search) with search for a target among distractors including items from the same colour category (within-category search). Distances between target and distractors in a 3D colour space (CIE-LUV) were the same in the two conditions. Orthogonally, we manipulated the linear separability of the target and distractors. If the target could be separated from all distractors by a plane in colour space, it was linearly separable. Participants search faster and more efficiently for targets in across-category than within-category conditions. Linear separability only influenced RT when the target was not categorically unique. We replicated the category effect with more discriminable colours. In our final experiment, participants search for a target among heterogeneous distractors drawn from the remaining 10 basic colour categories as defined by Berlin and Kay (1969). Colours were not equiluminant (as this would not make much sense with a set of colours including black and white). All these searches among highly heterogeneous distractors were efficient. Relative speed of search was better explained by relative luminance than by the position of colours in Berlin and Kay's linguistic hierarchy. These results demonstrate that, beyond effects of target-distractor similarity, distractor-distractor heterogeneity, and linear separability, the colour categorical status of the target has a significant effect on guidance of attention in visual search.

Attention: Interaction with Memory or Emotion

Author Presents: 4:00 - 5:45 pm

G13 782 **Do the contents of working memory capture attention? Yes, but it's under control.**

Suk Won Han[1] (hsw1770@yonsei.ac.kr), Min-Shik Kim[1]; [1]Department of Psychology, Yonsei University

There have been debates regarding the issue on whether working memory could guide attentional selection. Some researchers have reported that working memory contents guided attention automatically (Soto et al., 2005). On the other hand, Woodman and Luck (in press) reported that they found no evidence of attentional capture by working memory. The current study tried to find an integrative explanation for the conflicting results. In our experiments, while memorizing a single color, participants had to do a visual search task. Each search item had different colors. In one condition, one of search items had the same color as the memory prime (memory matching distractor). In the other condition, there was no memory matching distractor. Although the participants knew that the memory matching item would never be a target, the presence of the memory matching distractor slowed the visual search, reflecting memory-driven attentional capture. However, when perceptual processing of search stimuli was more demanding by increased target-distractor similarity, or the onset of the search was delayed long enough for cognitive control to be implemented, the effect of memory-driven attentional capture was eliminated. From these results, we suggested perceptual difficulty and the time course of cognitive control as explanations to resolve the conflict between the previous studies. We also suggested that the memory matching item was prioritized involuntarily in the visual search because a target template could be stored in visual working memory with other contents to be memorized. However, cognitive control could dissociate the target template from search-irrelevant working memory contents, modulating the effect of attentional capture by working memory.

Acknowledgement: This research was supported by a grant (M103KV010017-06K2201-01710) from Brain Research Center of the 21st Century Frontier Research Program funded by the Ministry of Science and Technology, the Republic of Korea.

G14 783 **Effects of Visual-Spatial and Verbal Working Memory Load on Visual Attention and Driving Performance**

Alex Chaparro[1] (alex.chaparro@wichita.edu), Satoru Tokuda[1], Nichole Morris[1]; [1]Department of Psychology, Wichita State University

Recent studies show that visual search is less efficient when loads are placed on working memory (WM) by having subjects manipulate information (i.e. count backwards from a target digit) but not when subjects simply maintain information in WM (i.e. rehearse a set of random digits). We tested the effects of different WM loads (maintain versus manipulate) on driver detection of peripheral letter targets and on driving performance using a driving simulator. Participants (n=40) performed secondary tasks that loaded either visuo-spatial working memory or verbal working memory (phonological loop). The verbal task required participants to either rehearse a string of random letters or to alphabetize the string while driving. In the visual task the participants were presented with an image of a human stick figure in different orientations (up-right, up-side down, facing forward or facing backward) and holding different geometric shapes in each hand. The participants were asked to either remember the figure or to identify what the figure was holding in one of the hands. The simulation consisted four equal length segments demarcated by stop lights. At the start of each road segment the participants were presented with a random letter string or a stick figure and asked to memorize the stimulus or to manipulate it (i.e, alphabetize or identify which hand held a particular shape) while driving. The results show that subjects detected fewer peripheral letter targets ($p = .016$) and responded more slowly to peripheral targets ($p=.002$) when manipulating information using WM regardless of modality (visual or verbal). Subjects also received more speeding tickets but drove slightly slower while engaged in the manipulation tasks. These data show that WM tasks that require participants to manipulate information regardless of modality (visual or verbal) negatively affect driving performance and interfere with a drivers' visual search of the driving environment.

G15 784 **Attentional filtering efficiency and individual differences in VSTM capacity**

Keisuke Fukuda[1] (keisukef@uoregon.edu), Edward Vogel[1]; [1]University of Oregon

The storage capacity of visual short-term memory (VSTM) for simple objects is known to be severely restricted and to vary considerably across individuals. These individual differences in capacity have often been proposed to be due to variability in memory storage space. However, it is also possible that much of the variability stems from the efficiency of attentional control mechanisms that restrict access to VSTM. In previous experiments, we used a change detection task in which task-irrelevant objects (distractors) were also present to gauge how efficient individuals are at filtering out distractors from being encoded into memory system. By using an ERP index of the current number of objects held in VSTM, we have shown that the efficiency of excluding distractors from VSTM is strongly predicted by an individual's memory capacity. That is, low memory capacity individuals maintain more irrelevant items in VSTM than high capacity individuals. In the current series of experiments, we extend these results by parametrically varying the attributes of the distractors (i.e. similarity to target, exposure duration, and onset timing) to investigate what makes them more or less likely to be unnecessarily stored in VSTM and how these selection factors may be moderated by an individuals memory capacity.

G16 785 **Spatial working memory loads can reduce search efficiency but not the rates of rapid resumption in interrupted visual search tasks**

Jee-Won Ahn[1] (ahn21@uiuc.edu), Alejandro Lleras[1]; [1]Department of Psychology, University of Illinois at Urbana-Champaign

Using an interrupted visual search task in which a briefly presented search display alternates with a blank display until response, Lleras, Rensink and Enns (2005) found participants were far better at resuming a search task following an interruption than they were at starting a search task from scratch (the rapid resumption phenomenon), evidence they took that memory processes were heavily involved in this task. Related studies by Oh and Kim (2004) and Woodman and Luck (2004) have also demonstrated a contribution of memory in visual search; increasing spatial-working memory (SWM) loads reduced the efficiency of visual search. The present research explored whether the memory benefit observed in rapid resumption comes from SWM. We adapted Oh and Kim's paradigm by replacing the static search display with an interrupted search task, while keeping the same SWM load manipulation. Our results showed a detrimental effect in the memory task in the dual-task condition (memory task + loaded interrupted-search task), with little effect of load in the interrupted search performance (Experiment 1). In Experiment 2, the discrimination in the search task was made perceptually more difficult. The results indicated an impairment on visual search efficiency. Overall, however, no effects of SWM loads were observed on the rates of rapid resumption in either experiment. This dissociation suggests that the memory processes responsible for rapid resumption are distinct from spatial-working memory. The results are in line with the proposal that rapid resumption stems from mostly unconscious processing of the target prior to the last interruption.

Acknowledgement: Research supported by a National Science Foundation grant to A.L., award # 0527361.

G17 786 **Visual memory or visual features coded verbally? An effect of working memory load on guidance during visual search**

Hyejin Yang[1] (hjyang@ic.sunysb.edu), Gregory Zelinsky[1]; [1]Department of Psychology, Stony Brook University, New York

Does holding multiple targets in working memory (WM) affect search guidance, and what WM representation underlies guidance in a search task? We addressed these questions by combining a working memory task and a search task. Subjects viewed 1, 2, or 4 objects in a target preview display, either with or without articulatory suppression (AS) during the preview period. Their task was to indicate whether any one of these objects appeared in the search display, which depicted either 0 (target absent) or 1 target and 8 or 9 random object distractors. Catch trials in which a distractor was replaced with a non-target exemplar from a target category (e.g., a bass was shown in the preview but a trout appeared in the search display) were used to encourage the encoding of visual information. Guidance was defined by the proportion of initial saccades directed to the target and by the proportion of first-object-fixations corresponding to the target. If guidance results from matching targets in visual WM, articulatory suppression should have no effect. However, if target visual features are coded verbally, articulatory suppression during the target preview should eliminate search guidance. We found a pronounced effect of WM load. As the number of potential targets increased from 1 to 4, guidance dropped to near chance and RTs almost doubled. Even asking observers to search for 2 targets, rather than 1, profoundly impaired search guidance. Moreover, this effect of WM load interacted with AS; search was guided less efficiently with AS, although above-chance guidance was still observed in single-target search. We conclude that target features are coded both visually and verbally in WM, and that both representations are used to guide search to targets.

Acknowledgement: This work was supported by NIH grant R01-MH63748.

G18 787 **Attentional Control: Be More Specific!**

Sei-Hwan Oh[1] (soh5@uoregon.edu), Margaret Sereno[1]; [1]Department of Psychology, University of Oregon

Most theories of selective attention in general agree that how attention is distributed is dependent on the complex interactions between stimulus-driven (bottom-up) and goal-driven (top-down) processes (Folk, Remington & Johnston, 1992; Desimone & Duncan, 1995; Egeth & Yantis, 1997). Whereas there has been much research on what factors make an object more salient such that it captures attention in a bottom-up fashion, there has not been much research on the important factors in top-down process. Moreover, there has been a discrepancy in views of the role of working memory in top-down attentional control, with some studies showing significant attentional biasing effects of working memory (Pashler & Shiu, 1999; Downing, 2000) and others reporting no effects (Downing & Dodd, 2004; Woodman & Luck, 2007). The current study proposes that the specificity of the goal (defined as task targets in working memory) determines to what extent it will influence attentional control. Using visual search and rapid serial visual presentation tasks, we demonstrate a biasing effect only when targets are specified. These results provide a potential explanation in terms of goal-specificity for why there has been discrepancy in the literature on the biasing effect of working memory.

G19 788 **Flexible target representations underlie repetition priming in visual search**

Jennifer McBride[1] (Jen.Mcbride@bristol.ac.uk), Ute Leonards[1], Iain D Gilchrist[1]; [1]Department of Experimental Psychology, University of Bristol

In visual search, repeating target features across consecutive visual search trials can influence response time (RT). It remains unclear, however, what representation of the target is stored across trials to produce this repetition priming. Two experiments were conducted to address this question and to investigate how priming is affected by feature type and the roles that features plays in defining the target. In Experiment 1, the target was defined as a bar differing from distractor bars in its orientation. Target colour was shared with some of the distractors and so was irrelevant for target definition and the search. Repeating the task irrelevant target colour across consecutive trials produced significantly faster RTs, but repeating the target-defining orientation significantly slowed RTs. In Experiment 2, the roles of colour and orientation were reversed: the target now differed from the distractors in colour, while target orientation was shared with some of the distractors and was irrelevant to the search. For Experiment 2, repetition of (target-defining) target colour produced significantly faster RTs, but no reliable cost or benefit was found for repeating task-irrelevant target orientation. Taken together, the results from Experiments 1 and 2 show that different priming effects are shown for different feature types (colour and orientation) and that swapping the roles played by these different target feature types also induces different priming effects.

The effects of repeating multiple target features interacted in a manner that is not consistent with views that priming operates either on feature-based or episodic (whole-object) representations of search targets. Instead, the representation of the target that is stored across trials and leads to priming seems flexible: it critically depends on the role of target features in the task (e.g. orientation once induced negative priming and once no reliable priming), and on the target feature types themselves.

Acknowledgement: This work was supported by a BBSRC studentship to Jennifer McBride (BBS/S/A/2004/11075)

G20 789 **2 deg. narrowed field of view can explain the process speed of tactile search for change**

Takako Yoshida[1] (tyoshida@wjh.harvard.edu), Kenji Yokoi[2], Yuki Miyazaki[3], Hiromi Wake[4], Tenji Wake[3]; [1]Vision Sciences Lab., Department of Psychology, Harvard University, [2]Research Center for Advanced Science and Technology, the University of Tokyo, [3]Department of Psychology, Chukyo University, [4]Department of Human Sciences, Faculty of Human Sciences, Kanagawa University

A 2D image that can be recognized easily by vision is not always recognized by touch. This is believed to be partly because haptic perception for 2D image makes heavy demands on working memory. During active exploration, we need to store not only the latest local sensory information, but also to integrate this with kinesthetic information of the hand and fingers location to generate a coherent percept. This tactile integration over time has not been studied as extensively as visual shape integration. Our initial purpose of the experiment was to compare the working memory storage of tactile exploration to that of visual exploration as measured in tactile and visual change detection tasks. We have reported a series of experiment that showed much longer search time and longer process speed per item to detect a change during tactile exploration than visual exploration (e.g., VSS '04). These results lead to the extremely small estimated tactile memory held during search as if suggesting that haptic system is almost amnestic outside the fingertips and little or no integration cross-position integration in 2D tactile perception either. Here, we tested the hypothesis that an extremely narrow field of view can explain our results. Using gaze-contingent moving window display system, an apparatus that actively narrows the visual field of view based on eye movements, we found that a narrow field of view also dramatically prolonged the process speed per item during active visual scanning. We manipulated the size of the window and realized that 2deg. visual field predicted the haptic data. These results indicate that our previous results can be attributed to a narrow field of view of tactile domain.

G21 790 The temporal dynamics of visual sensory memory while tracking multiple moving dots

Sathyasri Narasimhan[1] (S.Narasimhan@bradford.ac.uk), Srimant Tripathy[2], Brendan Barrett[3]; [1]Department of Optometry, University of Bradford, [2]Department of Optometry, University of Bradford, [3]Department of Optometry, University of Bradford

To investigate the role of visual memory while tracking multiple simultaneous trajectories, several experiments were conducted using variations of the paradigm presented in Tripathy and Barrett (2004). The stimuli consist of several linear, non-parallel, left-to-right moving dots, each travelling at the same speed. At the monitor's midline, halfway through the trajectories, one of the dots (the target) deviated clockwise/counter-clockwise while the remaining trajectories (distractors) continued without deviation. The observer reported the direction of deviation of the target and thresholds were estimated using the method of constant stimuli. When the target and distractor trajectories persisted through the length of the trial, deviation thresholds increased rapidly with the number of trajectories (Tripathy & Barrett, 2004). When a temporal delay was introduced at the mid-point of the trajectories, thresholds increased more rapidly as the delay was increased. These results suggest that observers' performance in multiple object tracking tasks of this kind is primarily influenced by the decay of trajectory traces in visual sensory memory. When the distractors disappeared about a 100ms before the target deviated, thresholds were substantially lower than when the distractors persisted through the length of the trial. In these experiments varying the dot speed identified the critical variable to be the time between the disappearance of the distractors and the deviation of the target, rather than length of the target trajectory between the two events. The earlier the distractors disappeared, the lower the thresholds were; in some observers thresholds continued to improve even when the disappearance of the distractors preceded the deviation of the target by 400ms. Taken together, our results suggest that it takes nearly 400 ms to shift attention to the target; this shift in attention helps to speed up the processing of the deviation which must be completed before substantial decay of the traces has occurred.

G22 791 Midstream order deficit occurs with phonological encoding of order

Kazuhiko Yokosawa[1] (yokosawa@l.u-tokyo.ac.jp); [1]The University of Tokyo

Repeated visual sequence presentations usually reinforce short-term memory, but sometimes cause a problem in recalling order. This is called the midstream order deficit (MOD). For example, Holcombe et al. (2001) reported that it was easier to recall the relative order of a 4-letter sequence from a single presentation than a repeated presentation. Using Kanji characters, which are logographic symbols in Japanese and have many homophones, Yokosawa (VSS, 2005) examined whether the MOD occurred for phonological encoding of relative order. The MOD was not found with stimulus sets of phonologically identical characters and written responses, while the MOD was obtained with stimulus sets of phonologically different characters and verbal responses. These results suggest an influence of phonological encoding on the MOD, although the manipulation of stimulus set and response method was confounded. In Experiment 1, sets of four phonologically different Kanji characters were used with written responses. After each sequence presentation, participants reported the order by connecting the printed characters on the response sheet using arrows. The results showed that the accuracy of recall of order was significantly lower in the cycling presentation trials than in the single presentation trials. This shows that the MOD was independent of the reporting method and need for phonological encoding. In order to determine more precisely the influence of phonological encoding, Experiment 2 added an articulatory suppression task, and MOD disappeared. Thus MOD disappears when phonological encoding of relative order is prevented, suggesting that phonological encoding is a critical determinant for the MOD.

Acknowledgement: Supported by JSPS

G23 792 Contextual Cueing and Response Conflict

Justin A. Junge[1] (justin.junge@yale.edu), Marvin M. Chun[1]; [1]Department of Psychology, Yale University

The phenomenon of spatial contextual cueing can be observed by presenting subjects with a mixture of novel and repeated visual search arrays. Over time, subjects implicitly learn that in each repeated array the spatial locations of distractors are correlated with the spatial location of a target, and come to search through repeated arrays faster than novel arrays. Identifying the processing stage wherein this response time benefit arises is a topic of ongoing research and debate. In the first paper reporting contextual cueing (Chun & Jiang, 1998) it was hypothesized that implicit context recognition guided attention to the target location. However, Kunar et al (VSS, 2006) challenged this claim, making the case that contextual cueing exerts its benefit later, at a response selection stage. They introduced response conflict on half of the trials, and surprisingly, contextual cuing was abolished by the response conflict. However, they employed an efficient, pop-out search task to measure the role of a response stage, whereas prior contextual cuing studies have typically used inefficient, serial search tasks. Thus, we sought to replicate their disruption of contextual cueing by response conflict by using serial search rather than pop-out search. Under conditions of serial search, there was robust contextual cueing and no effect of response conflict. These results call into question the inferences made about contextual cueing using a pop-out search task and the general role of response conflict in contextual cueing.

G24 793 Emotional Repetition Blindness

Carys K. Ball[1] (c.ball@bangor.ac.uk), Jane E. Raymond[1]; [1]University of Wales, Bangor

Repetition Blindness (RB) is a temporary visual processing deficit that occurs when two similar items are presented in close temporal proximity: perception of the second item is often impaired. Although studied primarily using words, RB has also been reported for dissimilar visual images that are semantically similar (e.g., images of a helicopter and an airplane). Here we ask whether an object's emotional valence (positive or negative), like its semantic properties, is also susceptible to RB. We presented participants with an RSVP stream containing 6 fillers and 2 objects (C1, C2) and asked them to report the emotional valence (good, bad; Exp 1) or category (animate, inanimate; Exp 2) of both objects. C1 and C2 were emotional colour images that were either (1) identical repetitions (e.g., C1 = knife, C2 = the same image of a knife); (2) emotional repetitions but unrelated semantically and visually (e.g., C1 = knife, C2 = shark); or (3) no repetition, where the two items had opposite emotional valences (e.g., C1 = shark, C2 = butterfly). We used two different report conditions (using the same stim-

Monday Posters

ulus set) to determine if emotional RB is due to a failure to individuate task-relevant features or whole object representations. We also consider that the successive presentations used in our experiment are similar to affective priming paradigms that show facilitation for report of a second stimulus when the first and second are emotionally congruent. Affective priming predicts enhanced performance for emotional repetition in both response conditions (i.e., no RB). Failure to report items seen in the three stimulus conditions and two report conditions will be compared. Our findings will be discussed in terms of how attentional states control and filter emotional awareness.

Acknowledgement: C. K. B. is supported by a studentship from the ESRC

G25 794 Affective consequences of exogenous attentional orienting

Helena J.V. Rutherford[1] (psp037@bangor.ac.uk), Jane E. Raymond[1]; [1]University of Wales, Bangor

Prior attentional state can have consequences for the emotional evaluation of stimuli. Stimuli previously seen as distractors in a visual search task are evaluated more negatively than previously seen target or novel stimuli (e.g. Raymond et al., 2003). Here, we probed whether exogenous attentional orienting mechanisms could contribute to this 'distractor devaluation' effect and to what extent object- versus location-based processes contribute. Previous studies used only affectively positive or neutral stimuli: here we used threat stimuli to determine if ignoring results in devaluation or suppression of affective intensity. Participants engaged in a simple standard inhibition of return (IOR) task and then evaluated items used as cues in the preceding task (or novel items). The IOR task consists of presenting a brief non-predictive cue to the left or right of fixation (causing reflexive orienting to the cue), brightening the fixation spot to re-orient attention to the centre, and then presenting a target at the cued or uncued location. With intervals between cue and target > 300 ms, responding is slower at cued v. uncued locations. This difference is called IOR. Here, we presented complex images as cues: spiders (negative) or leaves (neutral) and simple circles as targets. After target localization, we presented (at the target location or at fixation) the previously seen cue or a novel item from the same or different category as the cue. Each was then affectively rated (how positive, how negative). Our question was whether the putative inhibition of the cue and/or its location would be applied in the rating task to specific items (old versus new exemplars of the same category as the cue) regardless of location or to all items but only at cued locations. The results inform understanding of attention-emotion interactions and provide information about exogenous attentional orienting to valenced emotional stimuli.

Acknowledgement: HR is supported by an ESRC (UK) studentship

G26 795 Emotional consequences of stop-action responses to own- and other-race faces.

Nikki Westoby[1] (n.westoby@bangor.ac.uk), Jane E. Raymond[1]; [1]University of Wales, Bangor

Previous studies from our lab showed that stop-action signals engender emotional devaluation of associated stimuli. This effect may result from response inhibition (produced by the stop-action signal) becoming associated with the stored representation of the associated stimulus. When that stimulus is viewed later, this inhibition gets applied to its emotional evaluation, leading to devaluation. Here, we asked whether stop-action devaluation generalises to novel stimuli matched in category to stop-action stimuli and how much it depends on visual memory. We presented successive face images in a go/no-go speeded response task cued by either gender or race (Asian or Caucasian) to Caucasian and Asian participants (allowing us to exploit own-race v. other-race advantages in face memory, Meissner et al., 2001). After each block of 10 trials, we obtained trustworthiness ratings of novel and previously seen go and no-go faces. The response times (RTs) with gender cues were significantly faster than with race cues. Using gender cues (e.g., go males, no-go females), we found no evidence of stop-action devaluation. However, with race cues (e.g., go Asian, no-go Caucasian), previously seen no-go faces were rated as less trustworthy than previously seen go faces. This effect was found for both previously seen exemplars and for novel exemplars that matched the no-go category. Interestingly, stop-action devaluation was only found when the no-go category was own-race faces; other-race no-go faces did not get devalued. These data suggest that stop-action devaluation: (1) results when action inhibition is effortful (indexed by long go-RTs); (2) requires no-go stimuli to be successfully individuated, and (3) can generalize to novel images that share the no-go category if categorization is difficult (as it is for race) and exemplars can be individuated (as they can be for own-race faces). These findings support the idea that stop-action devaluation depends on memorial processes.

Acknowledgement: With support to N. Westoby from ESRC (UK) and to J. Raymond from BBSRC (UK)

G27 796 Context Matters: The Influence of Facial Emotional Expression on Gaze-Triggered Orienting When Gazed-at Targets Have Emotonal Meaning

Chris Kelland Friesen[1] (chris.friesen@ndsu.edu), Erin Kauffman[2], Kimberly Halvorson[3], Reiko Graham[2]; [1]Department of Psychology, North Dakota State University, [2]Department of Psychology, Texas State University - San Marcos, [3]Department of Psychology, University of Iowa

Several studies investigating whether the emotional expression of a gazing face might enhance spatial orienting to a gazed-at location have produced inconclusive or null results. Here, in two experiments, we investigated whether affective context might modulate the interaction between emotion processing and gaze-triggered orienting. A second consideration was that previous studies might not have given participants long enough to integrate gaze and expression information before the target appeared. In both experiments, each trial began with a face with a neutral expression, gazing straight ahead. The eyes of the face looked nonpredictively to the left or right, and then the face's expression changed to happy or fearful. The observer's task was to identify a peripheral target presented 225 or 525 ms after the gaze cue onset. In E1 the target was either threatening (a growling dog) or nonthreatening (a smiling baby), and in E2 the targets were neutral (the letters T and L). The gaze cuing effect (faster responses to gazed-at targets than to nongazed-at targets) was observed in both experiments. The critical finding in E1 with emotionally-valenced targets was that the gaze cuing effect was larger when the face was fearful compared to happy -- but only when observers were given sufficient time to process the face before target onset. In E2 with neutral targets, there were separate gaze and expression effects, but there were no significant effects involving gaze and expression. The results of E1 demonstrate that emotional expression can affect the magnitude of gaze-triggered orienting, but that the integration of gaze and expression information is time consuming. The results of E2 suggest, however, that without a meaningful context, additional processing time is not sufficient. We discuss how top-down factors might interact with bottom-up visual information to produce enhanced orienting in response to socially relevant stimuli.

Acknowledgement: Financial support for this research was provided by NIH/ NCRR COBRE grant P20 RR020151

G28 797 Affect and Arousal Influence the Attentional Blink

James T Enns[1] (jenns@psych.ubc.ca), Lisa Jefferies[1], Daniel Smilek[2], Eric Eich[1]; [1]University of British Columbia, [2]Waterloo University

Why does listening to music (Olivers & Niewenhius, 2005), being in a positive mood (Olivers & Niewenhius, 2006), employing a relaxation strategy (Smilek et al, 2006) or being distracted by task-irrelevant events (Arend et al, 2006) improve performance on attentionally demanding tasks? These effects have sometimes been attributed to the benefits of positive affect on cognitive performance and at other times to the benefits of dividing attention in tasks where participants tend to overemphasize slow executive processes when rapid automatic processes will do.

What has been overlooked in these discussions is that a participant's emotional state is determined by at least two separable dimensions: one corresponding to whether the state is pleasant or aversive (affect) and another that concerns the level of activation (arousal).

Here we examine the influence of each of these dimensions on performance in a standard attentional blink task. Four emotional states were induced using a music mood induction technique combined with autobiographical memory (Eich & Macauley, 2000): calm (positive, low arousal), happy (positive, high arousal), sad (negative, low arousal), anxious (negative, low arousal).

The results showed that the attentional blink was reduced in the low arousal states relative to the high arousal states. However, this main effect interacted with affect, such that the attentional blink was most severe when participants were highly aroused and negative (anxious) and least severe when they were less aroused (sad). Participants in a positive mood had an intermediate blink that did not differ with arousal (calm, happy).

These results imply (1) that the influence of emotions on attentional control cannot be assessed without taking both affect (positive-negative) and arousal (low, high) into account, and (2) that the influence of "distraction" on attentionally demanding tasks cannot be evaluated without considering the emotional consequences of the distractions.

Attention: Training Effects and Subitizing

Author Presents: 4:00 - 5:45 pm

G29 798 Training attention: Examining interactions between the attentional, motor, and oculomotor systems

Michael Dodd[1] (mike@psych.ubc.ca), Stefan Van der Stigchel[2], Daryl Wilson[3]; [1]Department of Psychology, University of British Columbia, [2]Department of Cognitive Psychology, Vrije Universiteit, Amsterdam, [3]Department of Psychology, Queen's University

We present three experiments in which we investigate whether the recently reported interactions between central cues (e.g., arrows) and reflexive attention are attributable to the overlearned spatial properties of certain central cues. In the first two experiments, a nonpredictive cue with arbitrary spatial properties (a color patch) is presented prior to a detection target in the left or right visual field. Reaction times to detect targets are compared before and after a training session in which participants are trained to associate each color patch with left and right space, either via a target detection task in which color predicts target location 100% of the time (Experiment 1), or via a left/right motor movement as a function of color (Experiment 2). In both experiments, a small but highly significant training effect is observed. Participants are faster to detect targets at congruent locations relative to incongruent locations post-training relative to pre-training, despite the fact that cue color was nonpredictive during the test sessions. Interestingly, the magnitude of the training effect in the two experiments was identical despite the fact that one of the training tasks required a visuospatial shift of attention to complete (target detection) whereas the other training task did not (motor movement), suggesting a tight coupling between the motor and attentional systems. In Experiment 3, we examine whether our target detection and motor training tasks also influence saccade trajectory in a prosaccade task post-training. Our results provide strong evidence that interactions between central cues and reflexive attention are attributable to the overlearned spatial associations of certain cues. Moreover, the present results are consistent with premotor theory of attention in that we observe interactions between the attention, motor, and oculomotor systems.

G30 799 Stimulus-specific improvements in attention with practice

Todd Kelley[1] (tkelley@jhu.edu), Steven Yantis[1]; [1]Department of Psychological and Brain Sciences, Johns Hopkins University

Many studies have shown that task performance improves with practice. Most such improvements are the result of stimulus over-exposure leading to automatic processing, or memorized stimulus-response mappings. The question of whether or not practice can lead to improved performance through an increased ability to suppress distracting information remains open. Subjects reported whether there were more red or green dots in a randomly generated 5x5 array. On half of all trials, a distracting item (a flashing red and green disk) appeared in either the upper left or lower right corners of the display, just prior to the array onset. Early in learning, this distractor captured the subjects' attention, resulting in slower discrimination response times (RTs). As learning proceeded, this RT cost declined, and eventually it was eliminated completely. This indicates that practice resulted in improved filtering of the distracting items. For a second group of subjects, the position of the distacting items was switched to the opposite corners of the display after several blocks of learning. This almost completely abolished the practice benefit; the benefit returned, however, by the end of the session. For a third group of subjects, the distractor disks were replaced with faces after several blocks. Again, this almost completely abolished the practice benefit. These data indicate that, although improvements in distractor filtering can develop rapidly, these improvements are specific to the identity and location of the distracting items, and do not transfer to new types of information.

G31 800 Spatially specific training effects in multiple spotlight attention

Brittany S. Cassidy[1] (britcass@bu.edu), Summer Sheremata[1], David C. Somers[1,2]; [1]Boston University, Department of Psychology, [2]Boston University, Program in Neuroscience

INTRODUCTION: Visual experience has been shown to improve performance in a range of visual attention tasks (Green & Bavelier,2003). Cross-task transfer of attention-related learning demonstrates that this phenomenon is distinct from perceptual learning, which exhibits strong task specificity. Less is known about whether learning to deploy visuospatial attention exhibits location specific enhancements, which are another hallmark of perceptual learning. We have examined this issue for multiple spotlight attention (McMains & Somers, 2004) using over-trained stimuli (letters) in a multiple Rapid Serial Visual Presentation (RSVP) paradigm.

METHODS: Over four days, subjects were trained to monitor two spatially separated RSVP streams of letters among twelve streams in a divided attention task. Testing assessed target detection performance at varied eccentricities in the four visual quadrants and assessed performance differences between and within the quadrants. Different target letters were chosen for each session.

RESULTS: Training enhanced performance improved in all quadrants, with subjects requiring shorter durations to correctly detect target letters. Training effects were significantly greater within the trained quadrants than in the untrained quadrants, but the effects fully transferred to different eccentricities within the trained quadrants. Thus, training effects were specific to the quadrant of the visual field, but did not exhibit the fine spatial specificity that is common in perceptual learning tasks.

CONCLUSIONS: These reuslts demonstrate that training with divided visuospatial attention produces both global and quadrant-specific enhancements in performance. Although many questions remain, these results help to further distinguish attentional learning from perceptual learning effects.

Acknowledgement: National Science Foundation BCS-0236737

G32 801 Cognitive Rehabilitation of Patients with Hemispatial Neglect: Effects of Vigilance Training on Components of Attentional Processing

Thomas Van Vleet[1,2] (tomvanvleet@gmail.com), Joseph DeGutis[1,2], Lynn Robertson[1,2]; [1]Department of Veteran Affairs, Martinez VA, [2]University of California, Berkeley

Monday Posters

Currently there exists no generalizable, long-lasting treatment for the debilitating spatial and non-spatial deficits exhibited in patients with chronic neglect. While several experimental interventions have been developed (e.g., optokinetic stimulation, self-cueing, sustained attention training), the effects of these interventions on components of attentional processing is not well understood. In the current study we developed a novel non-spatial vigilance training intervention and assessed improvements on psychophysical measures of spatial search, object-based attention, sustained attention, and selective attention. The vigilance intervention consisted of training patients to detect a target scene in a continuous stream of distracter scenes presented at fixation. Patients were required to continually make responses to all but the target scene during 3 12-minute blocks. Patients demonstrated improved discriminability (d') and decreased reaction time over the course of 10-training sessions (2 weeks). Post-training assessment revealed significant improvement in several attentional domains (e.g., spatial search, object-based attention, sustained attention, selective attention). Notably, vigilance training promoted balanced search efficiency between contra and ispilesional space. While effects on spatial processing faded over the course of follow-up testing (1-2 weeks), benefits in non-spatial domains of attention (e.g., selective attention, vigilance) were longer-lasting. These results suggest that training non-spatial mechanisms of attention may provide beneficial short-term improvements across a number of attentional processing domains while longer-lasting benefits may be specific to the training domain.

URL: http://www.ebire.org/VanVleet/

G33 802 Abstract withdrawn

G34 803 Subitizing sets and set-based selection: Early visual features determine what counts as an individual for visual processing

Justin Halberda[1] (halberda@jhu.edu); [1]Johns Hopkins University

Human adults can select a set of items that share an early visual feature (e.g. the red dots) from a scene that contains many spatially overlapping sets (e.g. different colored dots completely spatially intermixed) and encode set-based summary representations for this selected set, e.g. approximate number of items (Halberda et al, 2006). This selection appears to take place in parallel for all items in the set across the visual field. While it is well known which features support pop-out for a single item among distractors, virtually nothing is known about which features will support the selection of an entire set of items in a visual scene. Adults viewed brief presentations of spatially overlapping sets that differed in a single feature (e.g. tilted lines among verticals) and estimated the approximate number of targets. A wide variety of features were tested separately including all those considered to support item "pop-out" and key ones that do not (e.g. complex shape). Results indicate that, just as early visual features support parallel search for a single item, they support the selection of an entire set of items in parallel (e.g. 13 tilted lines intermixed with 15 verticals) (Experiment 1). This set-based selection also shows classic asymmetry effects (e.g. tilted easier than vertical) (Experiment 2). And, as further evidence that sets function as individuals for attention, adults showed classic "subitizing" signatures for precisely enumerating up to 3 sets accurately and in parallel (Experiment 3). These results extend what counts as an "individual" for visual processing to include entire sets of items that share an early visual feature.

G35 804 Differential effects of attention on subitizing and estimation processes

Carly J. Leonard[1] (carly@jhu.edu), Howard E. Egeth[1]; [1]Psychological & Brain Sciences, The Johns Hopkins University

In a series of three experiments, the role of attention in visuospatial enumeration was examined in order to better understand differences in the mechanisms involved in subitizing and estimation. In the first experiment, 0 to 9 target items were presented during a brief masked display (150 ms), either with distractors of a different color or without these distractors, to see whether feature-based attention could be used effectively. Accurate performance in the 0 to 3 range was found only in the no-distractor condition, indicating a failure of the subitizing system in the presence of distractors. The data suggests that the approximate number system may be used for the entire range (0 to 9) when distractors are present. However, even the approximate number system was impaired in the presence of distractors, in the form of underestimation for high numerosities. These results suggest that color cannot be used to efficiently segregate multiple targets for enumeration. In a second experiment, distractors of a different color were previewed and to-be-enumerated items appeared as abrupt onsets. In this condition, performance with distractors was no longer impaired in either the subitizing or estimation ranges. Because targets and distractors still differed in color, featural inhibition of the previewed distractor color may have been critical to improved performance rather than onset alone. In a third experiment, targets and distractors shared the same color and could only be identified by differences in time of onset. Performance in the distractor condition remained strong in the subitizing range, suggesting that exogenous attentional mechanisms can provide efficient access to multiple objects. In contrast, impairments in estimation returned when targets were only defined by temporal onset. Results are discussed with regard to the differing roles of attention and feature processing in subitizing and estimation.

G36 805 Visual enumeration under load: also subitizing needs attention

Petra Vetter[1] (p.vetter@ucl.ac.uk), Bahador Bahrami[1], Brian Butterworth[1]; [1]Institute of Cognitive Neuroscience, University College London

Traditionally, the enumeration of a small number of items (1 to about 4), referred to as subitizing, has been thought of as a parallel and pre-attentive process, particularly in comparison with the enumeration of larger numerosities. Using a dual-task paradigm, we tested subitizing performance under conditions of reduced attentional resources. Participants were asked to perform a central detection task of either low attentional load (detecting a certain colour) or high attentional load (detecting a certain colour-orientation conjunction). As a secondary task, participants were asked to judge the numerosity of surrounding high contrast gabor patches amongst low contrast distractor patches. Subitizing accuracy was already significantly decreased when visual attention had to be shared between the enumeration task and the low load detection task, but was even more severely impaired when the detection task required a high amount of attentional resources (high load condition). These results reject the traditionally held notion of subitizing as an attention-independent process.

Acknowledgement: supported by the European Commission

Search I

Author Presents: 4:00 - 5:45 pm

G37 806 In Difficult Visual Search, High Frequency Targets are Found at the Expense of Low Frequency Targets

Hayward J. Godwin[1] (hg102@soton.ac.uk), Tamaryn Menneer[1], Shaun Helman[2], Kyle R. Cave[3], Nick Donnelly[1]; [1]University of Southampton, [2]Qinetiq, [3]University of Massachusetts

Previous studies have demonstrated that searching simultaneously for two dissimilar targets is very inefficient compared to searching separately for each target. This study investigated how this multiple-target cost interacts with the relative frequency of the appearance of two target classes. Response accuracy was measured during simultaneous search for either of two classes of targets, and compared against performance in independent single-target searches. Targets and distractors were complex objects, and a target was present on 50% of trials. The frequency with which the two classes of targets appeared in simultaneous multiple-target search was varied in two ways. One group of participants searched for multiple target classes that appeared with an equal frequency to one another. For the second group, one target class appeared nine times more regularly than the

Monday Posters

other. Accuracy in multiple-target search was compared with the accuracy for each target in single-target search. Accuracy was lower in multiple-target search for both targets when they appeared at an equal rate to one another, demonstrating a multiple-target cost over single-target search. However, there was no reduction in accuracy in the multiple-target search for the higher-frequency target, but there was a large reduction in accuracy for the lower-frequency target. When one target class is more frequent, effort is devoted to finding it, at the expense of finding the less frequent target class.

G38 807 Correcting a miss: Error reduction in low-prevalence search

Mathias Fleck[1] (mathias.fleck@duke.edu), Stephen Mitroff[1]; [1]Center for Cognitive Neuroscience, Department of Psychology & Neuroscience, Duke University

Failing to find a tumor in an X-ray scan or a gun in an airport baggage screening can have dire consequences, yet error rates in such tasks are alarmingly high. These visual searches are alike in that they involve detecting very rare targets, yet there is conflicting evidence about whether this factor of target prevalence is indeed causally linked to high error rates. The present study reconciles the disparate findings by revealing that prevalence-related increases in misses are attributable specifically to response execution errors, not perceptual or identification errors. When targets are rarely presented in a visual search, observers adapt by responding more quickly, which in turn leads to high error rates. However, when offered the opportunity to correct their mistakes, observers can largely eliminate such action-based errors, and in doing so no longer exhibit high miss rates during low-prevalence search. Observers participated in one of two conditions: the No-Correction condition, a replication of Wolfe, Horowitz, & Kenner (2005), or the Correction condition, an identical design except the observers were provided with the option to change their last response during the subsequent trial. Whereas the No-Correction condition confirmed previous results showing increasing error rates with decreasing target prevalence, this relationship was entirely abated in the Correction condition by observers catching their own mistakes. Accuracy and response time data support that faster speeds lead to error, that observers are cognizant of their execution-based errors, and that such mistakes are correctable. The results motivate a shift towards exploring contributions to high error rates in real-world searches beyond target prevalence.

G39 808 Do rare features pop out? Exploring the boundaries of the low prevalence effect

Anina Rich[1,2,3] (rich@search.bwh.harvard.edu), Melina Kunar[4], Michael Van Wert[1], Barbara Hidalgo-Sotelo[5], Jeremy Wolfe[1]; [1]Visual Attention Laboratory, Brigham & Women's Hospital, [2]Harvard Medical School, Harvard University, [3]School of Behavioural Science, University of Melbourne, [4]Department of Psychology, Warwick University, [5]Department of Brain & Cognitive Sciences, Massachusetts Institute of Technology

A search for a rare target in a complex display is important in a number of important tasks, including baggage screening at airport security, or screening for cancerous cells. Wolfe, Horowitz and Kenner (Nature, 435, 2005) demonstrated that the probability of missing a target increases as target prevalence decreases. These high error rates seem to occur because low prevalence encourages participants to set a response criterion that causes them to make rapid 'target-absent' responses. Wolfe et al. used complex approximations of luggage x-rays as stimuli. Last year, we demonstrated that the effect of low prevalence could be seen with less complex stimuli where the search is nonetheless relatively inefficient (a search for a T among Ls; Rich et al. VSS 2006). How far can this effect be pushed? In simple feature search tasks, the target is said to "pop-out". Would observers miss a horizontal target among vertical distractors at low prevalence? Surprisingly, error rates were significantly greater at 2% target prevalence (~14%) than at 50% (~2.5%), demonstrating that participants miss even obvious targets if they are infrequent. In a second experiment, we forced participants to wait a minimum duration before responding. This effort to reduce possible speed-accuracy trade-offs reduced miss errors at low prevalence (~5%), although this rate was still higher than in 50% prevalence minimum exposure conditions (~2%). Thus, low prevalence can induce observers to miss highly salient targets and speed-accuracy trade-offs account for most but not all of this effect.

Acknowledgement: ANR is supported by NHMRC & R.G.Menzies Fellowships (Australia)

G40 809 "Curing" the prevalence effect in visual search

Michael Van Wert[1] (mike@search.bwh.harvard.edu), Todd Horowitz[1,2], Jeremy Wolfe[1,2]; [1]Brigham and Women's Hospital, [2]Harvard Medical School

In many socially important search tasks (e.g. medical and baggage screening) targets are rare. Previously, we have demonstrated that miss error rates are 2-3 times higher at low (1-2%) target prevalence than at high (50%) prevalence (Wolfe, Horowitz, & Kenner, Nature, 2005). This prevalence effect is robust and difficult to cure. Last year, we demonstrated that it reflects a persistent shift in decision criterion, rather than a loss of sensitivity (Van Wert, Horowitz, Place, & Wolfe, VSS06). At low prevalence, observers make more misses and fewer false alarms. In settings where miss errors are much less desirable than false alarms, we could "cure" the prevalence effect if we could get observers to maintain the high prevalence criterion (roughly equal false alarms and miss errors) during low prevalence search. Stimuli were simulations of baggage assembled from x-ray images of weapons and non-weapon objects. Bags contained 3, 6, 12, or 18 objects. Observers searched for guns and knives. In Experiment One, we added brief bursts of high prevalence trials to long periods of low prevalence search. This didn't work. Observers rapidly shifted criterion to the desired point when prevalence was high, but just as rapidly shifted back when prevalence was low. In Experiment Two, however, we had greater success by manipulating feedback. Observers received no feedback during low prevalence search and full feedback during 40-trial, high prevalence retraining episodes. Without retraining, miss error rates were 0.45 with these stimuli at low prevalence. With retraining, the low prevalence miss rate was 0.21, essentially the same as the 0.18 high prevalence rate. This retraining strategy may be practical in the field. Periodic high prevalence retraining with full feedback could proceed off-line, while the actual screening of baggage or medical images could proceed at low prevalence with minimal feedback.

URL: http://search.bwh.harvard.edu

G41 810 Faster is not necessarily better in visual search

David E. Fencsik[1,2] (fencsik@search.bwh.harvard.edu), Skyler S. Place[3], Jeremy M. Wolfe[1,2], Todd S. Horowitz[1,2]; [1]Visual Attention Lab, Brigham and Women's Hospital, [2]Department of Ophthalmology, Harvard Medical School, [3]Department of Psychological and Brain Sciences, Indiana University

How does the visual system use speed to guide visual search? According to the absolute speed hypothesis, proposed by Ivry and Cohen (1992), the fastest moving object in the environment is the most salient and readily captures attention. This hypothesis is supported by Ivry and Cohen's visual search studies showing that faster-moving targets among slower-moving distractors are more readily detected than vice versa. An alternative is the relative speed hypothesis, proposed by Rosenholtz (1999, 2001), according to which an object's salience depends on the absolute difference between its speed and the average speed in the environment. Rosenholtz argued that the bidirectional motion of the stimuli used by Ivry and Cohen may have enhanced the salience of their faster-moving stimuli, thereby confounding the experimental design. Here, we present a series of new experiments in which we replicate Ivry and Cohen's studies with stimuli that all move in one direction only. These experiments eliminate the confound and allow us to pit the predictions of the two hypotheses against one another. We found that a target moving 3.2°/s slower than the distractors was detected as quickly and accurately as a target moving 3.2°/s faster. Furthermore, a target moving 0.8°/s faster than the distractors was more difficult to detect than the slower target. These results reject the absolute speed hypothesis and support the relative speed hypothesis (and, by extension, Rosenholtz' general salience model). The visual system is not biased towards faster-moving objects at the expense of slower-moving ones.

Acknowledgement: Supported by NIH MH65576 to TSH
URL: http://search.bwh.harvard.edu/

G42 811 Time to Guide: Evidence for Delayed Attentional Guidance in Contextual Cueing

Melina Kunar[1] (M.A.Kunar@warwick.ac.uk), Stephen Flusberg[2], Jeremy Wolfe[3,4]; [1]The University of Warwick, UK, [2]Stanford University, [3]Brigham & Women's Hospital, [4]Harvard Medical School

Contextual cueing experiments show that when displays are repeated, reaction times (RTs) to find a target decrease over time even when the observers are not aware of the repetition. Recent evidence suggests that this benefit in standard contextual cueing tasks is probably not due to an improvement in attentional guidance (Kunar, Flusberg, Horowitz & Wolfe, submitted). Perhaps spatial layout information can guide search through a repeated display when participants are given a sufficiently long time to encode the display. In Experiment 1, we increased the display complexity so that it took participants longer to find the target. Here we found a larger effect of guidance by spatial layout than in a condition with shorter RTs. Experiment 2 gave participants prior exposure to the spatial layout, by either presenting empty placeholders marking the general location of the items or pre-masks that offset at the exact locations of the search stimuli. In the pre-mask condition where there was an exact match between mask and search array, participants could use spatial layout to guide attention to the target. This was not true for the placeholder stimuli. These results suggest that guidance by the remembered spatial layout of a display is possible but slow. The standard contextual cueing benefit may be, in part, due to other mechanisms such as response priming.

Acknowledgement: National Institute of Mental Health

G43 812 Is superior visual search in autism due to memory in search?

Todd Horowitz[1,2] (toddh@search.bwh.harvard.edu), Jeremy Wolfe[1,2], Brandon Keehn[3], Christine Connolly[4], Robert Joseph[4]; [1]Brigham & Women's Hospital, [2]Harvard Medical School, [3]University of California, San Diego, [4]Boston University School of Medicine

Plaisted and colleagues (J Child Psychol Psychiatry, 1998; JEP:HPP, 2001) demonstrated that children with autism are superior to typically developing children at visual search. They suggested that this superiority might be mediated by better memory for rejected distractors in autism. Horowitz & Wolfe (Nature, 1998) have previously argued that typical adults use little or no memory for rejected distractors. This conclusion relied on the randomized search paradigm in which a static control condition is compared to a dynamic condition in which stimuli are continually replotted during a trial, preventing any use of memory. If observers use memory in the static condition, RT X set size slopes would double in the dynamic condition. Studies on typical adults show similar slopes in the two conditions, though mean RTs are higher for dynamic search. We repeated this experiment with 18 children with autism and an age- and IQ-matched control group of typically developing children (ages 7-19). Measures of eye movement and RT were collected. The autism group responded faster than the control group. However, static and dynamic search were equally efficient for both groups. Children with autism do not use memory differently. Instead, they seem to respond more quickly once they locate a target. Analysis of eye movement patterns showed few differences between conditions or groups. Notably, neither group showed evidence of "sitting-and-waiting" for the target to come to them in the dynamic condition (c.f. von Mühlenen et al., Psychol Sci, 2003).

Acknowledgement: NICHD/NIDCD CPEA U19-DC-03610, NIMH K01-MH-073944, AFOSR F49620-97-1-0045

G44 813 The Breakdown of Color Selectivity in Multitarget Search: Evidence from Eye Movements

Kyle Cave[1] (kcave@psych.umass.edu), Tamaryn Menneer[2], Michael Stroud[1], Nick Donnelly[2], Keith Rayner[1]; [1]Psychology Department, University of Massachusetts Amherst, [2]School of Psychology, University of Southampton

Purpose. In difficult visual searches for a specified target, attention and eye movements are directed towards stimuli with features belonging to that target. Can search be directed simultaneously by more than one target? In most cases, searching for two targets simultaneously results in lower performance compared with conducting two independent searches, one for each target. By tracking eye movements during search, we were able to explore why there is a cost in searching for two targets simultaneously.

Method. In this search task, the stimuli were color-shape conjunctions, each comprising a combination of simple rectangular components, combined in one of four different ways. Each object was made of one or two colors, with a range of different colors being used across different objects. Each target was defined by a combination of shape and color. In Experiment 1, the targets differed from each other in shape, whereas in Experiment 2 the targets differed in both color and shape. Participants were students, with no previous experience in this search task.

Results. During single and dual-target searches for a target or targets of one color, with distractors of many different colors, most fixations were targeted at objects with a color similar to the target. However, in simultaneous search for two different-colored targets, there were more fixations to objects with colors that were different from either target.

Conclusion. Selection by color is very effective in single-target search and in dual-target search for same-color targets, but when two targets vary in the color dimension as well as shape, color selection breaks down to some extent, allowing the selection of objects that have a color that is not similar to either target.

Acknowledgement: Supported by the Human Factors Program of the Department of Homeland Security's Transportation Security Laboratory.

G45 814 People like big, bright things: Investigating the effects of saliency on visual search.

Yi-Fang Tsai[1] (ytsai1@gmu.edu), Matthew Peterson[1]; [1]Psychology Department, George Mason University

According to the saliency theories of visual search, basic features like luminance, orientation, and size are extracted in parallel across the visual field. Activation in a master saliency map is determined by local differences between these features, and this activation determines the allocation of attention (Itti & Koch, 2001). In a previous experiment, luminance was found to follow the saliency hypothesis that attention will visit items in order of their salience (Tsai & Peterson, 2006). In this study, participants were tested using a visual search task involving a target and distractor items arranged in a circle around the periphery of the display. The feature dimensions tested were luminance, orientation, and size. Salient objects were brighter, darker, larger, smaller, or more tilted than the other objects in the display. In addition, each display contained two salient objects, with one more salient than the other (psychophysically matched). The target coincided with any of the items at chance level. Subjects were faster to report the target in the brightest, darkest, or largest trials when it occurred in the most salient item. However, in contrast to the predictions of the saliency model, this speed advantage disappeared when the target appeared in the second-most salient item. That is, attention was biased to visit the most salient item first, but this bias did not extend to the visiting the second-most salient item next. In the conditions where the most salient item was the smallest or defined by orientation, there were no significant effects on reaction times.

G46 815 **Manipulating the Availability of Visual Information in Search.**

Joseph Schmidt[1] (schmidtjoseph@hotmail.com), Gregory Zelinsky[1]; [1]Stony Brook University

Visual search studies typically assume that an exact picture of the target is available to guide the search process, but targets are often defined categorically, with varying degrees of visual specificity. Is search still guided to complex targets in the absence of pictorial target descriptions? We manipulated the availability of target visual information in three target preview conditions: (1) a picture of the target (e.g., an orange), (2) a visually precise target label (e.g., the word "orange"), and (3) a visually imprecise target label (e.g., the word "fruit"). The preview was followed by a search display depicting 5 pictures of photorealistic objects; no pictures or object categories were repeated. Consistent with the literature, we found strong evidence for guidance to pictorial targets. Compared to the non-pictorial conditions, pictorial search was faster (1961 ms vs. 2675 ms), required fewer fixations to reach the target (1.94 vs. 2.87), and subjects fixated on fewer distractor objects before the target (.57 vs. 1.17). Importantly, guidance differences were also found between the two non-pictorial target conditions. Compared to imprecise-label search, precise-label search was again faster (2510 ms vs. 2840 ms) and resulted in fewer fixations to the target (2.71 vs. 3.03) and fewer fixated distractors before the target (1.07 vs. 1.26). However, in all conditions, even with an imprecise target label, we found above chance levels of guidance as measured by the cumulative probability of target fixation. We interpret these data as broadly suggesting that guidance is related to the availability of target-defining visual information. Moreover, this visual information need not be obtained from a picture of the target. Although generally less precise, to the extent that visual information can be extracted from a target label and loaded into working memory, this information too can be used to guide search.

G47 816 **Simple Summation Rule for Optimal Eye Movement Selection**

Jiri Najemnik[1] (najemnik@mail.cps.utexas.edu), Wilson Geisler[1]; [1]Center for Perceptual Systems and Department of Psychology, University of Texas at Austin

Humans can achieve near-optimal fixation search performance when compared to a Bayesian ideal searcher constrained with the human map of target detectability (d-prime) across the visual field (Najemnik & Geisler, 2005). Yet, the computations performed by the ideal searcher to select the next fixation location are nonlinear and complex, and hence seem improbable for an implementation within a biological nervous system. Here, we present a simple summation rule for optimal fixation selection in visual search. Specifically, we show that a weighted sum across the current priors on the target's location is an accurate measure of how much information about the target's location will be obtained for any considered next fixation. This weighted summation formula (the weights are the squares of the d-primes) becomes an exact expression in the limiting case of an infinite number of independent potential target locations across the search area, but serves as an excellent approximation even when the number of independent potential target locations is relatively small. We show that the new rule generally achieves search performance equal to that of the Bayesian ideal searcher. Currently, the most prevalent candidate rule for efficient fixation selection in visual search is a maximum a posteriori (MAP) rule. A MAP searcher always fixates the location with the highest posterior probability of containing the target. The MAP rule achieves a near-optimal search performance, but has a distribution of fixation locations across the search area that is very different from that displayed by both humans and the Bayesian ideal. The simple summation rule, on the other hand, leads to a human-like distribution of fixation locations, making it a plausible candidate for use by the nervous system. Other non-search applications of the summation formula will be discussed, such as its implications for efficient coding.

Acknowledgement: Supported by NIH grant EY02688

G48 817 **Perceptual Complexity in Visual Displays**

Jing Xing[1] (jing.xing@faa.gov), Chen Ling[2]; [1]Mike Monroney Aeronautics Center, Federal Aviation Administration, [2]School of Industrial Engineering, University of Oklahoma, Norman, OK

Information complexity of visual displays has become a bottleneck that limits their usefulness. Much of the research in visual complexity has been devoted to what makes a visual pattern complex and how to mathematically model complexity. However, what has been largely neglected in the research is the fact that complexity depends on how the information is intended to be used. Our approach to the complexity problem is to develop complexity measures from the perspective of users' task requirements. Previously we have identified three fundamental complexity factors: quantity and variety of basic information elements, as well as the relation between the elements. In this study, we first determined the generic perceptual tasks involved in using visual displays in time-demanding jobs such as air traffic control. The tasks include: 1) Instantly detecting onset of salient stimuli; 2) quickly and reliably searching for information; and 3) continuously monitoring (reading) text. We then developed three metrics of perceptual complexity based on the three complexity factors and these task requirements. The first metric is the number of fixation groups. A fixation group is defined as the visual stimuli that can be perceived by one fovea fixation. The second metric is the variety of basic visual features such as color, luminance contrast, symbol / texture, and spatial frequency (or size). The third metric is the effect of spatial masking. We experimentally tested these metrics with 20 screenshot images from several air traffic control displays. Eighteen subjects ranked the perceptual complexity of the images from the perspective of the task requirements described above. The subjects also quantitatively estimated the three metrics. The results indicated that all the three metrics were positively correlated with the complexity ranking. Yet, more data are needed to elucidate the mathematically relationship between the perceived visual complexity and individual metrics.

G49 818 **Eye movements across the macaque visual field during visually and memory guided search**

Bernard P. Gee[1,2] (bgee@cvs.rochester.edu), William H. Merigan[1,2]; [1]University of Rochester Eye Institute, [2]Center for Visual Science

A single saccade paradigm was developed to study search eye movements across the visual field of the macaque. We measured both visually and memory guided saccades during a search task performed monocularly within the central 30 deg field of view. Monkeys were required to make an eye movement to a cued target among zero to seven distractors. Positional jitter was used to make target and distractor locations unpredictable from trial to trial. Target and distractors were black discs presented on a gray background and targets could be either smaller or larger than the distractors.

Saccade metrics, such as latency and accuracy, were analyzed. Saccadic latency was defined as the duration from initial fixation offset to the beginning of the eye movement. Visually guided search showed shorter latencies than memory guided and did not differ with eccentricity. Memory guided search latencies decreased with eccentricity.

Saccade accuracy was evaluated by the distance from the saccadic endpoint to the target. Accuracy decreased with search eccentricity, and compared to visually guided search, memory guided eye movements were less accurate with more variability in saccadic endpoint location and became more hypometric with increasing eccentricity. In general, saccade endpoint variability increased with greater eccentricity.

Eye movements were also examined in each major visual field region. No consistent nasal-temporal field differences were found. Test subjects displayed the most accurate visually-guided saccades in the superior field.

For both visually and memory guided trials, search eye movements to the superior visual field were predominately hypermetric, while saccades in the other visual field regions were predominately hypometric.

Acknowledgement: Supported by NIH grant P30 EY01319 and Research to Prevent Blindness

G50 819 Where would you look? Guiding visual search with global spatial information.

Jeremy Wolfe[1,2] (wolfe@search.bwh.harvard.edu), Ester Reijnen[3], Hareem Ahmad[4], Michael VanWert[1]; [1]Visual Attention Lab, Brigham & Women's Hospital, [2]Ophthalmology, Harvard Medical School, [3]University of Basel, Switzerland, [4]Massachusetts Inst. of Technology

If you were looking for electrical outlets, your search would be guided by knowledge of where outlets are typically located. This differs from other forms of attentional guidance in visual search. You would not be guided by target features (as in a search for red among green) nor would you be guided by specific location information (as in spatial cueing experiments). Rather you would be guided by what could be called global or distributed spatial information (e.g. outlets are typically found on walls, near the floor). How does distributed spatial guidance compare to other forms of guidance? Observers viewed an unchanging loose pyramid of cubes. Each cube had three visible surfaces: the top and two sides. Cube tops did not form a coplanar surface. On each trial, Ts and Ls were distributed randomly over these surfaces and observers searched for the letter T. There were three conditions. In the No Guidance condition, observers simply searched for a T. In the Color Guidance condition, one third of items were red and observers were told that the T, if present, would be red. In the Global Location Guidance condition, observers were told that the T, if present, was on the top of a cube. The slope of the RT x Set Size function was 42 msec/item in the No Guidance condition. Color Guidance produced a slope of 18 msec/item, roughly what would be expected if observers restricted search to red items. Global Location Guidance produced a steeper slope (24 msec/item) and a substantially higher intercept (815 vs 615 msec for Color Guidance). Even in a fixed scene, global spatial information appears to take longer to become effective. Perhaps feature guidance can occur in a feed-forward manner while global spatial information requires reentrant processing.

Acknowledgement: supported by NIMH & AFOSR
URL: http://search.bwh.harvard.edu

G51 820 Searching for a target word in a web page: the three components of information seeking behavior

Rigutti Sara[1] (rigutti@psico.units.it), Fantoni Carlo[1], Walter Gerbino[1]; [1]Department of Psychology, University of Trieste, Italy

Although the role of web page layout has been found to affect the Information Seeking Behaviour ISB, cognitive models of web navigation emphasize semantic aspects: the higher the similarity between user's goal and label meaning the easier the selection. We report research demonstrating that ISB is driven by the implicit knowledge of the item to which a target word is most likely to belong (bar for basic vs. embedded links for subordinate), and on reading direction (from top to bottom regions of the page), rather than by a semantic alone component.

The effectiveness of each ISB component was studied in three experiments using a simulated web page. Observer performed a visual search for a target non-word (in experiment 1) or a target word (basic vs. subordinate in experiment 2 and 3). Within each positive trial, the label matching with the target were displayed in one of six possible positions: three within the navigation bar and three within the embedded links. In experiment 1 and 2 the navigation bar was on the top region while embedded links were on the bottom and vice-versa in experiment 3.

Results of experiment 1 was consistent with reading direction effectiveness: speed for searching the target non-word was larger when the label that matched was at the top. In experiment 2 and 3, visual search was faster for the basic target word than subordinate when the label that matched was in the bar: no matter on bar spatial position. The opposite occurred when the term matching the target was in the embedded links.

A weighted linear combination of all three ISB components explained the data trend. Overall results are relevant for both a broader view of web navigation modeling and a better understanding of ISB.

G52 821 Rapid Resumption: Temporal Asynchrony Reveals Contents of Perceptual Hypotheses

James Intriligator[1] (j.intriligator@bangor.ac.uk), Helen Tibboel[2], Chie Takahashi[1], James T. Enns[3]; [1]School of Psychology, University of Wales, Bangor, UK, [2]Department of Psychology, Ghent University, Belgium, [3]Department of Psychology, University of British Columbia, Canada

Visual search can be resumed more rapidly following display interruptions than it can be initiated to new displays (Lleras, Rensink & Enns, 2005). Studies of display changes during interruptions suggest these rapid responses are based on perceptual hypotheses regarding task-relevant features of the target (Lleras, Rensink & Enns, in press). Here we use asynchronous feature onsets to reveal the contents of such perceptual hypotheses. We reasoned that briefly delaying the onset of an attribute critical for rapid resumption (RR) would delay such responses.

Participants searched for a target T among L distractors and reported its color (blue, red) as rapidly as possible. Each search item consisted of a black shape (T or L) overlaid by a colored disk. Displays were presented for 100 ms "looks," interrupted by 1200 ms "waits," until target color was reported. Three different display types were intermixed across trials: shapes and colors onset and offset simultaneously (standard), black shapes appeared on gray disks for 30 ms before color was added (shape first), and colored disks appeared for 30 ms before shapes were added (color first).

Correct response times (RT) following the first look began after 600 ms but on subsequent looks RT began after 300 ms, a signature of the RR effect. RT distributions for standard and shape-first displays were identical; indicating that delayed onset of color information did not impact RR. In contrast, color-first displays had RT distributions delayed by approximately 100 ms on all epochs after the first look, pointing to the critical role played by shape in the perceptual hypotheses used in target confirmation.

We conclude that asynchronous feature onset in interrupted search tasks can help elucidate the contents of mental representations held during display interruption. We discuss how this paradigm can help reveal representations used in a variety of cognitive tasks.

G53 822 Evaluating the Ability of Visual Search Models Suggested for Computer-Vision to Predict Human Performance

Yaffa Yeshurun[1] (yeshurun@research.haifa.ac.il), Tamar Avraham[2], Michael Lindenbaum[2]; [1]Psychology Department, University of Haifa, Israel, [2]Computer Science Department, Technion, Israel

The COVER and FLNN algorithms were previously suggested for computer-vision visual search (Avraham and Lindenbaum, 2006). These computer-vision models capture the dependency of search difficulty on distracters' homogeneity and target-distracters similarity, as was suggested originally in Duncan and Humphreys (1989). In this study, we extended those models to account for internal-noise, and evaluated their ability to predict human search performance. In four experiments, observers searched for a tilted target presented among distracters of different orientations (orientation-search) or a gray target appearing among distracters of different colors (color-search). Distracters' homogeneity and target-distracters similarity were systematically manipulated. Search performance was then used to test our models. We compared our models to several prominent models of visual search including a SDT-based model (e.g., Palmer, Ames, and Lindsey 1993), the Temporal-Serial model (e.g., Bergen and Julesz 1983, Eckstein 1998), the saliency model (Rosenholtz 1999) and the Best-Normal model (Rosenholtz 2001). In comparison to these models of visual search, our models' predictions were the closest to human performance.

G54 823 **ROC curves refute an unequal-variance account of search asymmetry**

Richard Murray[1] (rfm@yorku.ca); [1]Centre for Vision Research, York University

One of the most unexpected phenomena of visual search is search asymmetry: the finding that switching the targets and distractors in a search task can drastically change the difficulty of the task. A well-known example is that it is easier to locate a letter C among O's than to locate an O among C's. One proposed explanation for such search asymmetries, based on signal detection theory, is that the internal responses generated by the two targets have different variances. We tested this explanation by measuring ROC curves. Method Three observers detected a C among O's, and vice versa, at contrast threshold, at set sizes one and eight. Observers responded on a six-point confidence rating scale, and we used the rating responses to generate ROC curves. Results At set size one, the slope of the ROC curves indicated approximately equal variances for the internal response distributions of letters C and O. At set size eight, the slope of an ROC curve does not directly indicate the ratio of the standard deviations of the responses evoked by C and O. However, a more careful analysis can still recover this ratio, and indicated that at set size eight, the response distributions for C and O again had approximately equal variances. Conclusions These findings are qualitatively inconsistent with the unequal-variance account of search asymmetry, which requires that the internal response distribution evoked by the easier target, in this case the letter C, has a greater variance. We will consider what alternative theories of visual search are consistent with these results.

URL: www.yorku.ca/rfm

G55 824 **Collaborative search in real-world scenarios**

Kelly A. Malcolmson[1] (ka2malco@watarts.uwaterloo.ca), Michael G. Reynolds[2], Daniel Smilek[1]; [1]Psychology, University of Waterloo, [2]Psychology, Trent University

Visual search is often a collaborative process. For instance, pairs of individuals will search luggage during security checks and physicians will collaboratively search for abnormalities in x-ray images. In three experiments we compared the search performance of two people searching together (collaborative condition) with the pooled performance of the two individuals searching separately (nominal condition). In Experiment 1, search in the collaborative condition was compared to search in a nominal condition in which the individuals worked separately and at the same time (i.e., in parallel). In Experiments 2 and 3, search in the collaborative condition was compared to search in a nominal condition in which pairs worked sequentially. Experiment 2 was designed to simulate security search and so any targets found by the first individual in the nominal pair were removed so that the second individual received fewer target items. Experiment 3 was designed to simulate medical diagnosis of X-rays by providing the second searcher in the nominal pairs with the responses given by the first searcher in the pair. In all experiments collaborative pairs were less likely than nominal pairs to correctly detect a target and they were less likely to make false alarms. Additionally, signal detection analyses revealed that collaborative pairs were more sensitive to the presence of the target and had a more conservative response bias than the nominal pairs.

Acknowledgement: This research was supported by a grant to D.S., a postdoctoral fellowship to M.G.R. and a graduate scholarship to K.A.M from the Natural Sciences and Engineering Research Council (NSERC).

Eye Movements: Effects on Perception

Author Presents: 2:00 - 3:45 pm

G56 825 **New results in motion constancy during smooth pursuit eye movements.**

Camille Morvan[1] (camille.morvan@college-de-france.fr), Jacques Droulez[1], Mark Wexler[1,2]; [1]LPPA, Collège de France/CNRS, [2]LPP, Université Paris 5/CNRS

Smooth pursuit adds a velocity field to the retinal image in the eyes opposite direction. To correctly perceive the objects physical motion, the visual system must compensate for this self-induced motion. Compensation is usually assumed to involve combining the retinal signal with an extra-retinal eye velocity estimate. According to the linear model, the estimated eye velocity is added to the retinal signal: the resulting motion is perceived as the physical stimulus motion. The linear model gained wide support from studies using collinear motion, and velocities close to the pursuit-target velocity. Furthermore, the pursuit-target has typically been available as a visual referent, allowing observers to judge object-relative rather than absolute motion. Such object-relative information would yield an egocentric bias in the responses. We studied the compensation problem using stimuli moving in different directions with a wide range of speeds. Furthermore, we eliminated the visual referent by relying on residual pursuit after the pursuit-target is extinguished. We fit the linear model to our data, and obtain an extraretinal gain of 0.4, which is in agreement with the eye velocity underestimation reported in the literature. However, we find that compensation for eye movements varies dramatically as a function of retinal motion along the axis of pursuit: retinal motion is compensated when is in the eyes opposite direction, but is perceived largely uncompensated for motion on the retina in the same direction as pursuit. These results contradict the linear model, and suggest that the compensation depends not only on eye movements but also on retinal information: stimulus direction and speed. Thus, our data challenge the classical view that compensation is derived solely from extraretinal sources. We suggest instead that retinal motion is compensated by an eye movement estimate derived from a combination of extraretinal and retinal signals, the latter based on a stationarity assumption.

URL: http://camille.morvan.free.fr/

G57 826 **Motion aftereffects of plaid stimuli for smooth pursuits**

Kazumichi Matsumiya[1] (kmat@riec.tohoku.ac.jp), Satoshi Shioiri[1]; [1]Research Institute of Electrical Communication, Tohoku University

After the adaptation to the moving stimulus that is composed of high and low spatial frequency sinusoidal gratings moving in the opposite directions, observers perceive motion aftereffect (MAE) in the direction opposite to the high and low spatial frequency components with static and flicker tests, respectively. (Shioiri & Matsumiya, VSS 06). We showed that smooth pursuit eye movements (SPEM) after the adaptation followed the similar pattern of MAE percept at a static test (Matsumiya & Shioiri, VSS 06). The present study investigated direction of MAE percept and SPEM after the adaptation to a plaid stimulus with static and dynamic tests. An adaptor was composed of two gratings with different spatial frequencies moving in the orthogonal directions of plus or minus 45 deg. The test stimulus was the same as the adaptor except for motion. The test was either static or 4Hz-flickered. The adaptor was presented for 20 s and followed by test gratings. Test stimulus was presented for 2 s and observers adjusted the direction of a probe to indicate the direction of MAE. We varied the contrast of the high spatial frequency grating with fixed contrast of the low spatial frequency grating to examine the effect of relative strength of MAE between the two components. High spatial frequency superiority of MAE was found for both perception and SPEM with the static test. The direction of SPEM as well as the MAE direction was closer to the opposite of the motion of the high spatial frequency grating than that of the low spatial frequency grating. Similarly, perception and SPEM showed low spatial frequency superiority of MAE with the flicker test. We also found that the effect of contrast was similar for perception and SPEM with both tests. These results suggest that pursuit and perception share a motion processing system.

Acknowledgement: This study was supported by Grant-in-Aid for Scientific Research #18330153 and #18047005 to S.S. and #18700253 to K.M.

G58 827 **Motion sensitivity changes depending on saccadic direction before saccadic eye movement**

Hyung-Chul Li[1] (hyung@kw.ac.kr); [1]Department of Industrial Psychology, Kwangwoon University

Monday Posters

A number of psychophysical studies have shown that non-veridical spatial perception is induced before saccades; the mislocalization of a flashed light in the direction of saccades, perceptual space compression toward a saccadic target, and bias in perceived direction opposite to the direction of saccades. In addition to this, physiological studies have reported some significant changes in neural firing rates at the LGN and visual cortex of cats and humans just prior to saccades. These psychophysical as well as physiological findings suggest that changes in motion sensitivity occur before saccades, and we examined this. Subjects were presented with a random dot kinematogram comprised of 100 random dots for 100 msec just before saccades. We manipulated the coherence rate (2%, 5%, 9%, 15%, 30%) of the random dots moving in a coherent direction among random dots moving in random directions as well as the consistency of the direction of motion signals and that of saccade (the same vs. the opposite). The subjects' task was to indicate whether the perceived global motion direction for the presented kinematogram was leftward or rightward. Eye fixation condition was also examined as a control condition. The coherence motion threshold was much lower in the case of the "same" condition while it was much higher in the "opposite" condition than in the fixation condition. These results imply that motion sensitivity changes significantly before saccades and that it depends on saccadic direction, suggesting that the neural correlates responsible for the motion sensitivity that change before saccade should be explored further.

Acknowledgement: Supported by the MIC Korea, under the ITRC support program supervised by the IITA-2005-C1090-0502-0038

G59 828 Abstract withdrawn

G60 829 TMS over the posterior parietal cortex disrupts transsaccadic memory

Steven L Prime[1,2] (sprime@yorku.ca), Michael Vesia[1,3], J. Douglas Crawford[1,2,3]; [1]Centre for Vision Research, York University, [2]Department of Psychology, York University, [3]Department of Kinesiology and Health Sciences, York University

We previously reported that transsaccadic memory has a similar capacity for storing simple visual features as basic visual memory (Prime & Crawford, VSS abstracts, 2006). Here, we tested how many object features and locations could be retained across saccades while applying single-pulse transcranial magnetic stimulation (TMS) over the right dorsal posterior parietal cortex (PPC). Five subjects were presented with a random number of targets (1, 3, 4, 5, 6, or 8) with different spatial positions and orientations. Subjects were instructed to fixate and remember the positions and orientations of the targets. Then, subjects made a saccade to a different random location and were presented with a probe at the same location as one of the pre-saccadic targets, but tilted 9E clockwise or counter-clockwise. Subjects made a force-choice response to indicate how the probe's visual feature differed from the original target. In each trial, we randomly delivered a single-pulse at one of seven different time intervals centred around the saccade-go signal (-300ms, -200ms, -100ms, 0ms, +100ms, +200ms, +300ms). Thereby, allowing us to obtain information of the timing of the contribution of the right PPC during task performance (causal chronometry). Our preliminary data shows that performance was disrupted during stimulation of the right PPC, particularly between 100ms to 300ms after the saccade-go signal. Stimulation at the other time intervals showed no statistical differences compared to the baseline (no TMS). The findings suggest that TMS over the right PPC transiently disrupt the putative spatial processing involved in transsaccadic memory.

Acknowledgement: Saihong Yan and Lauren Sergio for technical assistance

G61 830 Short-term and long-term influences on perisaccadicmisperceptions

Antonella Kis[1] (atorok9@yahoo.com), Matthias Niemeier[1,2]; [1]University of Toronto at Scarborough, [2]Center for Vision Research, York Univ.

The location of stimuli briefly flashed around the time of the saccade is misperceived. For example, often participants report a shift of the flashes in saccade direction. The mechanisms underlying these perisaccadic misperceptions remain poorly understood. Possible explanations include an increased uncertainty about the temporal alignment of visual information and eye position information, influences of spatial shifts of attention, and inaccuracies in the spatial representation of saccade targets. Here we manipulated saccade onset times as well as attention and spatial encoding by presenting saccade targets either at a location that was highly predictable or at a location that occurred less frequently. Predictable and unpredictable locations could change either slowly, across blocks of trials (experiment 1), or quickly from trial to trial (experiment 2). We found that saccades were slower for unpredictable target locations and flashes were perceived as more shifted on that side. However, saccade latencies and shifts were only poorly correlated, and the difference in shift vanished when predictable and unpredictable locations changed from trial to trial. Our data are not supportive of transient effects. Instead, they indicate a dominant influence of longer-term mechanisms, perhaps related to learning processes in the oculomotor system.

G62 831 Spatial context confines and distorts undergoing smooth pursuit mislocalization

Yasuki Noguchi[1] (noguchi@nips.ac.jp), Shinsuke Shimojo[1,2]; [1]California Institute of Technology, [2]JST/ERATO Shimojo Implicit Brain Research Project, Japan

The position of a flash presented during a smooth pursuit eye movement is mislocalized in the direction of the pursuit. This has been explained by a temporal mismatch between the slow visual processing of the flash and fast efferent signals for present eye position. Here we tested whether spatial context would also influence the perceived position of the flash. We put various continuously-lit objects (walls) between the veridical flash location and position where the flash would normally be mislocalized. Walls significantly reduced the mislocalization of the flash, largely preventing the flash from being mislocalized beyond the wall. No change in eye movements was observed that would reduce the mislocalization. When the wall was shortened or had a hole in its center, the number of trials in which the flash was mislocalized beyond the wall increased, but in those trials, the flash was vertically shortened as if cut off or funneled by the wall. The wall also induced color interactions – a red wall made a green flash appear yellowish if it was in the path of mislocalization. Finally, the critical time period for the presentation of the wall was found to be after the disappearance of the flash. These results indicate that features of the flash in pursuit-induced mislocalization are postdictively determined using broad spatial and temporal integration windows, which provides a new insight as to why the afferent signals of the flash are so delayed compared to the efferent eye-position signals.

G63 832 Perisaccadic flash mislocalization suggesting compression of visual space may come from a simple monotonic extraretinal signal whose onset time varies across the retina

Jordan Pola[1] (jpola@sunyopt.edu); [1]SUNY State College of Optometry

Mislocalization of a perisaccadic flash can vary according to the physical location of the flash relative to the saccade, especially when the saccade occurs in the presence of a continuous background stimulus (e.g., Ross et al., 1997; Lappe et al., 2000). For example, mislocalization tends to be in the saccade direction if the flash is near the saccade starting point, whereas the mislocalization is opposite to the saccade direction if the flash is beyond the saccade endpoint. These findings have been interpreted as reflecting a neural process concerned specifically with a transient compression of visual space. I have proposed a model showing that perisaccadic flash mislocalization comes from flash retinal signal persistence interacting with a post-saccadic monotonic extraretinal (exR) signal (Pola, 2004). This model simulates mislocalization when a saccade occurs in the dark, a visual circumstance in which there is little or no indication of compression. In contrast, the prior studies (above) involving a background, insofar as they suggest the existence of compression, raise the possibility that a background modifies the exR signal. I have used my model to explore what sort of exR signal modification might occur. The model suggests that a continuous background stimulus does not result in a process concerned specifically with compression. Instead, the background may simply have the effect of varying the exR signal onset time across the retina, e.g., the

Monday Posters

onset begins before the saccade for retinal loci corresponding to a flash near the saccade starting point, whereas the onset begins after the saccade for retinal loci corresponding to a flash beyond the saccade endpoint. This variation in onset time gives rise to many of the features of background-contingent flash mislocalization.

G64 833 Temporal interaction between visual and saccade-related signals in perceptual localization

Jan Churan[1] (jan.churan@gmail.com), Alby Richard[1], Christopher Pack[1], Daniel Guitton[1]; [1]Department of Neurology and Neurosurgery, Montreal Neurological Institute, McGill University

Subjects often mislocalize the position of visual targets that are presented near the time of saccade onset (Ross et al 1997). This mislocalization is manifested as a perceived compression of visual space toward the saccade target and a shift in the direction of the saccade. One explanation for the pre-saccadic spatial shift is that afferent processing delays cause uncertainty about the timing of localization targets (LTs) with respect to saccade onset (e.g. Schlag & Schlag-Rey 2002). However, in recent studies, varying the afferent processing delays by modulating luminance or contrast of LTs did not strongly affect the spatial shift (Boucher et al. 2001, Michels & Lappe 2004). To further investigate the role of afferent delays, we measured localization errors as well as the perceived temporal relationship between LT presentation and saccade onset, for different saccade amplitudes and LT luminances.

We found that the temporal relationship between saccade onset and LT presentation was systematically misperceived by all subjects. This temporal error is consistent with timing differences between incoming visual information and the eye-position signals, and it is greater for LTs at low luminance. Furthermore, spatial localization errors for LTs flashed in a time window between 50 ms before and 20 ms after saccade onset were dependent on both stimulus luminance and saccade amplitude. High LT-luminance in particular resulted in a reduced spatial shift.

These changes in spatial perception at different luminance levels are consistent with the idea that afferent delays play an important role in generation of pre-saccadic localization errors. The effect of saccade amplitude on perisaccaic spatial localization may be taken as further evidence for the interaction of the eye position signal and visual signals in modulating the resulting perceptual errors.

Acknowledgement: Supported by CIHR and NSF cognitive neuroscience grant

G65 834 Episodic Representations of Object Color

Sarah D. Vollmer[1] (sarah.vollmer@ndsu.edu), Robert D. Gordon[2]; [1]Department of Psychology , North Dakota State University, [2]Department of Psychology , North Dakota State University

We investigated the episodic representation of object color, within a trans-saccadic preview paradigm. While fixated on a central cross, participants viewed a preview display consisting of two objects located above and below a peripheral cross. Participants initiated a saccade to the peripheral cross immediately upon the appearance of the preview display. During the saccade, the preview display was replaced by a target display, consisting of a single familiar object in one of the previewed locations; the participant's task was to name the object as quickly as possible after the eyes landed. Half of the trials required the additional task of identifying whether the target object's color matched its color in the preview display. The results revealed an object-specific priming effect: that is, participants named the object more quickly when it appeared in its previewed location than when it appeared in the opposite location. On trials in which participants did not perform the secondary task, changing the object color reduced the size of the effect. However, when the secondary task was included object specific priming was unaffected by a change in target color. The results suggest that task requirements play a role in determining which features are critical to preserving object continuity.

G66 835 Contrast sensitivity during smooth pursuit initiation

Alexander C. Schütz[1] (alexander.c.schuetz@psychol.uni-giessen.de), Doris I. Braun[1], Karl R. Gegenfurtner[1]; [1]Department of Psychology, Justus-Liebig-University Giessen

Eye movements can change the way we perceive visual stimuli. During saccadic eye movements some stimuli are suppressed and perceptually compressed toward the saccade target [e.g. Ross, Morrone, Goldberg & Burr, Trends in Neurosciences, 2001]. Here we explore whether suppression also occurs during smooth pursuit initiation.

In a 2AFC design we investigated the sensitivity for threshold-level stimuli during the initiation of smooth pursuit eye movements. Subjects had to pursue a step ramp target [Rashbass, Journal of Physiology, 1961] which moved with a velocity of 10.57 deg/s. At any time from 400 ms before target onset to 500 ms after target onset, a blurred 0.3 deg wide horizontal line appeared for 10 ms either 2 deg above or below the pursuit trajectory. The line held the same width as the screen to avoid motion signals during horizontal eye movements. The peak contrast of the line was adjusted to a level just above threshold for each subject. Subjects had to indicate whether the line appeared above or below the pursuit target. Trials with initial saccades during pursuit initiation and trials with low pursuit gain were excluded from the analysis.

The results show distinct changes in contrast sensitivity at different presentation times. However, the pattern of suppression was distinctly different from saccadic suppression. First, the magnitude of suppression was less pronounced during pursuit initiation. Second, suppression was largest at the onset of stimulus motion, rather than at the onset of pursuit. Therefore pursuit suppression is likely to be influenced by other factors than saccadic suppression. Suppression during saccades has to compensate strong retinal motion signals generated by the saccade. The observed pursuit initiation suppression is more likely due to inattentional blindness, since the pursuit target requires the focus of attention during motion onset.

Acknowledgement: This work was supported by the DFG Forschergruppe FOR 560 "Perception and action".

G67 836 fMRI BOLD signal varies proportionally with the size of small saccades in human V1 and V2

Florian Baumgartner[1] (florian.Baumgartner@psychologie.uni-regensburg.de), Peter U. Tse[2], Mark W. Greenlee[1]; [1]Experimental Psychology, University of Regensburg, Germany, [2]Department of Psychology, Dartmouth College. NH

The goal of this research is to determine the neural correlates in early areas of visual cortex of small visually guided saccades executed during fMRI. Methods: We monitored voluntary saccades from one eye in the spatiotemporal domain of microsaccades using a Limbus infrared eyetracker (1 kHz sampling rate), while collecting fMRI data in a mixed event-related block design (3T Siemens Allegra scanner, TR = 402 ms, 7 slices along calcarine, TE = 30 ms, flip angle = 35°, 800 volumes, n = 6 subjects, 6-8 runs per subject). In blocks with small voluntary saccades (amplitudes: 0.16, 0.38, 0.82, 1.64, and 3.28 visual degrees; 12 pseudorandom events per epoch), subjects tracked with their gaze a small point that jumped either to the left or to the right. The fixation point was projected onto a one-degree wide horizontal white band superimposed onto a high-contrast, polar grating. In separate runs, retinotopic areas were mapped using the phase-encoding method (TR = 2000 ms, TE = 30 ms, FA = 90°, 30 slices, 152 volumes) in all subjects. Results: BOLD signals transiently increased in early visual areas during epochs with saccades of all sizes, relative to fixation epochs, including those that were as small as microsaccades. In V1 and elsewhere in visual cortex, the strength of the BOLD signal varied proportionally with the size of very small visually guided saccades. These results

Monday Posters

emphasize the need to monitor fixation behavior during fMRI and suggest that small saccadic and/or fixational eye movements can evoke significant responses in primary visual cortex.

Acknowledgement: Alexander von Humboldt Foundation, Bavarian Research Foundation
URL: http://www.psychologie.uni-regensburg.de/Greenlee/forschung/publikation.html

Motion Adaptation and Aftereffects

Author Presents: 2:00 - 3:45 pm

G68 837 Centrifugal propagation of motion adaptation effects across visual space

Paul McGraw[1] (pvm@psychology.nottingham.ac.uk), Neil Roach[1]; [1]Visual Neuroscience Group, School of Psychology, University of Nottingham

Prolonged inspection of a visual pattern has the potential to profoundly alter subsequent perception – via a process known as visual adaptation. These perceptual distortions, or after-effects, are greatest when the visual characteristics defining the adapting and test patterns are similar and both are presented in the same region of visual space. Adaptation effects are a ubiquitous feature of visual processing and are thought to arise through the selective stimulation of discrete subpopulations of neurons that respond to similar image features. Adapting to unidirectional motion results in an inveterate phenomenon known as the motion after-effect (MAE), whereby subsequently viewed objects appear to drift in a direction opposite to that of the adapting stimulus. In addition, motion adaptation induces a perceived shift in the spatial location of the stimulus as a whole. In the present study we examine the spatial specificity of motion-induced positional shifts as a function of adapting location. We demonstrate that when translational motion adaptation occurs close to fixation (0.5 deg. eccentricity), significant positional offsets result (~10 arcmin) and the after-effects propagate centrifugally across visual space, resulting in broad spatial tuning. In marked contrast, when motion adaptation occurs more peripherally (5 deg. eccentricity) greater positional shifts are observed (~15 arcmin), but more importantly, the effects are largely restricted to the adapted spatial region. This marked difference in tuning between adapted locations cannot be explained by changes in positional sensitivity - a factor that was equated across the range of eccentricities tested. We also show that this eccentricity dependant change in spatial tuning of the after-effect is unique to motion. Using almost identical stimuli and procedures, other classical after-effects (spatial frequency and orientation) show the opposite pattern, with narrow spatial tuning centrally and slightly broader tuning with increasing adaptor eccentricity.

Acknowledgement: PVM and NWR are supported by the Wellcome Trsut

G69 838 High spatial frequency superiority of MAE for global motion

Satoshi Shioiri[1] (shioiri@riec.tohoku.ac.jp), Kazumichi Matsumiya[1]; [1]Research Institute of Electrical Communication, Tohoku University

[Purpose] We identified two types of motion detectors previously with a motion adaptation technique: one is sensitive to low spatial and high temporal frequencies and the other is sensitive to high spatial and low temporal frequencies (VSS 06). After the exposure to overlapped sinusoidal gratings with different spatial frequencies moving in the opposite directions, motion aftereffect of the high spatial frequency grating was seen with a static test (high spatial frequency superiority) while that of the low spatial frequency was seen with a flicker test. To investigate contribution of each type of motion detectors to global motion, we compared MAEs between global and local motion.

[Experiment] We measured MAE duration of rotation and expansion using four gabor patches arranged circularly. Each patch had two sinusoidal components with different spatial frequencies, which moved in the opposite directions at 5 Hz. The contrast of each grating was set to 30 times of each threshold. The spatial frequency of the gratings was 0.53 c/deg and 2.13 c/deg. After 20 s of adaptation, the observer judged the duration and the direction of MAE in the static or the flicker (4 Hz) stimulus of the same gabor patche(s).

[Results] The static test showed high spatial frequency superiority of MAE whereas the flicker test showed low spatial frequency superiority for the global motion as did for the single gabor motion. The duration of static MAE was longer for the global motion than that for the single gabor motion whereas flicker MAE showed similar duration for both types of stimuli.

[Discussion] The results suggest that the output from the motion detector that is sensitive to high spatial and low temporal frequencies is integrated for global motion perception while that of the motion detector sensitive to low spatial and high temporal frequencies is not.

Acknowledgement: MESSC GASR(B) 18330153-2006

G70 839 Linking Perceptual Motion Adaptation with Neural Adaptation in Human Visual Cortex

Hyun-Ah Lee[1] (hlee11@snu.ac.kr), Sang-Hun Lee[1,2]; [1]Interdisciplinary Program in Brain Science, Seoul National University , Seoul, [2]Department of Psychology

There have been attempts to localize motion adaptation in human visual cortex using the fMRI adaptation technique. However, the presence of adaptation in an area does not necessarily mean that adaptation occurs in that area intrinsically because adaptation effects may be inherited from earlier visual areas (Krekelberg et al., 2006). To address this problem, we measured tuning curves of motion adaptation along the hierarchy of visual areas in the dorsal stream using fMRI and compared them with psychophysical tuning curves of motion adaptation.

In the fMRI experiment, we measured fMRI responses to drifting low-contrast dots (800 msec duration) of varying direction before and after adaptation to 1 minute, high-contrast dots drifting coherently. During the post-adaptation scans, top-up adaptation stimuli (4.4-s) were inserted in between test stimuli. By probing changes in response after adaptation at a range of test directions relative to the adapting direction, we obtained tuning curves of adaptation. In the psychophysical experiment, the stimuli and procedures were identical to those for the fMRI experiment except that subjects performed the 2IFC task during the test period by reporting which of two intervals contained a coherent motion signal. Psychophysical tuning curves of adaptation were derived by measuring a set of thresholds at directions relative to the adapting direction by varying the contrast and coherence of test stimuli.

The amplitude and bandwidth of fMRI tuning curves became progressively lower and broader, respectively, from the early (V1) to later visual areas (MT, MST). The psychophysical tuning curves of adaptation were better accounted for by fMRI tuning curves in MT/MST than by those in early visual areas. Our findings imply that activity of MT/MST is closely linked to perceived motion adaptation, but the adaptation effect per se in MT/MST is likely to be inherited from the early visual cortex (Rust et al., 2006).

Acknowledgement: This research was supported as a Brain neuroinformatics Research program by Korean Ministry of Commerce, Industry, and Energy.

G71 840 Enhancement of motion aftereffect by reference stimuli: a comparison between luminance and chromatic motions

Akiyuki Inokuma[1] (ainokuma@l.u-tokyo.ac.jp), Kazushi Maruya[2,3], Takao Sato[1]; [1]Graduate school of Humanities and Sociology, the University of Tokyo, [2]Intelligent Modeling Laboratory, the University of Tokyo, [3]Department of Ophthalmology, the Jikei University School of Medicine

Motion aftereffect (MAE) is enhanced by static reference stimuli presented adjacent to adaptor and test stimuli. This suggests contributions of relative motion detection to MAE, but the effect is known only for MAE with luminance stimuli. Although no direct examination has been attempted, it is quite plausible that there is no reference effect for chromatic motion, since spatial integration is generally weak between chromatic motions. In the present study, we examined the reference effect with isoluminant chromatic MAE. The stimuli were moving vertical sinusoidal gratings. They were modulated along either achromatic luminance, isoluminant L-M, or isoluminant S axis in MBDKL color space. All combinations of the three stimulus types were used as adaptor/test pairs (3 x 3 design). References were rectangular-wave luminance gratings. In with-reference conditions, references were presented above and below adaptor and test throughout each trial, and results were compared with those from no reference conditions. Duration of MAE was recorded. Significant reference effect was found when adaptor and/or test stimuli were achromatic. In contrast, there was no effect when both adaptor and test were chromatic. We also conducted experiments with flickering (counterphasing) test stimuli (dynamic MAE), and found no reference effect at all. The present results, therefore, indicate that relative motion has an important role in MAE, and that relative motion is rather ineffective with chromatic inputs. The results with dynamic MAE indicate that the reference effect is a relatively low-level phenomenon. In addition, the reference effect was found when either adaptor or test alone was luminance modulated. The effect in adaptation phase can be explained by assuming strong adaptations of relative motion detectors caused by references. The effect in test phase might be accounted for by sensitivity enhancement of motion detection for luminance stimuli in the test phase.

G72 841 Asymmetry between motion and stereo aftereffects following concurrent adaptation

Wonyeong Sohn[1] (wysohn@gmail.com), Sang-Hun Lee[2]; [1]The institute of psychological science, Seoul National University, [2]Department of Psychology, Seoul National University

Representation of motion and stereopsis share a common set of areas along the dorsal stream of visual cortex, suggesting interactive relationships between neural substrates specialized for those two features. To explore these relationships, we measured motion and stereo aftereffects following adaptation to a stimulus defined by motion and binocular disparity.

During adaptation, observers adapted to 77 random dots moving coherently in one direction (0 deg) within a circular aperture of 2.48 deg radius. All dots drifted with the same speed (1.5 or 10 deg/sec) at the same depth (+ 0.3 deg). In the test period for motion aftereffects (MAE), we presented randomly moving dots at the same disparity as the adapting stimulus (+0.3 deg) or at the other side of fixation (- 0.3 deg). We varied the proportion of dots moving in 0 and 180 deg and observers reported the perceived direction of motion. We measured the proportion of directionally coherent dots required to cancel the MAE. For stereo aftereffects (SAE), the test dots coherently moved either in the same direction as the adaptor (0 deg) or in the opposite (180 deg). Analogously to the MAE test, we placed dots over a range of disparity (- 0.3 to + 0.3 deg) and manipulated the number of dots at crossed and uncrossed disparities. Observers reported whether the majority of dots were at the near disparity or at the far relative to fixation.

In all conditions, we observed considerable amount of aftereffects. The magnitude of the MAE was larger when the test stimulus was presented at the same disparity as adapting stimulus than when it was not. Such contingent aftereffect was not observed in the SAE. The results suggest that directional information may be coded in a stereo-dependent manner, but disparity processing is not dependent on the directions of its moving carriers.

Acknowledgement: This work is supported by Brain Neuroinformatics Research, by Korean Ministry of Commerce, Industry and Energy.

G73 842 The effect of adaptor velocity on motion induced shifts in perceived position in visual and auditory domains.

Ross Deas[1] (ross.deas@gmail.com), Neil Roach[1], Paul McGraw[1]; [1]Visual Neuroscience Group, School of Psychology, University of Nottingham, UK

Emerging evidence suggests commonality between neural mechanisms that encode visual and auditory motion. Following adaptation to unidirectional visual motion, perceived position of a visual stationary stimulus appears offset in the direction opposite to the adapting motion, showing a direct interaction between mechanisms that encode motion and spatial position. In this study, we examine the effects of motion adaptation on the perceived location of subsequently presented stationary stimuli in both auditory and visual domains. Previous studies suggest that motion-induced offsets in position exhibit band-pass velocity tuning, with little or no offsets beyond adapting velocities of 32°/s. By systematically varying adaptor spatial frequency, we demonstrate substantial motion induced shifts up to 128°/s. This suggests that that the differences in tuning limits can be explained by changes in the detectability of adapting stimuli. Using individual head-related-transfer-functions (HRTF) we created auditory motion stimuli in the horizontal plane that could vary in angular velocity, spatial extent and duration. Following adaptation to unidirectional auditory motion, participants made a spatial localisation judgment of a stationary auditory stimulus relative to their internal midline. Consistent with visual findings, all subjects showed a marked direction-dependant shift in perceived auditory position, relative to a ‘no adaptation’ baseline measure. Furthermore, this phenomenon exhibited similar band-pass tuning to that found in the visual domain. Finally, we present data showing that adapting to visual motion results in perceived shifts in stationary auditory stimuli, showing a cross modal interaction of motion and position. Similarities between velocity tuning of shifts for each sensory modality are explored.

Acknowledgement: RWD, NWR and PVM are supported by the Wellcome Trust.

Motion in Depth and Optic Flow

Author Presents: 2:00 - 3:45 pm

G74 843 The temporal property difference and the way of interactions between monocular and binocular motion mechanisms

Ryusuke Hayashi[1] (rhayashi@brain.med.kyoto-u.ac.jp), Kenichiro Miura[1], Hiromitsu Tabata[1], Kenji Kawano[1]; [1]Department of Integrative Brain Science, Graduate School of Medicine, Kyoto University

We have developed three types of binocular motion stimuli whose monocular components are dynamic random-dot patterns (1) without coherent motion, (2) patterns moving in the same direction as binocular motion, (3) those moving in the opposite direction to binocular motion (e.g., motion after binocular fusion moves downward while visual input to each eye is upward motion). Here we utilize such novel stimuli to investigate how our visual system processes monocular and binocular motions. Exp. 1: Seven observers were instructed to view 6 motion stimuli whose monocular and binocular motions were in opposite directions with variable intensity ratio (M/B stimuli) under 5 different stimulus durations. Then the observers reported which motion direction was perceived as dominant. The results showed that monocular motion perception becomes more dominant as stimulus duration becomes shorter, indicating that our ability to detect binocular motion over time is poor compared with detection of monocular motion. Exp. 2: To examine the time course of motion processing in detail, we measured ocular-following responses (OFR) elicited by 27 motion stimuli (n=3). The onset latency of the OFR elicited by monocular motion is faster than that of binocular motion by 20-50 ms, and the amplitude of initial OFR is determined by the monocular motion intensity alone. When monocular and binocular motions are in opposite directions, the OFR waveforms elicited by M/B stimuli can be fitted very well with the linear summation of OFR waveforms induced by exclusively monocular and exclusively binocular motions, suggesting that these motions are processed parallel without strong interaction. On the other hand, when monocular and binocular motions move in the same direction, we find nonlinear response enhancement as a result of facilitative interaction between monocular and binocular motion mechanisms. The latency of the enhanced response components is considered to reflect the time delay for the interaction.

G75 844 Probabilities of perceptual depth ordering in transparent motion and the relative effect of different depth cues

Ruben Moreno-Bote[1] (rmoreno@cns.nyu.edu), Asya Shipiro[1], John Rinzel[1,2], Nava Rubin[1]; [1]Center for Neural Science, New York University, [2]Courant Institute of Mathematical Sciences, New York University

During 'transparent motion' perception of plaids, subjects often report bistable alternations in the depth ordering of the two constituent gratings. To study this we used plaids with large angles between the gratings' directions of motion, so that incoherent grating motion is perceived nearly 100% of the time. Observers were asked to indicate which of the two gratings was perceived as behind. This allowed us to examine the role of different depth cues on the segmentation of the scene into different surfaces. We varied the spatial frequency, the duty cycle and the speed of one of the rectangular wave gratings while keeping fixed the properties of the other grating. We found that the mean fraction of time that a grating appeared to be in the back increased gradually as its wavelength and/or duty cycle decreased. This suggest that the visual system treats higher spatial frequency and lower duty cycle as cues for a surface being more distant, consistent with the ecological properties of the visual world (distant objects produce smaller projected images on the retina). The effect of varying speed was to make the faster grating appear to be behind more often. This result (which some regard as counter-intuitive) can be explained by noting that when we fixate on a static nearby object as we move in the environment, static objects behind the fixated one produce faster retinal motion the further they are. These depth cues were strong enough to overcome conflicting disparity cues, again showing a graded change in the fraction of time that the stereoscopically-far grating was seen in the back. Our results suggest that the fraction of dominance time of each percept is a measure of the probability the brain assigns to it, and that these probabilities are determined based on prior knowledge about the visual world.

Acknowledgement: Swartz Foundation for funding

G76 845 Does retinal slip explain deficits in the perception of depth from motion parallax?

Mark Nawrot[1] (mark.nawrot@ndsu.edu), Lindsey Joyce[1], Parker Ogden[1]; [1]Center for Visual Neuroscience, Department of Psychology, North Dakota State University

The perception of unambiguous depth from motion parallax relies on an extra-retinal signal from the pursuit eye movement system. Consistent with this link between pursuit and motion parallax, observers with abnormal visual pursuit due to ethanol intoxication (Nawrot, Nordenstom & Olson, 2004) and asymmetric smooth pursuit associated with esotropia (Nawrot, Frankl & Stockert, 2004) show elevated thresholds in motion parallax tasks. Are these motion parallax deficits due to a fundamental disruption to the integrity of the pursuit signal, or are they a "secondary" deficit due to retinal slip of the motion parallax stimulus caused by inadequate pursuit velocity? We studied normal observers using a Rogers & Graham (1979) type random-dot motion parallax stimulus in which the fixation point was translated independently from, and more slowly than, the motion parallax stimulus window. This generated increased retinal slip of the motion parallax stimulus, and mimicked the retinal stimulus for an observer with reduced pursuit gain (0.2 –0.25 for ethanol intoxication, and 0.1 for the gain asymmetry between temporalward and nasalward pursuit in esotropia). In one condition the motion parallax stimulus window remained stationary on the monitor while the fixation point translated in proportion (0.05 to 0.35) with the observer's head translation. In another condition the observer's head remained stationary, while the motion parallax stimulus window translated from side-to-side. The fixation point moved in proportion (0.9 to 0.6) to the stimulus window motion. Depth perception thresholds were only minimally affected by the increased retinal slip. Retinal slip of the motion parallax stimulus does not explain the motion parallax deficits found with reduced pursuit gain in ethanol intoxication and asymmetric pursuit with esotropia. Other causes, such as integrity of the pursuit signal, or interruption of the pursuit signal by the saccadic system, could be more direct causes for these motion parallax deficits.

G77 846 The Effects of Blood Alcohol Content on Pursuit and Perceived Depth from Motion Parallax

Lindsey Joyce[1] (Lindsey.Joyce@ndsu.edu), Mark Nawrot[1]; [1]North Dakota State University Center for Visual Neuroscience

Extra-retinal information from the smooth pursuit system is required for the perception of unambiguous depth from motion parallax (Nawrot & Joyce, 2006). Ethanol intoxication, which disrupts smooth pursuit by reducing eye movement velocity (gain) (Moser et al., 1997), also increases thresholds for the perception of depth from motion parallax (Nawrot et al., 2004). Considering the importance of visual depth perception, motion parallax in particular, for driving, we wondered at what blood alcohol content (BAC) levels the first significant changes in the perception of depth from motion parallax would be evident. Perception of depth from motion parallax was assessed with a procedure that separates the translational vestibulo-ocular response (TVOR) and pursuit eye movement components during lateral head translations (Nawrot & Joyce, 2006). In this procedure, perceived depth sign (phase) of a random-dot motion parallax stimulus (Rogers & Graham, 1979) changes with a change in the direction of the observer's pursuit eye movement signal, regardless of head translation and TVOR. We hypothesized that this depth perception task would be more sensitive to the effects of ethanol on pursuit than previous motion parallax paradigms. Participants were administered a dose of ethanol proportional to body weight to achieve a BAC near 0.08 percent. Motion parallax and pursuit were assessed on both the ascending and descending limbs of the intoxication curve. Consistent with previous results, ethanol intoxication did affect both pursuit gain and the perception of depth from motion parallax. Eye movement recordings show a decrease in smooth pursuit gain (and an increase in saccades) with an increase in BAC. Participants had a significant shift in performance in the motion parallax task with a mean BAC level between 0.04% and 0.06%. This is the BAC range in which many perceptual and motor functions are showing impairment (Moskowitz & Fiorentino, 2000).

G78 847 Decoding visual awareness and voluntary control perception during ambiguous structure-from-motion

Gijs Joost Brouwer[1] (G.J.Brouwer@phys.uu.nl), Raymond van Ee[1]; [1]Helmholtz Institute

We investigated whether perceptual states, and voluntary control over perceptual states during ambiguous structure-from-motion (SFM) can be predicted by decoding activation from retinotopic visual cortex and parietal motion-sensitive areas, using functional magnetic resonance imaging (fMRI) and multivariate statistics (support vector machines, SVM).

Our results indicate that prediction of perceptual states can be very accurate, when using activation from dorsal visual areas V3A, V4D, V7, MT+ and parietal areas responsive to SFM to decode and predict. Detailed analysis of eye movements revealed that strategic eye movement patterns are not the cause of the prediction accuracy based on cortical activation.

To examine the role of voluntary control, subjects were instructed to either switch their perceptual states as often as possible, or to hold the perceptual state as long as possible. Within a single run (of a total of 10), we interleaved the switch epochs (switch as often as possible) with hold epochs (hold the current perceptual state as long as possible). Prediction of the intention of subjects (switching/holding) was highly accurate when data from the frontal eye fields was used, decoding intention using the activation of dorsal visual areas was poor, but still possible with an accuracy higher than chance.

We conclude that during perceptual rivalry, dorsal visual areas, area MT+ and parietal cortex actively represent the content of visual awareness. In addition, frontal eye field activation is predictive for the intention of subjects: the voluntary control task (switching or holding a perceptual state).

G79 848 **Projected size and projected speed as indicators of change in motion path**

Shaw Gillispie[1] (gillesps@uci.edu), Myron Braunstein[1], George Andersen[2]; [1]University of California, Irvine, [2]University of California, Riverside

Todd (1981) showed that the trajectory of an object moving in a 3D scene can be recovered from the rate of change in its projected size and speed, together with the initial projected size and speed. This suggests that changes in either the projected size or speed functions during motion should alter the perceived direction. The present study examined an observer's perception of an object's motion path as it underwent changes in the projected size or speed functions or in both functions. Observers viewed naturalistic scenes containing simulated objects that traveled along the ground on a straight path oblique to the observer's point of view. The projected path was constant across conditions. Midway through the motion path, the projected speed function was changed from linear to exponential or vice versa, or the projected size function was changed from constant projected size to constant simulated 3D size, or both functions were changed. Observers were asked to predict where an object would cross a track that had been placed within the scene by adjusting a marker along the track. We found that a change in the speed function affected observers' perception of the motion path, but a change in the size change function did not have a significant effect. This result was unexpected because a constant 3D size constraint should be more salient than a constant 3D speed constraint. A possible explanation is that size changes affected the perceived elevation of the object in the 3D scene rather than the position in depth at which the object appeared to cross the track.

G80 849 **The identification of a moving object by a moving observer.**

Patrick Finn[1] (Pffinn08@holycross.edu), Constance Royden[1]; [1]Department of Mathematics and Computer Science, College of the Holy Cross

A person moving through the world must be able to detect and identify moving objects to avoid collisions. In previous studies we examined how well people can detect a moving object within a radial optic flow field simulating observer motion. In this study, we examined the problem of moving object identification by a moving observer. Observers viewed a radial flow field, consistent with observer motion in a straight line. In every trial a target circle moved at an angular deviation from this radial pattern. Observers used the cursor to select the circle that they believed moved differently from the pattern. We measured the percentage of correct responses for angles of deviation between 8 and 40 degrees and for trial durations of .25, .5, .75 and 1 sec. We tested scenes containing 4, 9, 16, or 25 circles. The results for 6 observers show that as the trial duration increased the thresholds for identifying the target tended to decrease. Observers had nearly the same accuracy for 9, 16 or 25 circles, with average thresholds of about 12.5, 11.6 and 11.7 deg, respectively, for a 1 sec duration. These are very similar to the thresholds for simple object detection, which for 25 circles was 13.6 deg for a 1 sec duration (Royden, Connors & Mahoney, 2005). Observers showed much lower accuracy with 4 circles, with average threshold of 36.5 deg for 1 sec duration. This decrease in accuracy is similar to that seen with simple object detection. These results suggest that if an observer can detect that some object is moving within the flow field, then they can identify specifically which object it is.

Acknowledgement: Supported by NSF grant #0343825

G81 850 **Perception of radial motion in Japanese macaque (Macaca fuscata) infants**

Nobu Shirai[1,2] (mayuget@ybb.ne.jp), Tomoko Imura[2,3], Yuko Hattori[2,4], Masaki Tomonaga[5], Masami K. Yamaguchi[1,6]; [1]Department of Psychology, Chuo University, [2]Japan Society for the Promotion of Science, [3]Department of Psychology, Kwansei Gakuin University, [4]Department of Psychology, Kyoto University, [5]Primate Research Institute, Kyoto University, [6]PRESTO Japan Science & Technology Agency

Radial motion is an important cue to perceive motion-in-depth, such as the observer's own forward/backward locomotion or an approaching/receding object to/from the observer. Early development of radial motion sensitivity in human infants has been described by several psychophysical researches (e.g., Gilmore & Rettke, 2003; Gilmore et al., 2004; Shirai et al., 2004a, 2004b, 2006). On the other hand, there are few data regarding development of radial motion sensitivity in non-human primates (but see Schiff et al., 1962). Here we report early development of radial expansion/contraction sensitivity in Japanese macaque monkeys. Fifteen 1- to 5-month-old infant monkeys (mean age=90.3days, SD=43.0) participated in the present study. We examined the infants' preference for radial motion using almost same experimental methods as those of Shirai et al. (2005). Our stimulus was composed of two dynamic random dot patterns (RDPs) placed side by side. One RDP was a radial expansion (or contraction) and the other was translation (up, down, right, or left-ward: counter balanced across infants). Each RDP consisted of 100 moving dots, which moved at constant speed (10.62/deg). Hence each RDP has no speed gradient. There were two experimental conditions ("expansion vs. translation" and "contraction vs. translation"), and each infant participated in both conditions. Each experimental condition consisted of 12 trials. In each trial, a stimulus was presented to the infants for 3 s. One observer, who was naïve for the stimulus identity, made 2AFC judgment about the infant's first gaze direction (left or right) in each trial (FPL method). The current results indicate that the infants showed significant preference for expansion to translations, but did not show significant preference for contraction. We will discuss about the early development of radial motion sensitivity in primates, based on the results of present monkey study and those of previous human infant studies.

Acknowledgement: This research was supported by the Cooperation Research Program of Primate Research Institute, Kyoto University.

G82 851 **The role of area V5/MT+ in the centripetal bias in global motion perception**

Deborah Giaschi[1,2,3] (giaschi@interchange.ubc.ca), Amy Zwicker[2], Simon Au Young[3], Bosco Lee[1], Bruce Bjornson[3,4]; [1]Department of Ophthalmology and Visual Sciences, University of British Columbia, [2]Department of Psychology, University of British Columbia, [3]Children's Brain Mapping Centre, BC's Children's Hospital, [4]Department of Pediatrics (Neurology), University of British Columbia

We previously reported lower coherence thresholds for centripetal (inward) relative to centrifugal (outward) frontoparallel global dot motion (VSS 2004, 2005). This direction anisotropy was observed at fast but not slow speeds of motion. The purpose of the present study was to examine the role of the motion sensitive cortical area V5/MT+ in this speed-tuned centripetal bias using functional MRI. A block-design localizer task in which epochs of dots in expanding/contracting radial motion alternated with epochs of stationary dots was used to identify area V5/MT+ in six adults with normal vision. On the global motion centripetal (centrifugal) task, epochs of dots moving from the left and right, or from the top and bottom, toward (away from) the center alternated with epochs of stationary dots. The coherence of the moving dots was 85%, 25% or 0% on alternate blocks. The motion speed of each run was either 8 or 1 deg/s. A region of interest analysis revealed greater activation in V5/MT+ at 25% coherence than at 85% or 0% coherence. This region also responded more to centripetal motion than to centrifugal motion at both speeds. These results suggest that V5/MT+ plays a role in the direction, but not the speed-tuning, of the perceptual motion anisotropies. A centripetal bias is unlikely to be the result of selective exposure to optic flow, which is usually in a centrifugal direction. A centripetal bias has instead been linked to the precise control of arm movements towards fixation (Edwards & Badcock, 1993; Shirai, Kanazawa & Yamaguchi, 2006; Steinmetz, Motter, Duffy & Mountcastle, 1987). We speculate that the centripetal bias for optic flow in the central visual field, reported here, is related to mechanisms for visually-guided reaching, while the centrifugal bias for optic flow in the peripheral visual field, reported by others, is related to mechanisms for locomotion.

Acknowledgement: funded by Natural Science and Engineering Research Council of Canada

G83 852 Decoding heading directions from human cortical activity.

Hiroaki Shigemasu[1] (hshige@real.tutkie.tut.ac.jp), Yoichi Miyawaki[2,3], Yukiyasu Kamitani[3], Michiteru Kitazaki[1,4,5]; [1]Research Center for Future Vehicle, Toyohashi University of Technology, [2]NICT, [3]ATR Computational Neuroscience Laboratory, [4]Intelligent Sensing System Research Center, Toyohashi University of Technology, [5]Department of Knowledge-based Information Engineering, Toyohashi University of Technology

Recently, Kamitani & Tong (2006) showed that ensemble patterns of fMRI voxels exhibit robust direction selectivity that allows for accurate prediction of motion direction. Here, we investigated whether ensemble activity patterns contain reliable information about heading direction that requires higher-level of motion processing. For heading stimuli, we used radially expanding optic flow patterns that simulated heading either left or right direction. fMRI signals were measured while subjects viewed optic flow. A linear decoder was trained to classify voxel intensity patterns induced by left or right heading directions, then evaluated with independent test data. The ensemble activity from area MT+ led to good predictions (~90 %) and the performance was better than other cortical areas. As humans perceive accurate heading direction even when their eyes are rotated, we also tested if the performance of the decoder is generalized to optic flow with additional motion of eye-movement. In eye movement condition, subjects pursued a horizontally moving point in an optic flow display. Testing the decoder on the activity patterns of the eye movement condition, area MT+ showed less robust but still relatively high decoding performance. Subjects also viewed the optic flow display simulating additional motion of the eye-movement while they fixated a stationary point. The decoder was trained with the activity patterns of the simulated display condition and tested on those of executed eye-movement condition. Although the retinal flows were identical between training and test conditions, the decoding performance of area MT+ was worse than the decoder trained with the condition without motion information of the eye-movement. These results suggest that area MT+ is involved in heading perception and coding head-centric motion with compensation of extra-retinal information, as suggested by previous studies. More generally, our study shows that decoding technique can be used to reveal the function of the cortical activity.

Acknowledgement: This work was supported by Nissan Science Foundation.

G84 853 The effect of reversing seeing of initial and final locations of shortly presented high speed contracting and dilating objects

Sergey Artemenkov[1] (slart@ostrov.net); [1]MSUPE/MGPPU

Visual appearance of moving or size-changing (either dilating (A) or contracting (B)) objects, which are shortly presented during the gaze fixation period (GFP), is usually connected with impossibility of clear seeing the start of the movement processes, while other stages of them basically is possible to observe. This is understandable assuming that perception of the movement location requires the possibility of organizing relations between signals coming at different moments of time, and realizing that initially these relations is not possible to obtain locally. It was shown (Artemenkov, VSS, 2005) that for high size-changing speed (around 40 deg/s and more) human visual perception (HVP) of A and B objects presented within a range of short durations (10-100 ms) is accompanied with unusual differences, e.g. appeared in effect of reversing seeing of initial and final locations of A and B contour objects: for A it is still impossible to perceive the initial stage and possible to see the final stage of the process, while for B there is quite opposite situation – the initial location is perceived and it is not possible to observe the end of the process. Studies of this phenomenon reveal that it may indicate the presence of an internal center-symmetric process anisotropy in the form creation process (FCP) having place during the GFP. If time needed for the initial FCP (or overall space integration) is increased with the size of the object and this process has a certain speed of formation then in case of high enough speed of objects' contraction their pictures coming later in time may reach the FCP image earlier than pictures, which came earlier. These causes presenting effect which may become a useful psychophysical tool for revealing internal mechanisms of the HVP and the determination of functional range of the form and movement perception.

URL: www.trans-psych.org.uk

G85 854 Visual and Auditory Processing of Distance and the Time-To-Collision of an Approaching Object

Jing-Jiang Yan[1] (sunhong@mcmaster.ca), Liu Zhou[1], Chao-Xiang Xie[1], Jennifer Campos[2], Hong-Jin Sun[2]; [1]School of Psychology, Southwest Univertisy, China, [2]Department of Psychology, McMaster Univesity, Canada

Information about the impending collision of an approaching object can be specified by visual and auditory means. We examined the discrimination thresholds for vision, audition, and vision/audition combined, in the processing of distance and the time-to-collision (TTC) of an approaching object. The stimulus consisted of a computer simulated car approaching on a flat ground towards the subject that was presented through a stereoscopic screen and stereo headphones. Subjects (Ss) either viewed, heard, or both viewed and heard, two approaching movements in succession (a reference and a comparison), which disappeared at a certain point before collision. Ss then pressed a button to indicate which of the two movements would result in the car arriving sooner OR having a shorter distance from the subject at the moment it disappeared. The TTC and distance were held constant for the reference stimulus, but varied for the comparison stimuli according to the method of constant stimuli, with the order of the two randomized. The approaching speed, the size and sound level of the car were also held constant for the reference stimulus but varied for the comparison stimuli. We analyzed the sensitivity to both the difference in TTC and the difference in distance for both the TTC task and the distance task. The results of both the TTC and distance tasks showed that Ss were more sensitive to the difference in TTC provided by vision than by audition, but more sensitive to the difference in distance provided by audition than by vision. The performance for the vision/audition combined condition was almost identical to the vision only condition for TTC sensitivity and almost identical to the auditory only condition for the distance sensitivity in TTC task only. This indicates that, when both cues are available, the most accurate source of information is used.

Acknowledgement: Supported by Key Subject Grant from Southwest University

G86 855 Closer is better: Distance, independent of spatial frequency, influences circular vection

Laura Trutoiu[1] (lctrutoi@mtholyoke.edu), John J. Rieser[2], Douglas Morse[2]; [1]Mount Holyoke College, [2]Vanderbilt University

Vection is the illusion of making observers feel as though they are in motion when they are not through the use of moving visual stimuli. We studied circular vection by situating stationary adults in an optokinetic drum (2m diameter) with black and white stripes each subtending an angle of approximately 20 degrees that rotated at a constant speed of 5 rpm. In all previous studies that we know about, the subjects were centered in such a drum and so the visual flow specified a simple rotation in place. And other studies investigated sensitivity to simple translations while subjects stood in place within a rectangular room that translated to and fro. In our three experiments subjects stood off-center in an optokinetic drum. In these situations the visual input specified self-movements that were simple rotations, or the translations combined with rotations that would occur when one walks around the perimeter of an optokinetic drum. Five viewing positions were used: the center and positions near the optokinetic drum's curtain located behind, in front of, left of, and right of center. This is one of the first studies to compare judgments of the perception of vection for simple rotations with vection for rotations combined with translations. The results showed highly significant effects of viewing position, indicating large differences in latencies for perceiving simple rotations compared with perceiving curved paths.

Navigation

Author Presents: 4:00 - 5:45 pm

G87 856 Guidance of Walking in Cluttered Environments: Effect of Distant Obstacles on Route Selection

Martin Gérin-Lajoie[1] (martin_gerin-lajoie@brown.edu), William H. Warren[1]; [1]Department of Cognitive & Linguistic Sciences, Brown University

The ability to avoid obstacles is crucial for human mobility in most natural environments. Fajen and Warren (2003) proposed a steering dynamics model in which locomotor paths emerge on-line, without advanced planning. Goals act as attractors and obstacles as repellers of heading (the direction of travel), where heading is determined by the current eccentricities and distances of the goal and nearby obstacles (< 4 m). Here we ask whether human routes are also affected by more distant obstructions (up to 8 m), implying more advanced planning. In addition, we investigate possible optimality principles for preferred routes. Participants walk in an immersive virtual environment to a goal post (13 m) while avoiding a near obstacle post (6 m) and a far barrier (8, 10 m or no barrier). Participants are instructed to take their preferred route to the goal, or one of the three possible routes through the obstacle course. If they anticipate the effect of a distant obstruction, their paths should be influenced by the presence and position of the far barrier. Measures on the observed paths assess whether the preferred path tends to minimize travel time, travel distance, and/or the total impulse (F x t) acting on the walker's center of mass. The results provide a test of the adequacy of the near-obstacle control model and suggest possible modifications to incorporate distant obstructions. In addition, they allow us to evaluate the properties of preferred locomotor paths that tend to be optimized, suggesting a basis for observed model parameters. A model that describes human paths through cluttered environments would prove useful in applications such as robot locomotion, pedestrian traffic engineering, and gait rehabilitation.

Reference: Fajen BR, Warren WH (2003) Behavioral dynamics of steering, obstacle avoidance, and route selection. J. Exp. Psychol. Hum. Percept. Perform. 29:343-62.

Supported by NIH EY10923.

G88 857 Avoiding moving obstacles on foot: Can people learn to anticipate obstacle motion?

Justin Owens[1] (jmo@brown.edu), William Warren[1]; [1]Department of Cognitive & Linguistic Sciences, Brown University

When moving through the world, humans often encounter moving obstacles that threaten to impede their path. Fajen & Warren (2004, in press; Cohen & Warren, VSS 2005) proposed a dynamical model of moving target interception and moving obstacle avoidance based on first-order information about object motion, requiring no higher-level path planning. This model has been supported in instances of novel target and obstacle motion; however, repeated exposure to one target trajectory (but not two) can lead to anticipation of the target's motion and a more direct interception path (Owens & Warren, VSS 2005, 2006). Here we investigate whether people can learn to anticipate more than one moving obstacle trajectory, whether this is aided by obstacle shape and color cues, and whether explicit instruction on these cues can aid learning. Participants walk in the VENLab, a 12m x 12m virtual environment with a head-mounted display (60 deg H x 40 deg V) and a sonic/inertial tracking system (latency 50-70 ms). On each trial, participants walk to a stationary target at 6m while avoiding an obstacle that moves across their path. Participants complete three blocks of trials – one control block with constant obstacle speed and direction, one block in which obstacles change direction mid-trial, and one block in which obstacles change speed mid-trial. Each obstacle trajectory is cued by its shape and color. The Number of obstacles per block (2 vs. 3) and Instructions (cue-explicit or neutral) are varied between subjects. Preliminary data indicate that participants can learn to anticipate two obstacle trajectories without explicit cue instructions; it is expected that the addition of cue instructions will increase the speed of learning and the number of trajectories learned. The results suggest that people can learn to anticipate the motion of more than one obstacle if given sufficient information.

Acknowledgement: Supported by NIH EY10923

G89 858 Wormholes in Virtual Reality: What spatial knowledge is learned for navigation?

Benjamin Schnapp[1] (Benjamin_Schnapp@brown.edu), William Warren[2]; [1]Brown University, [2]Brown University, Department of Cognitive and Linguistic Sciences

The underlying geometry of cognitive maps could take a number of forms. At one extreme, spatial knowledge might have a Euclidean structure that preserves metric distances and angles (Gallistel, 1990). At the other, it might have a topological graph structure that only preserves the connectivity between known places. We introduce two "wormholes" that rotate and/or translate a walker between remote places in a virtual hedge maze, making it non-Euclidean. A Euclidean control maze has the same layout and graph structure, but no wormholes. Previous research (Rothman & Warren, VSS 2006) found that participants learn the wormhole maze as quickly as the Euclidean maze, and take advantage of the wormholes, but do not even notice the inconsistent Euclidean structure. Here we probe their spatial knowledge by asking them to take novel shortcuts between learned places. In the experiment, participants walked in an immersive virtual environment (12m x 12m) while wearing a head-mounted display (60° x 40° FOV) with a sonic/inertial tracking system (50-70ms latency). On learning trials, they explored the environment, visiting all 8 objects, and then were trained to a criterion of two successful trials walking from a Home location to each object. In the test phase, participants walked from Home to object A, the entire maze was removed, and they then took a direct shortcut to the remembered location of object B. If participants acquired a metric cognitive map, they should walk to definite locations – either to the initial object positions or their post-wormhole positions (e.g. rotated by 90°). If instead they acquired a topological graph, shortcuts should be highly variable. The results will provide insight into the nature and consistency of the spatial knowledge that is learned for navigation.

Acknowledgement: Supported by NSF BCS-0214383

G90 859 Influence of landmarks on path integration

Xiaoang Irene Wan[1] (xwan@uiuc.edu), Ranxiao Frances Wang[1], James Crowell[1]; [1]University of Illinois at Urbana-Champaign

Path integration is a navigation process by which moving animals integrate self-movement vectors using internal and/or external cues to estimate their current position and orientation relative to the origin. We used hallway-mazes in an immersive virtual reality Cube to examine whether the presence of landmarks can facilitate path completion tasks. In our maze, position changes (driving along the hallway) were purely visual, controlled by button presses. Orientation changes (turning at the intersection between two hallway segments) were controlled by physical turning along with optical flow information. Participants traveled along random paths with five segments, either with or without distinctive landmarks at segment intersections. Then they were instructed to return to the origin directly from the end of the path. Theoretically, the existence of the landmarks may improve path integration performance by providing salient anchors at the critical points of the path structure and therefore facilitate the construction of the pathway representation. However, landmarks may also introduce a cost because landmarks require the navigator to encode, remember and update more locations (both the origin and the landmark locations), and consequently increase working memory load. We found no landmark advantage for homing performance. In order to encourage participants to pay attention to the landmarks, a second experiment required participants to return to one of the landmarks in a subset of the landmark-present trials. The data again showed no evidence of improvement in homing performance with the landmarks than without. Instead, homing performance was slower in the landmark-present condition than in the no-landmark condition, possibly due to increased working memory load and/or task complexity.

Acknowledgement: Supported by NSF Grant BCS 03-17681 to R. F. Wang.

G91 860 Metric vs. Ordinal Place Structure in Active Navigation

Huiying Zhong[1] (huiying_zhong@brown.edu), Marianne C. Harrison[1], William H. Warren[1]; [1]Brown University

We have reported that humans depend on topological spatial knowledge and landmarks rather than metric spatial knowledge when navigating in a virtual maze (Foo et al, JEP: LMC, 2005; Harrison et al, VSS, 2001, 2002; Zhong et al, VSS 2005, 2006, Psychonomics, 2005). Topological ordinal place structure consists of the sequence (and sign) of places passed on routes between locations in 2D. Metric place structure consists of the distances and angles between places in 2D. Zhong et al (Psychonomics, 2006) found that making previously learned places visible dramatically reduced variability in novel shortcuts to hidden targets, consistent with ordinal knowledge. Here we manipulate the configuration of visible places to test whether people rely on ordinal structure or the metric distance of the target from neighboring objects. Participants actively walk in a virtual hedge maze containing five pairs of places marked by distinctive objects (A-B). During learning, participants freely explore and are then trained to walk from Home to A and then B. During testing, they walk from Home to A, the hedges are removed (making all objects visible except the target), and they take a shortcut to B. On expansion trials, the metric distance of each object from the target is increased while ordinal structure remains constant. On rotation trials, each object is rotated about the target by a random angle, changing ordinal structure but leaving distance from the target constant. If participants rely on ordinal place structure, variable error (but not constant error) should increase in expansion trials, and should increase dramatically in rotation trials. If they rely on metric distance from visible objects, constant error (but not variable error) should increase in expansion trials, and both should remain constant in rotation trials. The results allow us to compare the contributions of ordinal and metric knowledge to active navigation.

Acknowledgement: Funded by NSF BCS-0214383

G92 861 Separating the Two Main Components of Active Navigation for Learning a Virtual Environment: Decision-Making and Control

Jonathan Bakdash[1] (jzb3e@virginia.edu), Sally Linkenauger[1], Dennis Proffitt[1]; [1]Department of Psychology, University of Virginia

Active navigation consists of two main components, decision-making and control. The current study examined the separate and combined roles for each of these components in learning the spatial layout of a virtual environment (VE). In the learning phase, participants were asked to learn the locations of targets in a virtual city environment. They navigated and learned virtual city environment on a display under one of three conditions (decision-making only, control only, and decision-making and control combined). During the test phase, knowledge of the environment was assessed by having participants point at the unseen targets in virtual reality.

In the decision-making only condition, participants decided where to go by giving verbal directions to the experimenter whom controlled movement through the VE. Based on the previous trajectory taken by a participant in the decision-making only condition, the experimenter gave directions to a matched participant in the control-only condition, telling them where to go. Therefore, the visual information in the decision-making and control conditions was comparable. In the combined condition, participants both decided where to go and had control of movement through the VE.

Preliminary results indicate that spatial knowledge was superior with decision-making only compared to control only. However,performance in the combined condition was similar to the decision-making condition. These findings suggest that decision-making, as a component of active navigation, is important in learning the spatial layout of a VE than control.

G93 862 Navigation Strategies Utilized by Sight Altered Individuals

Jayne Fry[1] (jayne.fry@envisionus.com), James Nolan[2]; [1]Envision, [2]Envision

The ability to navigate in ones environment is an essential skill. A skill that requires individuals to posses numerous cognitive skills including sensing, attention, identifying destination, assessing and avoiding hazards developing short-cuts, planning trajectories and executing plans. Navigating successfully in an environment requires utilizing such skills and choosing optimal navigational strategies to determine an effective route. Various strategies may be used such as landmark, path integration, or piloting; to reference previous research see (Barlow, 1964; Riser, Guth, and Hill, 1982). Sholl (1987) as well as, Siegal and White (1975) indicate the importance of picture like images of spatial information and their effect on an individual's ability to navigate. These cognitive skills along with spatial knowledge or mental representation enables individuals to solve spatial and navigation problems. These processes plus sensory information, along with strategies utilized during exploration of a new environment appear to combine and develop into a cognitive spatial representation, which are created and used by all. The purpose of this study was to investigate the process, formation, and role of cognitive maps or mental representations of sight altered individuals in relation to navigational strategies, as compared to those possessing standard vision and the effectiveness of those strategies. It was hypothesized that the process of forming mental representations for the purpose of navigation is qualitatively different, but effective in sight altered individuals as compared to standard vision individuals. Our results indicate that mental representations, exploration strategies, spatial knowledge, and navigation of a novel environment by sight altered individuals (congenitally blind and late onset blind) are equal to or as effective as those employed by sighted controls. The varying level of visual experience did not reveal any significant differences in effectiveness of completing tasks.

Tuesday Talk Sessions

Tuesday, May 15, 2007

Shape, Picture, and Scene Perception

Tuesday, May 15, 8:30 - 10:00 am, Hyatt Ballroom South
Moderator: Diane Beck

8:30 863 Memory for objects in virtual environments

Tom Troscianko[1] (tom.troscianko@bris.ac.uk), Nick Mourkoussis[2], Fiona Rivera[2], Katerina Mania[2], Tim Dixon[1], Rycharde Hawkes[3]; [1]Dept Experimental Psychology, University of Bristol, UK, [2]Dept Informatics, University of Sussex, UK, [3]Hewlett Packard Laboratories, Bristol, UK

Schema theory proposes that memory for objects in scenes depends on the degree to which the objects appear to belong to a particular scene (consistent objects) or not (inconsistent objects). However, the degree to which an object will be consistent with a scene is likely to depend on whether the perception of the scene is itself consistent with our previous experience. Thus, for example, if a familiar scene is presented in an unfamiliar manner, the effect of object consistency on memory is likely to change. We wished to see whether this kind of effect can be used to investigate the degree to which a virtual environment (VE) is perceived as "normal", i.e. consistent with our usual experience of similar environments, or "abnormal", i.e. markedly different from our previous experience. Two initial studies measured the effect of rendering quality on memory for consistent and inconsistent objects in conditions of varying quality of radiosity (Experiment 1) and polygon count (Experiment 2). Participants interacted with the scenes wearing VGA resolution, head-tracked HMDs. They were then tested for memory for inconsistent and consistent objects. There was little effect of rendering quality except in one condition in which individual objects were hard to recognize. Experiment 3 therefore used a more extreme set of rendering types: wireframe with added color, and full radiosity. The proportion of inconsistent/consistent objects was varied, and object recognition tests ensured that all objects were easily recognized in all conditions. The results showed a significant interaction between rendering type, object type, and consistency ratio. This suggests that inconsistent objects are only preferentially remembered if the scene looks "normal" or if there are many such objects in an "abnormal" scene. We conclude that memory for objects can be used to assess the degree to which the context of a VE appears normal.

Acknowledgement: Funded by EPSRC grant number GR/S58386/01

8:45 864 There is no symmetry like orthogonal symmetry

Matthias Treder[1] (M.Treder@nici.ru.nl), Peter van der Helm[1]; [1]Nijmegen Institute for Cognition and Information, Radboud University Nijmegen

Where does the saliency advantage of two-fold symmetry over one-fold symmetry stem from? Is it only the presence of an extra symmetry axis, or is it also the fact that the symmetry axes are orthogonal? So far, empirical studies identifying the superiority of two-fold symmetry considered exclusively orthogonal symmetry axes. To shed more light on the role of orthogonality in two-fold symmetry, we used stimuli consisting of two non-overlapping spatial frequency bands. Each band contained either a perfect one-fold symmetry or a random noise pattern. This allowed for the construction of orthogonal and non-orthogonal two-fold symmetries. The resulting stimulus comprised either an orthogonal or a non-orthogonal two-fold symmetry, a one-fold symmetry or a random pattern. While each symmetry was perfect within its own spatial frequency band, the combination of the bands yielded noisy symmetries at a pixel level. Non-cardinal axes, tilted ±22.5 degrees relative to the vertical or horizontal, were used to prevent confounding effects of differentially salient axis orientations (e.g., vertical and horizontal). The task of the observer was to discriminate between symmetric and random stimuli. Results show that two-fold symmetries with orthogonal axes are significantly more salient than two-fold symmetries with non-orthogonal axes. We currently explore whether this difference is due to the mutual enhancement of orthogonal symmetry axes, or, vice versa, the mutual interference of non-orthogonal axes.

9:00 865 Decoding distributed patterns of activity associated with natural scene categorization

Eamon Caddigan[1,2] (ecaddiga@uiuc.edu), Dirk Walther[1], Justas Birgiolas[2,3], Jonathan Weissman[3], Diane Beck[1,2], Fei-Fei Li[1,3,4]; [1]Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, [2]Department of Psychology, University of Illinois at Urbana-Champaign, [3]Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, [4]Department of Computer Science, Princeton University

Human observers are able to quickly and efficiently perceive the content of natural scenes (Potter, 1976). Previous studies have examined the time course of this rapid classification (Thorpe et al, 1996) as well as the brain regions activated when subjects categorize natural scenes (Epstein & Higgins, 2006). Using statistical pattern recognition algorithms similar to those employed by Cox and Savoy (2002) to decode the neural states associated with object categories, we asked whether we can identify and discriminate distributed patterns of fMRI activity associated with particular natural scene categories (beaches, mountains, forests, tall buildings, highways, and industrial scenes). fMRI data was aquired while subjects viewed 100 images from each of six categories, in 6 blocks of 10 images each of the same category, organized into 10 runs. A subset of the voxels was selected via traditional univariate statistics comparing stimulus presentation versus blank screen conditions. We tested several pattern recognition algorithms (e.g. Support Vector Machines, Gaussian Naive Bayes, etc.) in a leave-one-run-out procedure on the selected voxels and found that all algorithms predict the natural scene category seen by the subject well above chance. Furthermore, prediction accuracy was still well above chance when retinotopic cortex was excluded from the analysis, suggesting that this multi-voxel analysis does not rely solely on differences in simple visual features or differences in the retinotopic representation of the stimuli.

Acknowledgement: Financial support for this work was provided by UIUC Critical Research Initiative Planning Grant (to DB and LF) and a Beckman Postdoctoral Fellowship to DW

9:15 866 Photorealistic Rendering: How Realistic Is It?

Hany Farid[1] (farid@cs.dartmouth.edu), Mary Bravo[2]; [1]Dartmouth College, [2]Rutgers-Camden University

The US Supreme Court recently ruled that portions of the 1996 Child Pornography Prevention Act are unconstitutional. The Court ruled that computer generated (CG) images depicting a fictitious minor are constitutionally protected. Judges, lawyers, and juries are now being asked to determine whether an image is CG, but there is no data on whether they can reliably do so. To test the ability of human observers to discriminate CG and photographic images, we collected 180 high-quality CG images with human, man-made, or natural content. Since we were interested in tracking the quality of CG over time, we collected images created over the past six years. For each CG image, we found a photographic image that was matched as closely as possible in content. The 360 images were presented in random order to ten observers from the introductory psychology subject pool at Rutgers. Observers were given unlimited time to classify each image. Observers correctly classified 83% of the photographic images and 82% of the CG images (d'=2.21). Observers inspected each image for an average of 2.4 seconds. Among the CG images, those depicting humans were classified with the highest accuracy at 93% over all six years (d'=2.60). This accuracy declined to 63% for images created in 2006. Because the experiment was self-paced, inspection times differed among observers, and the results show a strong speed-accuracy trade-off. The observer with the longest inspection time (3.5 seconds/image) correctly classified 90% of all photographic images and 96% of all CG images (d'=3.00). This observer correctly classified 95% of CG images depicting humans (d'=2.92), and his only errors occurred with 2006 images, where he achieved an accuracy of 78%. Even with great advances in computer graphics technology, the human visual system is still very good at distinguishing between computer generated and photographic images.

URL: http://www.cs.dartmouth.edu/farid/publications/vss07_1.jpg

9:30 867 Different roles of the parahippocampal place area (PPA) and retrosplenial cortex (RSC) in scene perception

Soojin Park[1] (soojin.park@yale.edu), Marvin M Chun[1]; [1]Department of Psychology, Yale University

One of the biggest challenges for human visual system is to create a seamless continuous world from multiple snapshots. Mediating this ability, there are at least two scene-sensitive regions of the brain, the parahippocampal place area (PPA) and retrosplenial cortex (RSC). Whereas the PPA is sensitive to changes in viewpoint of the same scene (Epstein, Graham & Downing, 2003), RSC may encode a more abstract scene-based representation independent of specific viewpoint (Bar & Aminoff, 2003; Epstein & Higgins, 2006; Park et al., 2006). To directly test this hypothesis, we presented different snapshot views from panoramic scenes. These views overlapped with each other by only 30%, so that they represented clearly different views, but appeared to come from the same panoramic scene. Using fMRI adaptation, we tested whether the PPA and RSC treated these panoramic views as the same or different. In the panoramic condition, three different views from a single panoramic scene were presented. In the identical condition, three identical views were presented. If the activity within the scene-selective ROI reflects an integrated scene representation, then we should observe attenuation in the panoramic condition. On the other hand, if the scene activity is specific to views, then we should observe no attenuation for panoramic repetition. We did not find any attenuation for panoramic repeats in the PPA, replicating a previous study (N=17). In contrast, the RSC showed significant attenuation for the panoramic condition. Both the PPA and RSC showed significant attenuation for the identical repetition. These results demonstrate that the PPA and RSC play different roles in scene perception: the PPA focuses on selective discrimination of different views while RSC focuses on the integration of scenes under the same visual context. Such integration may facilitate perception of a continuous world from multiple snapshots arising from eye and head movements.

Acknowledgement: Supported by NIH grant EY014193.

9:45 868 Framing Aesthetics: Effects of Spatial Composition

Stephen Palmer[1] (palmer@cogsci.berkeley.edu), Jonathan Gardner[1]; [1]Psychology Department, U. C. Berkeley

Painters, photographers, and other graphic artists continually face the problem of how to compose their subjects within rectangular frames in aesthetically pleasing ways. Despite the importance and generality of such issues, they have seldom been addressed empirically. We report the results of a series of experiments that investigate people's aesthetic responses to simple pictures consisting of one or two objects differing only in spatial position (both horizontal and vertical), size, and facing direction relative to a surrounding rectangular frame. The results, using paintings, photographs, and rendered digital images show strong, consistent preferences in the spatial composition of images depicting familiar objects, configurations of multiple objects, and even novel shapes. Viewers prefer single objects to be positioned at or near the center of the frame (the "center bias"), to face toward the center of the frame (the "facing bias"), and to occupy roughly half of the frame without cropping (the "full frame bias"). Similar preferences characterize configurations of multiple objects. The results are discussed in terms of aesthetic preferences reflecting conditions providing optimal perception of the content of the image. The implications for understanding the principles underlying art are also considered.

Blindness, Amblyopia, Dyslexia, and Rehabilitation

Tuesday, May 15, 8:30 - 10:00 am, Hyatt Ballroom North
Moderator: David Jones

8:30 869 Beyond BOLD: Expanding the Role of fMRI in Low Vision Rehabilitation

Christopher B Glielmi[1] (christopher.glielmi@bme.gatech.edu), Xiaoping P Hu[1], Ronald A Schuchard[2]; [1]Department of Biomedical Engineering, Emory University / Georgia Institute of Technology, Atlanta, Georgia, [2]Rehabilitation Research & Development Center, VA Medical Center, Atlanta, Georgia

Purpose: Retinitis Pigmentosa (RP) is a common cause of peripheral first and then central visual field loss [1]. Virtually all fMRI studies of visual field loss utilize BOLD contrast despite longitudinal and inter-subject variability [2]. However, recent studies in animals and healthy humans demonstrate cerebral blood flow (CBF) and cerebral metabolic rate of oxygen ($CMRO_2$) measures are more consistent over time within subjects and also between subjects [2-4]. The current study provides the first MRI application of CBF and $CMRO_2$ estimation in the low vision population providing a platform for future rehabilitation and cortical reorganization studies.

Methods: Two RP patients (age 34,45, visual acuity 20/90,110, central visual field 15, 5 deg.) participated in a monocular study. Four flashing stimuli (rings at two eccentricities and checkerboards at two resolutions) were used as subjects fixated on a central target. Anatomical and functional (simultaneous CBF and BOLD images) were acquired with a Siemens 3T Trio [5]. Data were analyzed using Matlab with SPM2 functionality, estimating $CMRO_2$ using a highly respected model [6].

Results: Activation maps demonstrate CBF's improved spatial specificity relative to BOLD. Furthermore, %*f*$CMRO_2$ estimates, %*f*CBF and absolute CBF results agree with previous studies that showed closer association with neuronal activity than BOLD alone.

Conclusions: The current work demonstrates for the first time that fMRI can be used to measure absolute and relative CBF and estimate relative $CMRO_2$ in people with visual field loss. Integration of these techniques into future studies will demonstrate their benefit in rehabilitation intervention and cortical reorganization studies.

References: [1] National Advisory Eye Council. Bethesda: Natl. Inst.Health, MD; DHHS Publ. No. 93-3186. [2] Tjandra TI. NeuroImage 2005. 27:393-401. [3] Wong EC. Functional MRI 1999. 63–9. [4] Sicard KM. NeuroImage 2005. 25:850-8. [5] Alsop DC. Radiology 1998. 208:410-416. [6] Davis TL. Proc Natl Acad Sci USA 1998. 95:1834-9.

Acknowledgement: Supported by VA Rehabilitation R&D Service and NIH RO1 EB002009.

8:45 870 Responses to auditory motion within visual motion area MT+ in early blind and sight recovery subjects

Melissa Saenz[1] (saenz@caltech.edu), Lindsay B. Lewis[2], Alex G. Huth[1], Ione Fine[3], Christof Koch[1]; [1]Caltech, [2]University of California, San Diego, [3]University of Southern California, Los Angeles

Over the last decade a series of brain imaging studies in humans have demonstrated that the visual cortex of people who become blind early in life responds to a variety of auditory, tactile, and verbal tasks. However, it remains unclear whether these cross-modal responses map onto the normal functional subdivisions of visual cortex found in sighted individuals. Here, using functional magnetic resonance imaging (fMRI), we tested whether visual cortical area MT+, well established for its role in visual motion processing in sighted subjects, is selectively recruited for auditory motion processing in early blind subjects.

We measured BOLD fMRI responses to moving vs. stationary auditory white noise stimuli in seven normally sighted control subjects, five early-blind subjects, and two formerly (early) blind subjects with partial sight recovery (due to corneal stem cell replacement and cataract removal). Auditory motion stimuli were generated by varying inter-aural level differences (ILD) on stereo headphones. A sparse pulse sequence limited interference of MRI scanner noise with auditory stimuli. In the sighted control and sight recovery subjects we also measured responses to moving vs. stationary visual stimuli in order to functionally locate MT+. In early-blind subjects but not in sighted control subjects, we found that MT+ responded significantly to auditory motion. In sight recovery subjects MT+ responded to both auditory and visual motion.

These results show that in early-blind subjects visual area MT+ can maintain enhanced responses to motion, despite receiving input from a novel modality. This suggests an organizational principal behind cortical cross-modal plasticity, whereby reorganization is influenced by the normal functional role of a given region. In sight recovery subjects, we found that responses to auditory motion in visual area MT+ were at least as strong as the responses to visual motion. Thus, cross-modal responses can persist after sight recovery, coexisting with regained visual responses.

9:00 871 Molecular Correlates of Amblyopia and Visual Recovery

Brett Beston[1] (bestonbr@mcmaster.ca), Kathryn Murphy[1,3], David Jones[2,3]; [1]Psychology, Neuroscience & Behaviour, McMaster University, [2]Electrical & Computer Engineering, McMaster University, [3]McMaster Institute for Neuroscience Discovery & Study, McMaster University

Monocular deprivation early in development leads to anatomical and physiological changes in visual cortex that result in poor visual acuity in the deprived eye. Behavioural studies have shown that binocular visual experience is necessary for optimal recovery, however, the mechanisms that promote this recovery are not well understood. Multiple mechanisms mediate plasticity in developing visual cortex including excitatory (NMDA, AMPA) and inhibitory ($GABA_A$) receptors. To address this question, we initiated a comprehensive study of changes in excitatory and inhibitory plasticity in visual cortex of cats reared with either normal vision, monocular deprivation, or monocular deprivation followed by a brief period of binocular vision. Using Western blot analysis of samples from different regions of visual cortex, we examined changes in excitatory (NR1, NR2A, NR2B, GluR2) and inhibitory ($GABA_A$ ·1, $GABA_A$ ·3) receptor subunit expression. Monocular deprivation promoted a complex pattern of changes that were most severe in regions of visual cortex where the central visual field is represented. To analyze these changes, we applied a neuroinormatics approach using Principle Component Analysis (PCA) to characterize the global pattern of change in these plasticity mechanisms. PCA showed that monocular deprivation causes a significant shift of the developmental trajectory, bypassing a large proportion of the normal developmental path, and accelerates maturation of the global receptor subunit expression. These changes suggest that monocularly deprived animals have less developmental plasticity and lack the molecular machinery needed for functional maturation of cortical circuits. A brief 4 day period of binocular vision was sufficient to restore these important plasticity mechanisms towards that of normal animals. Together, these results provide insights into molecular mechanisms underlying amblyopia, and why binocular vision is crucial for optimal recovery.

9:15 872 High-density verps show distinct mechanisms for global form and motion processing in adults and infants

Oliver Braddick[1] (oliver.braddick@psy.ox.ac.uk), John Wattam-Bell[2], Deirdre Birtles[1,2], Janette Atkinson[2], Claes von Hofsten[3], Pär Nyström[3]; [1]Dept of Experimental Psychology, University of Oxford, UK, [2]Visual Development Unit, Dept of Psychology, University College London, UK, [3]Department of Psychology, Uppsala University, Sweden

Sensitivity to global form and global motion are presumed indicators of extra-striate processing in ventral- and dorsal-stream visual areas respectively. Previously we have studied development in the two streams using single-channel steady-state visual evoked potentials (VEPs). We have extended this approach to high-density (128-channel) VERP recordings, to examine whether global form and motion responses have distinguishable topographic signatures.

In the form stimulus, dots form short concentric arcs giving a static global circular organization. For global motion the dots moved along similar arcs, yielding global rotation. Each of these patterns alternated (2 Hz) with patterns of randomly arranged arcs with no global structure. A positive VERP response to global organization is indicated by a first harmonic (F1) frequency component with significantly higher amplitude than the background noise.

Adult subjects showed strong, posteriorly-located F1 responses to both form and motion. The focus of the motion response was close to the midline, while the form response was more lateralised. A MANOVA on F1 amplitudes at each EEG channel confirmed this topographic difference as a significant form/motion x channel interaction.

In initial tests on 3-5 month old infants, the majority showed significant global motion responses close to the occipital midline, but fewer showed a significant form response, consistent with our previous findings that global form processing lags behind motion in development. Where there were responses to both stimuli there was, as in adults, a significant difference in topography with form responses having a more lateralised focus. Results on a wider range of infants will be reported.

These results show that global form and motion responses have distinct scalp distributions, implying distinct neural sources, in both adults and infants. The high-density multichannel method opens the possibility of tracking developmental changes, and the effects of perinatal risk factors, in the relationship between these sources.

Acknowledgement: Supported by Medical Research Council G790850 & by Swedish Research Council grant VR2003-1508 to Kerstin Rosander

9:30 873 Deficits in External Noise Exclusion Underlie the Etiology of Dyslexia

Anne Sperling[1] (sperlinga@mail.nih.gov), Zhong-Lin Lu[2], Franklin Manis[2], Mark Seidenberg[3]; [1]Office of Science Policy, Planning, & Communications, NIMH, [2]Department of Psychology, University of Southern California, [3]Department of Psychology, University of Wisconsin, Madison

Although dyslexia is usually diagnosed by poor reading and phonological impairment, the underlying neurobiological cause remains unclear. Individuals with dyslexia frequently exhibit impairments in other, non-linguistic areas, such as visual processing. The variety of observed impairments suggests that reading problems may be only one of several outcomes of neurological deficits. To identify the source of processing inefficiencies in dyslexia, we employed the external noise method and the observer model approach that was originally developed to study mechanisms of attention (Lu & Dosher, 1998). In the first study, signal-noise discrimination was evaluated in children with and without dyslexia, using magnocellular and parvocellular visual stimuli presented either with or without high noise. We found that dyslexic children had elevated contrast thresholds when stimuli of either type were presented in high noise, but performed as well as non-dyslexic children when either type was displayed without noise. In the second study, we compared motion-direction discrimination thresholds of adults and children with good or poor reading performance, using coherent motion displays embedded in external noise. We found that both adult and child poor readers had higher thresholds in the presence of high external noise, but did not differ from their respective peers in low external noise or when the signal was clearly demarcated. We conclude that deficits in noise exclusion, not magnocellular or temporal processing, contribute to the etiology of dyslexia. Our results may provide a critical step toward understanding the neural basis for phonological and other proximal causes of reading difficulties in dyslexia.

Acknowledgement: Supported by NICHD grant HD29891. No official support or endorsement by the National Institute of Mental Health is intended or should be inferred.

9:45 874 Three new visual methods for generating phantom sensations: case studies in the relief of upper and lower phantom limb pain, and benign essential tremors

David Peterzell[1,2,3] (peterzel@psy.ucsd.edu), Roberta Cone[1,3], Christian Carter[1,3], Judy Epler-Ortega[1], Alexandrea Harmell[1,2], Deborah Velez[1], Kathleen Parkes[1,2], Vilayanur Ramachandran[2], John McQuaid[1,2]; [1]VA San Diego Health Care System, [2]University of California, San Diego, [3]Alliant International University

A mirror box apparatus has been used previously to reduce or eliminate phantom limb pain in amputees and to generate phantom sensations (e.g., tingling) in normal subjects (Ramachandran, Altschuler). We created three apparati that generate phantom sensations in patients and normals, using them to reduce clinical symptoms in some instances when the mirror box was ineffective. The first apparatus uses three vertical mirrors, much like mirrors used in garment stores, with panes oriented at angles that enable viewers to see reversed mirror images of themselves from the side. The second uses two mirrors to provide alternative angles for lower-limb amputees. The third uses a real-time video image of the individual that flickers between a normal image and a mirror-reversed image at rates varying from 0.5 to 3 cycles/sec (with a .2 sec delay). The first and third methods induce sensations of tingling, movement, and temperature change in the hands and arms of some normal subjects. Participants were four amputees (left arm) using the first and third apparati, one lower limb (right leg) amputee using the second, and a woman with benign essential tremors using the third. When arm-amputees moved their remaining arm and hand while viewing modified images, they experienced sensations and movement in the missing limb. One upper limb amputee reports complete and permanent cessation of phantom pain following use of the tripartite mirror. The first and third apparati generate or amplify sensations of the phantom hand on the cheek, even in amputees who did not experience referred sensations previously. The two-mirror apparatus contributed to the reduction and near cessation of phantom pain in the lower limb amputee. The third apparatus produced a noticable reduction in tremors in the remaining subject, including tremors affecting speech. We speculate that human mirror neurons play roles in producing these effects.

Attention to Locations and Features

Tuesday, May 15, 10:30 am - 12:15 pm, Hyatt Ballroom South
Moderator: Marisa Carrasco

10:30 875 Feature-based attention modulates orientation-selective responses in human visual cortex

Taosheng Liu[1,2] (taosheng.liu@nyu.edu), Jonas Larsson[1,2], Marisa Carrasco[1,2]; [1]Department of Psychology, NYU, [2]Center for Neural Science, NYU

Goal: Spatial attention increases neural responses in retinotopic areas in a spatially specific manner, enhancing the responses of all neurons representing the attended location, irrespective of their selectivity. It has been suggested that feature-based attention can selectively enhance the response of neuronal subpopulations that prefer the attended feature, regardless of the spatial location of such feature. We used adaptation, measured with fMRI and psychophysically, to investigate whether feature-based attention modulates orientation-selective responses in human visual cortex.

Methods: The adapting stimulus consisted of two superimposed sinusoidal gratings (contrast: 50%, ± 20 deg off vertical, presented within a 1-4 deg annulus around fixation), whose spatial frequencies were smoothly modulated over time. Before each scan, observers viewed the adapting stimulus for 40 s while attending to one oriented component grating. During the scan, each trial contained a 4 s adapting stimulus (top-up) during which observers continued to attend to the same component. The top-up was followed by a 1-s test stimulus, a single grating (20% contrast) either in the attended or the unattended orientation. We also assessed orientation-selective adaptation psychophysically by measuring the tilt aftereffect with the same adapting stimulus and attentional instructions.

Results: We found a significant fMRI adaptation effect (lower fMRI response for the attended than unattended orientation) in all visual areas examined (V1, V2, V3, V3ab, V4, V7, LO1, LO2). Furthermore, we found a correlation between the magnitude of the tilt aftereffect and the attentional modulation in V1. These results show that feature-based attention can selectively increase the response of neuronal subpopulations that prefer the attended feature, even though the attended and unattended features share the same retinotopic location. These selective modulations occur as early as V1, the earliest site of orientation coding.

Acknowledgement: NIH EY016200-01A2 and the Seaver Foundation to NYU

10:45 876 Mechanisms of Covert Attention: External Noise Exclusion and Stimulus Enhancement in Early Visual Areas

Zhong-Lin Lu[1] (zhonglin@usc.edu), Xiangrui Li[1], Bosco S. Tjan[1], Barbara A. Dosher[2], Wilson Chu[1]; [1]Department of Psychology and Dana and David Dornsife Cognitive Neuroscience Imaging Center, University of Southern California, Los Angeles, [2]Department of Cognitive Sciences, University of California, Irvine

Using external noise analysis and a theoretical framework from the perceptual template model, we showed that covert spatial attention operates via two independent mechanisms (Dosher & Lu, 2000; Lu & Dosher, 2000): (1) excluding external noise/distractors around the target, and (2) enhancing the target stimulus. Behaviorally, external noise exclusion is only effective in high external noise conditions; stimulus enhancement only benefits performance in low external noise conditions. Here, we investigated the effect of covert attention in high external noise on the BOLD contrast response functions in retinotopically defined early visual brain areas. Using a rapid event-related design, BOLD responses to a brief (100 ms), spatially windowed (5-7½ annulus) sinusoidal grating embedded in high external noise were obtained in V1, V2, V3, V3A, and V4v. A counter-balanced pseudo-random sequence tested four grating contrast conditions in each fMRI run: 0, 1x, 3x, and 10x of each subject's orientation identification threshold in noise. In separate runs, subjects reported either the orientation of the grating (45±5½) ("attended") or the identity of a letter in the center of the display ("unattended"). In V1 and V2, BOLD responses without attention were relatively independent of signal contrast, reflecting responses to external noise. Covert attention reduced the BOLD responses for low signal contrasts and increased them for high contrasts, increasing the role of signal and decreasing the role of external noise. In higher cortical areas, attention did not alter the magnitude of the BOLD responses for low contrasts but increased them for high contrasts. Attention reduces the impact of external noise in early visual areas, resulting in increased signal to noise ratio and therefore better performance. Attention also enhances stimulus ("contrast gain"), which does not affect signal to noise ratio in high external noise – a finding unobservable psychophysically in high noise (Lu & Dosher, 1998).

Acknowledgement: Supported by NSF 04207994 and NEI EY016391

11:00 877 Sustained spatial attention in the human lateral geniculate nucleus and superior colliculus

Keith Schneider[1] (ks@rcbi.rochester.edu), Sabine Kastner[2]; [1]Rochester Center for Brain Imaging and Center for Visual Science, University of Rochester, [2]Department of Psychology and Center for the Study of Brain, Mind and Behavior, Princeton University

Introduction: Multiple visual streams arising from distinct populations of retinal ganglion cells become largely mixed in the cortex but remain segregated in subcortical nuclei. High-resolution functional magnetic resonance imaging and recently the application of super-resolution processing techniques have permitted the detailed study in humans of the internal structure of small subcortical structures such as the lateral geniculate nucleus (LGN) and superior colliculus (SC). Here we investigate the effects of sustained spatial attention.

Methods: In the first experiment, subjects fixated and performed a difficult motion coherence task that required attention to one of the two sides of a bow-tie stimulus composed of moving dot fields. As the stimulus slowly rotated in the visual field, the attended and unattended sides of the stimulus passed through the retinotopic receptive fields of LGN and SC neurons, and the attentional modulation was measured as the difference in the hemodymanic response between the two parts of the stimulus. In the second experiment, the bow-tie stimulus was composed of transient objects that differed in color and shape. The subjects' equally difficult task in this experiment was to detect particular feature conjunctions that appeared in only one side of the stimulus.

Results: The results show that both the LGN and SC are modulated by attention—the SC remarkably so, likely including both the superficial and deeper layers. No variation throughout the structure of the LGN or dependence on contrast sensitivity was noted that would suggest any differential modulation between the magnocellular and parvocellular layers, although the spatial resolution was not sufficient to determine this definitively. The strength of attentional modulation in both the LGN and SC was found to be independent of whether the task involved motion coherence or feature conjunctions, which is consistent with a purely spatial mechanism of attention.

11:15 878 Impaired attentional selectivity following lesions to human pulvinar

Jacqueline Snow[1] (j.c.snow@bham.ac.uk), Harriet Allen[1], Robert Rafal[2], Glyn Humphreys[1]; [1]Department of Psychology, University of Birmingham, [2]School of Psychology, University of Wales, Bangor

Relatively little is currently known about the functional role of the pulvinar nucleus of the thalamus, particularly in humans. From an anatomical and functional perspective, the pulvinar is well placed to play a critical role in selective attention. In non-human primates, the pulvinar shows strong connections with brain areas known to be involved in coding visual salience, including the parietal and frontal lobes. In addition, bidirectional connections between the pulvinar and consecutive topographically organized maps in striate and extrastriate cortex suggest a critical role for this structure in co-ordinating activity across different brain areas. The current study examined the possible role of the human pulvinar in filtering out competing salient visual distractors. We tested a group of three neuropsychological patients with circumscribed unilateral pulvinar lesions and a group of healthy age-matched controls using a sensitive psychophysics task. Observers were required to discriminate the orientation of a covertly attended target grating that appeared to the left or right of fixation. The target was flanked above and below by distractor discs of increasing contrast. As in previous studies, distractor contrast had little effect on orientation sensitivity for healthy controls. For patients with lesions to the ventral pulvinar, however, increasing distractor contrast impaired orientation sensitivity. Interestingly, distractors impaired orientation sensitivity in both the contralesional and ipsilesional fields. These findings are consistent with previous suggestions that the pulvinar plays a key role in selective attention, particularly in representing target salience and filtering of distractors across the visual field.

11:30 879 Prism adaptation reduces the 'disengage deficit' in right brain damage patients

Christopher Striemer[1] (clstriem@watarts.uwaterloo.ca), James Danckert[1]; [1]Department of Psychology, University of Waterloo (Canada)

Recent research has shown that prism adaptation alleviates some of the symptoms of neglect. Although prism adaptation can aid patients with neglect, the mechanisms underlying these benefits remain largely unknown. One way in which prisms may work is by altering attentional orienting mechanisms which are known to be impaired in neglect. To investigate this hypothesis we tested four right brain damaged patients (two with neglect) on a reflexive covert attention task before and after rightward prism adaptation and compared them to a group of healthy controls (N=26) who underwent sham prism adaptation. Results demonstrated that rightward prism adaptation reduced both the rightward attentional bias, and the disengage deficit in patients with right brain damage irrespective of the presence of neglect. This provides for the first time, a cognitive mechanism by which prism adaptation may aid patients with neglect. Furthermore, the current results suggest that prism adaptation may also be useful for rehabilitating spatial deficits in right brain damage patients without neglect.

Acknowledgement: This research was supported by a Heart and Stroke Foundation (HSFO) of Canada Masters Award, and a Natural Sciences and Engineering Research Council of Canada (NSERC) PhD Award to C.S. and HSFO Grant-in-aid and NSERC Discovery, and Canada Research Chair Awards to J.D.

11:45 880 Attentional suppression spreads throughout the visual field

Zoltán Vidnyánszky[1,2,4] (vidnyanszky@digitus.itk.ppke.hu), Viktor Gál[1], István Kóbor[1], Lajos Kozák[2], John Serences[3]; [1]Department of Information Technology, Péter Pázmány Catholic University, Budapest, [2]MR Research Center, Szentágothai J. Knowledge Center - Semmelweis University, Budapest, [3]Department of Cognitive Sciences, University of California, Irvine, [4]Neurobiology Research Group, Hungarian Academy of Sciences – Semmelweis University, Budapest

Visual attentional selection enhances the neural response to relevant features and suppresses the response to competing irrelevant features. Feature-based enhancement is known to operate across the visual field, and here we use fMRI in human observers to determine if attentional suppression is restricted to the currently attended spatial location or if attentional suppression also operates in a spatially global manner. On one side of fixation, two moving-dot apertures were presented (e.g. one to the upper right and one to the lower right of fixation) and each aperture contained two orthogonal directions of motion (e.g. leftward and upward motion in one aperture, rightward and downward in the other). Observers monitored the speed of the dots moving in one direction in one of the two apertures (e.g. monitor leftward motion in the upper aperture). We then measured the BOLD response evoked by an additional to-be-ignored unidirectional motion stimulus presented on the other side of a fixation. Consistent with previous reports, the BOLD response was larger when the ignored stimulus matched the currently attended direction compared to when it matched any of the unattended directions. However, the BOLD response was lowest when the ignored stimulus matched the irrelevant direction of motion that was presented in the same aperture as the target compared to one of the other unattended directions. We suggest that the presence of irrelevant features within the focus of spatial attention triggers an attentional suppression mechanism that attenuates the response to the suppressed feature across the entire visual field.

Acknowledgement: Supported by Hungarian Scientific Research Fund (OTKA T048949) JS supported by National Research Service Award F32EY01726

12:00 881 **Attentional load modulates subconscious orientation processing.**

Bahador Bahrami[1,2] (bbahrami@ucl.ac.uk), David Carmel[1,2,3], Vincent Walsh[1,2], Geraint Rees[1,3], Nilli Lavie[1,2]; [1]Institute of Cognitive Neuroscience, University College London, [2]Department of Psychology, University College London, [3]Wellcome Department of Imaging Neuroscience, Institute of Neurology, University College London

In load theory of attention (Lavie, 1995, 2005), competition between task-relevant and task-irrelevant stimuli for limited-capacity attention does not depend on conscious perception of the irrelevant stimuli. Here we examine whether the level of perceptual load in a relevant task would determine unconscious processing of invisible stimuli. Subjects performed an RSVP task at fixation under conditions of low perceptual load (detecting color targets) or high perceptual load (detecting conjunctions of color and shape). A task-irrelevant tilted grating was also presented monocularly in the periphery, and was suppressed from awareness by continuously flashing a mask stimulus at the same peripheral location in the other eye. Increasing the perceptual load of the fixation task reduced orientation-specific adaptation to the irrelevant and effectively invisible tilted grating. We conclude that even unconcious perception of orientation depends on the availability of spare attentional capacity from a foveal task. These results extend load theory to account for unconscious perception and rule out claims that attentional effects are restricted to conscious representations (Lamme, 2003; Block, 1996).

Motion Mechanisms

Tuesday, May 15, 10:30 - 12:15 pm, Hyatt Ballroom North
Moderator: Tony Movshon

10:30 882 **Integration of sensory responses in coarse and fine motion discriminations**

Mehrdad Jazayeri[1] (mjaz@cns.nyu.edu), Anthony J. Movshon[1]; [1]Center for Neural Science, New York University

To make perceptual judgments, the brain must decode the responses of sensory cortical neurons. The direction of visual motion is represented by the activity of direction selective neurons. These neurons are often broadly tuned and inherently noisy, so to infer the direction of motion reliably the brain must appropriately integrate their responses. The optimal integration strategy is task-dependent. For coarse direction discriminations, neurons tuned to the directions of interest provide the most reliable information, but for fine discriminations, neurons with preferred directions off to the sides of the target directions are more reliable. To examine how the visual system pools the activity of direction selective neurons, unbeknownst to observers engaged in a coarse of a fine direction discrimination of random-dot stimuli, we added subthreshold motion signals of different directions to the stimulus to perturb the responses of different groups of direction selective neurons. The pattern of biases induced by subthreshold signals of different directions indicate that (1) subjects' choice behavior relies on the activity of neurons with a wide range of preferred directions and, (2) for coarse discriminations, observers' judgments are most strongly determined by neurons tuned to the target directions, but for fine discriminations, neurons with preferred directions off of the stimulus direction have the largest influence. Our results therefore show that perceptual decisions rely on a population decoding strategy that takes the statistical reliability of sensory responses into account.

10:45 883 **Image velocity estimation based on vector averaging of MT neuron responses: the problem of spatial scale**

John A. Perrone[1] (jpnz@waikato.ac.nz), Richard J. Krauzlis[2]; [1]Department of Psychology, The University of Waikato, New Zealand, [2]Salk Institute for Biological Studies, U.S.A.

It is unknown how the visual system encodes local image velocity. Neurons in cortical area MT/V5 respond selectivity to image speed independently of spatial frequency (Perrone & Thiele, 2001), but their activity is tuned to particular speeds rather than linearly related to image velocity. Thus, extracting image velocity presumably involves a computation based on a population of MT neurons, such as vector averaging (Lisberger & Movshon, 1999; Priebe & Lisberger, 2004). Here, we identify a major problem with these vector average schemes and explore possible solutions. Using a model of MT neurons that can be tested with 2-d image sequences (Perrone, 2004), we have found that the performance of vector average schemes is compromised by the problem of spatial scale. The problem arises because MT neurons tuned to high speeds have larger receptive fields than those tuned to slow speeds. As the distance from a moving edge increases, neurons tuned to slow speeds are disproportionately omitted from the summation operation. Consequently, the vector average result is biased towards higher velocities in the region surrounding a moving edge. We have tested an alternative mechanism that incorporates a set of 12 different MT neurons (4 spatial frequencies x 3 temporal frequencies) at each image location, (x, y). An edge moving at speed V forms a ridge of peak activity in the MT array. At (x, y), the maximum output occurs in the MT neurons tuned to speed V. The pattern of activity is different for image locations away from (x, y). Therefore the ridge of maximum MT activity occurring at (x, y) can be isolated using derivatives (both across and along the ridge) and a veridical estimate of local image velocity can be found despite the differences in receptive field sizes across the population of MT neurons.

Acknowledgement: Supported by a Royal Society of New Zealand Marsden Fund grant.

11:00 499 **Spatial frequency tuning of motion integration across space and orientation**

Shin'ya Nishida[1] (nishida@brl.ntt.co.jp), Kaoru Amano[1], Mark Edwards[2], David R. Badcock[3]; [1]NTT Communication Science Labs, NTT Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa, Japan, [2]School of Psychology, Australian National University, Canberra, [3]School of Psychology, The University of Western Australia

Motion sensors early in motion processing (e.g., V1) have small receptive fields and are selective for orientation. The sensor signals are integrated across space and orientation in later stages (e.g., MT/V5). The motion sensors are also tuned to spatial frequency. Using global motion stimuli comprised of drifting-carrier (static-envelope) Gabors (Nishida et al, 2006, Journal of Vision, 6(6), 1084a), we examined the role of spatial frequency

(SF) when local 1D motion signals are simultaneously integrated across space and orientation. Signal Gabors (S) had carrier drift-velocities consistent with a given global-2D velocity, while the drift velocities of the noise Gabors (N) were inconsistent. First, we varied the carrier SF independently for S and N. The noise masking effects, estimated from the threshold S/N ratio required to identify global motion direction, showed broad low-pass tuning regardless of the SF of S. The results remained the same when we used random orientations, or changed orientation similarity between S and N. This broadband tuning is consistent with previous studies using global motion stimuli comprised of bandpass 2D dots. Second, we used two signal groups, S1 and S2 (no noise Gabors), with each group having a common SF and orientation. When S1 and S2 had similar SFs, they were perceived to move coherently in the global IOC direction for a wide range of S1-S2 density ratios. However, such stable integration was not observed when S1 and S2 had a 2-octave SF difference even if their orientation difference was small. These results are in contrast to the noise masking effect and to the results for standard plaid stimuli. In conclusion, motion integration across space and orientation is not simply broadband in SF, retaining selectively possibly for segmenting motion signals of separate objects based on SF differences.

Acknowledgement: Supported by: the Japan Society for the Promotion of Science (KA) Australian Research Council (ARC) Grant # CE0561903 (ME) ARC Grant # DP0666206 (DRB)

11:15 885 Bistable Illusory Rebound Motion: Event-related functional magnetic resonance imaging of perceptual states and switches

Po-Jang Hsieh[1] (Po-Jang.Hsieh@dartmouth.edu), Gideon Caplovitz[1], Peter Tse[1]; [1]Department of Psychological and Brain Sciences, Dartmouth College

Here we use fMRI to determine the neural correlates of a recently discovered visual illusion that we call ‘illusory rebound motion’ (IRM). This illusion is remarkable because motion is perceived in the absence of any net motion energy in the stimulus. When viewing bars alternating between white and black on a grey background, the percept alternates between one of flashing bars (veridical) and the IRM illusion, where the bars appear to shoot back and forth, rather like the opening and closing of a zipper. The event-related functional magnetic resonance imaging (fMRI) data reported here reveal that (1) the blood oxygen-level dependent (BOLD) signal in the human analog of macaque motion processing area MT (hMT+) increases when there is a perceptual change from “no IRM” to “see IRM,” and decreases when there is a perceptual change from “see IRM” to “no IRM,” although the stimulus remains constant; and (2) the BOLD signal in early retinotopic areas (V1, V2, and V3d) shows switch-related activation whenever there is a perceptual change, regardless whether from IRM to no-IRM or vice versa. We conclude that hMT+ is a neural correlate of this novel illusory motion percept because BOLD signal in hMT+ modulates with the perception of IRM.

11:30 886 A 'Perceptual Scotoma' Theory of Motion-Induced Blindness

Joshua New[1] (joshua.new@yale.edu), Brian Scholl[1]; [1]Department of Psychology, Yale University

In motion-induced blindness (MIB), salient target objects will fluctuate into and out of conscious awareness when superimposed onto certain global moving patterns. Previous studies have delimited several factors that mediate MIB, but there is little consensus on why it occurs at all. Here we explore a new possibility: MIB occurs due to the visual system's attempt to separate distal stimuli from artifacts of damage to the visual system itself. When a small target object is invariant with respect to changes that are occurring to large regions of the surrounding visual field, the visual system may discount that stimulus as akin a scotoma, and may thus fill it in. We discuss how this theory can account for many previous MIB results, and then describe and demonstrate several new effects that support this idea. Three examples: (1) Motion itself is not required: similar effects are obtained from other manipulations, such as cyclic global changes to the luminance of a static global pattern. (2) MIB is stronger with monocular vs. binocular viewing of the target, when the global motion pattern is always binocular. (3) MIB is vastly stronger when both the target and fixation point move together, compared to when they move relative to each other (e.g. in opposite directions). These and other results are all consistent with the hypothesis that the visual system treats the target object as an artifact or insult to its own structure and processing, rather than as an object in the external world. This new account is considerably different than previous accounts of MIB, but helps to connect it with other types of visual phenomena. In the end, 'motion-induced blindness' may be better described as just a special case of 'perceptual scotomas'.

URL: http://www.yale.edu/perception

11:45 887 A cortical locus for high-level motion processing?

Julian Wallace[1] (Julian.Wallace@bris.ac.uk), Nicholas Scott-Samuel[1], Andy Smith[2]; [1]Department of Experimental Psychology, University of Bristol, [2]Department of Psychology, Royal Holloway University of London

There is good evidence for at least two motion processes: 1) a low-level process based on motion energy, with no reference to spatial structure, and 2) a high-level process based on the changing location of spatial image features or primitives. A number of imaging studies have attempted to identify the cortical location of high-level motion processing. The lack of consensus from these studies may be attributed to the wide variety of stimuli used. We attempted to identify pure high-level motion responses across different stimulus types, and controlled for stimulus flicker. The stimuli were a radial version of the missing-fundamental stimulus (Georgeson & Harris, 1990), and the reverse phi stimulus (Anstis, 1970). With no inter-frame interval (IFI), motion is perceived in the (low-level) energy direction, and at longer IFIs, motion is perceived in the opposite (high-level) features direction. In an event-related stimulation paradigm, these stimuli and corresponding flicker controls were viewed passively (n=12), and functional images were acquired (3T Siemens Scanner at Royal Holloway University of London). The data were analysed using SPM2, and first-level contrasts of individual stimuli against flicker, and motion-type (collapsed across stimuli) versus flicker were then assessed using a second-level random-effects group analysis. The resulting activations were different for low-level and high-level contrasts, and identified a high-level motion specific response in the region of the intra-parietal sulcus (IPS). This area has previously been identified with attention, and the result is therefore consistent with theories that high-level motion processing involves attentional control for ‘feature tracking’.

Acknowledgement: Supported by the BBSRC (BBS/B/08795)

12:00 888 Brain activity reflects implied motion in abstract paintings

Chai-Youn Kim[1] (chai-youn.kim@vanderbilt.edu), Randolph Blake[1]; [1]Department of Psychology, Vanderbilt Vision Research Center, Vanderbilt University

Background: Early 20th century artists including Duchamp and Balla tried to portray moving objects on static canvas by superimposing objects in successive portrayals of an action. We investigated 1) whether viewing those kinds of paintings activate motion-sensitive brain areas, and 2) whether activations are associated with previous exposure to these kinds of artwork. Experiment 1: We tested two groups of observers, one with prior exposure to such paintings and others without such knowledge. Twelve abstract paintings intended to portray motion (MP) and twelve "static" paintings (SP) were shown to observers, who used a 5-point scale to rate the extent to which each painting implied visual motion. Both groups of observers (knowledgeable and naïve) rated MP higher in implied motion than SP, but there was a statistically significant interaction between painting types and observer experience. Experiment 2: We used functional magnetic resonance imaging to measure brain activity in observers who viewed abstract paintings rated the highest and the lowest in terms of motion. MT+, but not V1, showed greater BOLD responses to MP than to SP, only in observers with prior experience viewing those kinds of paintings. Conclusion: Evidently the neural machinery ordinarily engaged during perception of real visual motion is activated when people view paintings explicitly designed to convey a sense of visual motion. Unintentionally, artists like Duchamp and Balla succeeded in manipulating the human brain to transcend the static limitations imposed by painted images frozen on the canvas. Experience, however, is necessary to achieve this sense of motion.

Acknowledgement: Supported by EY14437

Perceptual Learning IV

Tuesday, May 15, 2:00 - 3:30 pm, Hyatt Ballroom South
Moderator: Allison Sekuler

2:00 889 Electrophysiological correlates of performance and learning in the backward-masked texture-discrimination task

Nitzan Censor[1] (nitzan.censor@weizmann.ac.il), Yoram Bonneh[1], Dov Sagi[1]; [1]Dept. of Neurobiology, Brain Research, The Weizmann Institute of Science, Rehovot, Israel

Experimental evidence from texture discrimination tasks using backward pattern masking shows performance dependence on the stimulus-to-mask onset asynchrony (SOA) as well as the amount of prior practice. In the following study we examine whether human event-related potentials (ERPs) correlate with the level of texture discrimination performance and thus enable to reveal underlying mechanisms of learning and backward masking effects on the level of performance. The standard texture stimulus was used, briefly presented (40 ms) and backward masked as in Karni and Sagi (1993). Observers decided whether an array of 3 diagonal bars embedded in a background of horizontal bars was horizontal or vertical. In each session the SOA decreased gradually to obtain a psychometric curve. ERPs were recorded over occipital electrode sites and time-locked to the onset of the target visual stimulus. Both naïve and experienced observers participated in the experiment. At large SOAs (>200 ms) there was a clear separation between target responses and mask responses, with maximal response to the target at 100 ms. The latter was found to be constant in each observer, independent of SOA (60-340 ms) and performance level. Performance level was found to correlate with the temporal separation between target and mask responses which in turn depend on SOA and experience with the task. It seems that performance fails when the presented mask limits the effective processing of the target signal. The correlation found here between the ERP response and the discrimination performance may have an essential role in the underlying mechanism of backward masking effects on texture discrimination performance. Practice with the texture task seems to improve the temporal separation between target and mask.

Acknowledgement: The research was supported by the Nella and Leon Benoziyo Center for Neurological Diseases at the Weizmann Institute of Science.

2:15 890 Electrophysiological Substrates of Configural Learning

Leslie Blaha[1] (lblaha@indiana.edu), Thomas Busey[1]; [1]Department of Psychological and Brain Sciences, Indiana University, Bloomington

Perceptual unitization, or "perceptual chunking," of novel object features results in a fundamental shift in perceptual processing strategy, as evidenced by the qualitative shift in processing capacity found by Blaha and Townsend (VSS, 2006). Unitization thus provides a potential learning mechanism for the development of configural processing strategies or representations. Evidence from studies of both real-life and laboratory-trained experts demonstrate N170 differences for the visual response to objects of expertise. Often these are similar to the responses to faces. Researchers proposed this neurological response of visual expertise results from configural processing strategies, to which the N170 is sensitive (Busey & Vanderkolk, 2005). We propose that the observed changes in information processing over the course of configural learning should be accompanied by changes in neurological measures of perception; in particular, we expect the N170 to change as configural object representations are developed in a unitization learning task. Participants unitized novel object features in a categorization task requiring conjunctive processing for correct category identification. Capacity analyses of response times replicate our previous findings of shifts from extreme limited to extreme super capacity processing over the course of learning. On the initial training day, participants exhibited no N170 differences between novel objects. Seven days of training resulted in an N170 amplitude change for the unitized object. Unitization thus alters this neural response when objects can be processed in a configural manner, as indexed by the behavioral measures. These results provide converging evidence that configural learning via perceptual unitization fundamentally alters the perceptual processing strategies or representations employed in object identification. Further, this study may serve as a platform for developing models to bridge response time behavioral measures and the neurological signals in ERPs.

2:30 891 Superior identification of familiar visual stimuli a year after learning

Zahra Hussain[1] (hussaiz@mcmaster.ca), Patrick Bennett[1,2], Allison Sekuler[1,2]; [1]Psychology, McMaster University, [2]Centre for Vision Research, York University

We examined the time-course of perceptual learning of face- and texture-identification, and the robustness of that learning across years. On the first session (baseline), observers performed a total of 840 trials of 10AFC face- or texture-identification in three levels of external noise. Method of constant stimuli was used to display the images at one of seven different contrasts at each level of external noise. Proportion correct and identification thresholds were measured. Observers returned the next day to complete the second session under the same experimental conditions. Perceptual learning was indicated by a significant increase in proportion correct relative to baseline in both tasks. The time course of learning revealed substantial within-session gains during the first session followed by some overnight improvement, with performance continuing to improve during the second session. Observers then returned to perform a third session about 12-18 months later, and were tested in two conditions. One condition used the same stimuli that were used during the first two sessions. The other condition used novel stimuli. Even after more than a year, for both faces and textures, there was almost complete retention of perceptual learning. However, some differences between faces and textures were observed. Identification of previously-viewed faces was slightly less accurate than the second session performed over a year prior, but was still considerably greater than baseline. Moreover, there was no evidence that learning transferred to novel faces. Identification of previously-viewed textures was virtually identical to that measured during the second session over a year earlier, and learning partially generalized to the novel textures. Clearly, perceptual learning of faces and textures endures for years, and the specificity of learning depends on stimulus type.

Acknowledgement: This research was supported by NSERC operating grants 105494 and 42133 and the Canada Research Chairs Programme (ABS & PJB), and an NSERC PGS-D fellowship (ZH)

2:45 892 Unsupervised learning of higher order statistics of visual features: evidence for relational encoding

Elan Barenholtz[1] (Elan_Barenholtz@brown.edu), Michael J. Tarr[1]; [1]Brown University Dept. of Cognitive and Linguistic Sciences

A number of important theories of visual recognition assume that objects are represented on the basis of parts and their explicitly defined relations (e.g. Biederman, 1987). Much of the evidence pertaining to the encoding of relations between features (as opposed to encoding of the features themselves) comes from so-called 'configural effects', such as the advantage in recognizing one part of a face when other parts are present (Tanaka & Sengko, 1997). However, many of these findings might be explained by invoking 'larger' features that incorporate multiple smaller features, e.g. using a single 'eye-and-nose' feature, rather than separate 'eye' and 'nose' features in a particular spatial relationship. The current research aims to disassociate the roles of features and their relations: subjects viewed patterns composed of multiple, distinct polygonal shapes in which the spatial relations between spatially non-contiguous features were controlled, so that specific pairs of features ('base-pairs) always appeared together, and in the same spatial relation to one another, across multiple patterns. Across three experiments, we tested whether subjects had learned the statistics of the patterns in terms of the joint and conditional probability of the positions of base-pair features. Our results showed that subjects could learn the statistical properties of non-contiguous features while discounting the properties of features located between them. These results are inconsistent with a plausible 'larger feature' hypothesis, which would necessarily include the spatially intermediate features, and provide direct support for the explicit encoding of relations between features in unsupervised learning.

References:

Biederman, I. (1987). Recognition by components: A theory of human image understanding. Psychological Review, 94, 115–147.

Tanaka, J. W., & Sengco, J. A. (1997). Features and their configuration in face recognition. Memory & Cognition, 25, 583–592.

Acknowledgement: Both authors funded by NGA Award #HM1582-04-C-0051.

3:00 893 Beyond pair-wise statistics in visual scene perception

József Fiser[1,2] (fiser@brandeis.edu), Gergõ Orbán[1], Richard Aslin[3], Máté Lengyel[4]; [1]Volen Center for Complex Systems, Brandeis University, [2]Department of Psychology, Brandeis University, [3]Department of Brain and Cognitive Sciences, Center for Visual Science, University of Rochester, [4]Gatsby Computational Neuroscience Unit University College London, UK

The dominant view on how humans develop new visual representations is based on the paradigm of iterative associative learning. According to this account, new features are developed based on the strength of the pair-wise correlations between sub-elements, and complex features are learned by recursively associating already obtained features. In addition, Hebbian mechanisms of synaptic plasticity seem to provide a natural neural substrate for associative learning. However, this account has two major shortcomings. First, in associative learning, even the most complex features are extracted solely on the basis of pair-wise correlations between their sub-elements, while it is conceivable that there are features for which higher order statistics are necessary to learn. Second, learning about all pair-wise correlations can already be intractable since the storage requirement for such representations grows exponentially with the number of elements in a scene, and learning progressively higher order statistics only exacerbates this combinatorial explosion. We present the results of a series of experiments that assessed how humans learn about higher-order statistics. We found that learning in an unsupervised visual task is above chance even when pair-wise statistics contain no relevant information. We implemented a formal normative model of learning to group elements into features based on statistical contingencies using Bayesian model comparison, and demonstrate that humans perform close to Bayes-optimal. Although the computational requirements of learning based on model comparison are considerable, they are not incompatible with Hebbian plasticity, and offer a principled solution to the storage-requirement problem by generating optimally economical representations. The close fit of the model to human performance in a large set of experiments suggests that humans learn new complex information by generating the simplest sufficient representation based on previous experience and not by encoding the full correlational structure of the input.

3:15 894 Culture and visual context learning

Diyu Chen[1] (chendi@gse.harvard.edu), Yuhong V. Jiang[1]; [1]Department of Psychology, Harvard University

Recent research by Nisbett and colleagues suggests that visual perception differs significantly across cultures, with European descendents attending more to individual objects and East Asians attending more to the context. This study investigates cultural differences in visual tasks requiring explicit memory, explicit context learning, or implicit context learning. We tested European descendents who grew up in the US, and East Asians who grew up in China and had been in the US for less than 2 months. In the explicit picture memory task, participants judged the likeability of animals presented against a background. Explicit recognition of the animals was later tested. We confirmed that a new background presented during testing tended to impair East Asians' recognition of the central animals more than it did on European descendents. In an explicit context learning task, participants searched for a T among Ls overlaid against natural scenes. The location of the target was either consistently paired with a particular scene or was randomly placed. Participants developed explicit knowledge of the scene-target association and became faster at locating the target on consistently paired trials. Learning occurred earlier for East Asians than European descendents. These results confirmed that East Asians are apparently more contextually driven than European descendents. However, in an implicit visual learning task, we found no difference between cultural groups. Participants searched for a T among Ls and on some trials the locations of the Ls reliably predicted the location of the T. Both groups became faster finding the T on predictive displays than random displays although they were unaware of the association. The magnitude and pace of implicit context learning were comparable between the two groups. We conclude that East Asians are more contextually driven than European descendents in explicit visual learning and memory tasks but not in implicit tasks.

Acknowledgement: Supported by NIH 071788 and NSF 0345525

Color, Luminance and Receptors

Tuesday, May 15, 2:00 - 3:30 pm, Hyatt Ballroom North
Moderator: Andrew Stockman

2:00 895 Scission causes large color-induction effects in textured center-surround stimuli

Daniel Wollschläger[1,2] (dwoll@psychologie.uni-kiel.de), Barton L. Anderson[1]; [1]Department of Psychology, The University of New South Wales, Sydney, Australia, [2]Institut für Psychologie, Christian-Albrechts-Universität zu Kiel, Germany

Our ability to perceive invariant object colors requires mechanisms that disentangle object properties from context dependent influences like illumination, inter-reflections, and transparency. Previous work has shown that varying the mean and the covariance structure of surround colors induces changes in the appearance of embedded targets. Such phenomena are usually explained with low-level mechanisms like gain control and adaptation. However, recent studies showed that such processes fail to explain the pattern of color induction observed in homogeneous center-surround stimuli. Instead, color induction was suggested to result from scission: a contrast-dependent decomposition of the local image into two simultaneously present color components. Here, we show that scission can also induce large changes in the color appearance of randomly-variegated displays. We constructed center-surround displays in which the central target contained a distribution of random colors with an achromatic mean. The surround also contained a random distribution of colors, but the mean of this distribution was shifted in some direction away from the neutral point. These displays induce a clear percept of multiple layers: namely, a homogeneous colored target superimposed in a pattern of random noise. Asymmetric color-matching experiments revealed large opponent color induction effects in the center target region. The color-induction observed in our variegated displays far surpassed that observed in corresponding uniform center-surround stimuli. Importantly, strong color induction was only evident when the pattern of contrast along the border of the center pattern was compatible with scission, even if the same global color statistics were present. Color induction was also only observed if the chromatic contrast of the central region was less than that of the surround, consistent with models of transparency. These results cannot be accounted for by structure-blind adaptation or gain control mechanisms, and reveal that the importance scission in color induction is not restricted to homogeneous displays.

2:15 896 **Cone-specific gain changes compensate color appearance for differences in spectral sensitivity**

Deanne Leonard[1] (the_doc_2b@yahoo.com), Michael Webster[1]; [1]Psychology, University of Nevada, Reno

Color appearance shows complete compensation for age-related changes in lens pigment density (e.g. Werner and Schefrin JOSA 1993) and for eccentricity-dependent changes in macular pigment density (Beer et al. JOV 2005). However, the mechanisms underlying this compensation are not known. We examined whether the adjustment for macular pigment reflects differences in the intrinsic sensitivity of the cones (or cone-specific pathways), by measuring how achromatic settings are biased by chromatic adaptation in the fovea and periphery. The stimulus was a 20 cd/m2 circular field shown in an otherwise dark room. The field subtended 2 deg and was presented in the fovea or at an eccentricity of 8 deg. Subjects adjusted the chromaticity of the field until it appeared a neutral white, and settings were repeated either after dark adapting or during adaptation to different chromaticities in the field that varied S cone excitation over a large range spanning the nominal white point. Dark-adapted white settings at the two loci were similar, despite the large differences in spectral sensitivity predicted by differences in macular screening. Adapting to a high S-cone, purple field causes the test to appear yellowish green and thus shifts the white settings toward purple, while adapting to a low S-cone color induces the opposite aftereffects. The intermediate adapting S level that does not bias the white settings thus defines the neutral, baseline sensitivity of the chromatic mechanisms at the sites affected by the adaptation. These adaptation effects were again similar at the two eccentricities and had neutral points close to the dark adapted white point. Since the chromatic adaptation largely reflects cone-specific sensitivity changes, our results suggest that much of the neural compensation for color appearance may happen at an early cone-specific stage, perhaps by matching the intrinsic gains of the cones to the long-term history of stimulus exposure.

Acknowledgement: supported by EY10834

2:30 897 **Bayesian Models of Color Appearance: Understanding the Appearance of Small Spot Colors**

David H. Brainard[1] (brainard@psych.upenn.edu), Heidi Hofer[2], David R. Williams[3]; [1]Department of Psychology, University of Pennsylvania, [2]College of Optometry, University of Houston, [3]Center for Visual Science, University of Rochester

Hofer et al. (Journal of Vision, 2005) report that observers provide a wide range of color names in response to very small monochromatic spots. Here “very small” means spots with a retinal size comparable to that of a single cone (achieved through the use of adaptive optics), and “wide range” includes the term white. We present a Bayesian calculation that models the data as a natural consequence of information loss arising from chromatic sampling: although the retina as a whole is trichromatic, it is monochromatic at the scale of single cones. The calculation starts with the simulated responses of the individual L-, M-, and S-cones actually present in the cone mosaic and uses these to estimate the trichromatic L-, M-, and S-cone signals that were present at every image location. The calculation incorporates precise measurements of the optics and chromatic topography of the mosaic in individual observers, as well as the spatio-chromatic statistics of natural images. We carefully simulated the experimental procedures of Hofer et al., and predicted the color name on each simulated trial from the average chromaticity of the LMS image estimated by our calculation. There were no free parameters to describe variation between observers. None-the-less, the striking individual variation in the percentage of spots named white emerged naturally as a consequence of the measured individual variation in the relative numbers and arrangement of L-, M- and S-cones. The model also makes testable predictions for experiments that may soon be feasible, including how color naming should vary with spot size and with the local structure of the cone mosaic surrounding the presented spot.

Acknowledgement: Supported by NIH EY10016.

2:45 898 **The achromatic mechanisms do not combine cone signals additively: a new experimental approach.**

Rhea T. Eskew, Jr.[1] (eskew@neu.edu), Jessica Goodrich[1]; [1]Department of Psychology, Northeastern University

Many standard models of color vision include a "luminance" mechanism that combines signals from the L and M cones additively (e.g., Boynton, 1979; Guth, 1991; Lennie, Pokorny, & Smith, 1993). Experiments that employ "equiluminant" stimuli generally assume linearity, explicitly or implicitly. The luminance mechanism is often studied using moderate to high frequency flicker or motion stimuli. However, brief, weak equichromatic flashes are also generally believed to be detected by this mechanism (Eskew, McLellan, & Giulianini, 1999; Krauskopf, Williams, & Heeley, 1982). The present experiments were undertaken to determine if the mechanism that detects "white" Gaussian blobs, on a gray background, combines the L and M cones linearly, using a new approach that was developed to study the linearity of mechanisms detecting S-cone isolating flashes (Giulianini & Eskew, 2007). A test flash is embedded in masking noise (flickering lines covering the test region). In different runs, the noise consists of L-cone modulations only, M cone modulations only, or the superposition of the two cone component noises (L&M noise). If the detection mechanism combines its L and M cone inputs linearly, the threshold elevation produced by the compound L&M noise is predictable from a specific combination of the elevations produced by the two component noises. Previous results with this method found that S cone mechanisms are nonlinear, but that the 'green' mechanism is remarkably linear. In the present study, we measured the masking effect of 8 different compound noises and their associated L and M components. The results show that the mechanism that detects achromatic flashes does not combine its L and M cone inputs linearly. This result, along with others using flicker detection (Stockman & Plummer, 2005; Stromeyer, Chaparro, Tolias, & Kronauer, 1997), calls into question the generality of the idea of equiluminance.

3:00 899 **Vμ*(?): a generalized luminous efficiency function for any condition of chromatic adaptation**

Andrew Stockman[1] (a.stockman@ucl.ac.uk), Herbert Jägle[2], Markus Pirzer[2], Lindsay Sharpe[1]; [1]Institute of Ophthalmology, University College London, UK., [2]Division of Experimental Ophthalmology, University Eye Clinic, Tübingen, Germany

Introduction: We recently proposed a luminous efficiency function, V*(Î), for 2° photopic viewing based on heterochromatic flicker photometric (HFP) measurements made under daylight (D_{65}) adaptation (Sharpe, Stockman, Jagla, & Jägle, 2005). V*(Î), is defined as a linear combination of the Stockman & Sharpe (2000) long-wavelength sensitive (L-) and middle-wavelength sensitive (M-) cone fundamentals. However, the applicability of V*(Î) is limited to its measuring conditions, because the relative contributions of the L- and M-cones to luminous efficiency depend strongly on the state of chromatic adaptation. Here, we extend its applicability by characterizing its dependence on background chromaticity.

Methods: 25 Hz HFP matches were obtained in 6 genotyped male observers on 23 different 3.0 $\log_{10}$ photopic troland adapting fields (μ): 14 spectral ones (μ = 430 to 670 nm); 7 bichromatic mixtures (μ = 478 + 577 nm) that varied in luminance ratio; and 2 corresponding to CIE Illuminants A and D65 daylight. Each of the resulting 23 luminous efficiency functions, Vμ*(Î), was characterized as a best-fitting linear combination of the cone fundamentals, aL(Î) + M(Î), where a, the L-cone weighting factor, varies with μ, the effective background wavelength.

Results: As expected, short-wavelength fields increase a, by decreasing the relative M-cone contribution, and long-wavelength fields decrease a, by decreasing the relative L-cone contribution. However, the changes in a are larger on short wavelengths fields and smaller on long-wavelengths ones than predicted from reciprocal sensitivity adjustment (Weber's Law). Shorter and longer wavelength chromatic fields both relatively suppress the M-cone contribution to Vμ*(Î) in excess of Weber's Law.

Tuesday Talks

Conclusions: Our generalized model accounts for Weber's Law and the chromatic suppression of the M-cone contribution to Vμ*(Î). It allows a(μ), and therefore Vμ*(Î), to be predicted for a standard observer for any chromatic background of 1000 td.

Acknowledgement: Grants: JA997/5-1 to HJ

3:15 900 **Early scotopic dark adaptation; change in gain versus change in noise.**

Adam Reeves[1] (reeves@neu.edu), Rebecca Grayhem[1]; [1]Psychology Dept., Northeastern University

Just after turning off a steady adaptation field, the log threshold for cone vision abruptly drops half-way to absolute threshold, before the leisurely process of dark adaptation begins. The abrupt drop is due, we have argued, to the removal of photon-driven (square-root) noise consequent on shuttering the adaptation field (Krauskopf & Reeves, Vision Research 20, 193-196; Reeves, Wu, Schirillo, Vision Research, 38, 2639-2647). We now document that the same half-way drop occurs with rod-mediated vision, over a range of 3 log units of field intensity, using stimulus parameters which isolate rods (a 1.3 deg, 200 ms, 500 or 530 nm test spot, seen at 10 deg eccentricity in Maxwellian view). The comparison between increment thresholds and thresholds obtained just after the field is extinguished extends the range of the well-known Rose- DeVries square-root law from low scotopic levels, where rods do not adapt, to higher levels at which rods do light adapt. That both rod and cone increment thresholds approach or equal Weber's law indicates that in both systems, not only does photon noise from the field drive up threshold (following the Rose-DeVries square-root law), but light adaptatio reduces sensitivity by a further factor, also proportional to the square-root of field intensity.

Acknowledgement: AFOSR
URL: http://www.atsweb.neu.edu/psychology/a.reeves/WEBSITE/

Attention: Selection Over Space and Time

Tuesday, May 15, 4:00 - 5:45 pm, Hyatt Ballroom South
Moderator: Arni Kristjansson

4:00 901 **Temporal dynamics in the expansion and contraction of the attentional window.**

Lisa N. Jefferies[1] (ljefferi@gmail.com), Vincent Di Lollo[2]; [1]University of British Columbia, [2]Simon Fraser University

The vast amount of visual information in the world necessitates a selective mechanism that limits visual processing to objects or locations of interest. Visual attention fulfils this selective function, and may be allocated with varying degrees of success over tasks, space, and time. We propose a qualitative model that accounts for the modulation of the spatial extent of the focus of attention across time, and we test that model in a series of experiments. Specifically, we employed the Attentional Blink (AB) and Lag-1 sparing, to test the spatiotemporal modulations of attention. When two sequential targets are inserted in a rapid stream of distractors, perception of the second target is impaired at short inter-target lags (AB deficit). Paradoxically, this deficit disappears when the second target appears directly after the first (Lag-1 sparing). Lag-1 sparing always occurs when the two targets appear in the same spatial location, but occurs to targets in different spatial locations only if the focus of attention encompasses both locations. Given this, the incidence and magnitude of Lag-1 sparing provides a sensitive measure of the degree to which the focus of attention encompasses the location of the second target. The present research utilized two simultaneous distractor streams to measure our ability to shift and expand spatial attention over time. Two main findings emerged: first, when the second target appeared directly after the first, there was a progressive transition from Lag-1 sparing to AB deficit as the SOA between successive items was increased. This provides a measure of the spatiotemporal modulations of the focus of attention. Second, the change from Lag-1 sparing to AB deficit was related linearly to SOA. This strongly suggests that the spatial extent of attention varies linearly over time and that the expanding and shrinking of the focus of attention may be analog in nature.

Acknowledgement: Supported by a Canada Graduate Scholarship to LNJ and a Discovery Grant to VDL by the Natural Sciences and Engineering Research Council of Canada

4:15 902 **Readout from Iconic Memory Involves Similar Neural Processes as Selective Spatial Attention**

Arni Kristjansson[1,2] (ak@hi.is), Christian C. Ruff[1,3], Jon Driver[1,3]; [1]Department of Psychology, University of Iceland, [2]UCL Institute of Cognitive Neuroscience, University College London, [3]Wellcome Department of Imaging Neuroscience, University College London

Iconic memory and spatial attention are often considered as distinct topics, but may have functional similarities. Here we provide fMRI evidence for common underlying neural effects. In a partial-report paradigm, participants counted how many circles in one hemifield of a bilateral array had gaps in them, while keeping fixation. The relevant hemifield for partial report was indicated by an auditory cue, which was presented either before the visual array (pre-cues, spatial attention) or shortly after (post-cues, iconic memory). Pre and post-cues led to similar activity modulations in lateral occipital cortex, contralateral to the cued side, indicating that readout from iconic memory involves similar neural activity in visual cortex as spatial attention. We also found common bilateral activation of a fronto-parietal network for post-cue and pre-cue trials. These results show that common neural mechanisms may underlie selective spatial attention and readout from iconic memory. Some differences for pre- and postcueing were also found, with post-cues leading to higher activity in right middle frontal gyrus.

4:30 903 **Perceptual load modulates the temporal resolution of visual awareness**

David Carmel[1,2,3] (d.carmel@ucl.ac.uk), Pascal Saker[1,2], Geraint Rees[1,3], Nilli Lavie[1,2]; [1]Institute of Cognitive Neuroscience, University College London, UK, [2]Department of Psychology, University College London, UK, [3]Institute of Neurology, University College London, UK

Subjective visual experience depends not only on the spatial arrangement of the environment, but also on the temporal pattern of stimulation. For example, flickering and steady light presented in the same location evoke a very different conscious experience due to their different temporal patterns. Does attention play a role in temporal aspects of visual awareness? Here, we examine whether the availability of processing resources affects the temporal resolution of visual awareness – the ability to distinguish rapid changes in light intensity, detecting visual temporal patterns. According to load theory (Lavie, 1995, 2005), exhausting perceptual capacity in a task will result in reduced awareness of task-unrelated stimuli. Participants detected flicker in a fixated LED which flickered at or around the individually-adjusted critical flicker fusion threshold, while searching for a target letter presented either on its own (low load) or among other letters (high load) in the periphery. A series of experiments showed that the same flickering stimulus was more likely to be categorized as 'fused' under high load in the peripheral letter search. We also established the effect of perceptual load on psychophysical measures of sensitivity to flicker, while ruling out alternative accounts such as criterion or stimulus prioritization differences, and differential likelihood of forgetting the correct response under different load conditions. These results are the first to demonstrate that perceptual load determines visual awareness of temporal patterns.

Acknowledgement: This research was supported by the Wellcome Trust

4:45 904 **Pre-trial fMRI Activity Predicts Behavioral Success**

Andrew B. Leber[1] (andrew.leber@yale.edu), Nicholas B. Turk-Browne[1], Marvin M. Chun[1]; [1]Yale University

Attentional control affords great flexibility in adapting to new goals and task challenges in the visual environment. However, this process of adapting can carry significant costs, revealing that the exertion of control is not always fully successful. How can the degree of success be predicted? In this study, we examined the possibility that pre-trial fMRI activity might reflect the current capability to implement control. Subjects were scanned while switching between two tasks in which they categorized visual stimuli. On each trial, a cue informed them to make either a parity or magnitude judgment on a subsequent target digit presented 1000 ms later. This procedure yielded robust behavioral costs of switching between tasks: trials in which the current task was switched from the previous task were associated with slower responses than those in which the task was repeated. A fronto-parietal "attentional control network" was identified by contrasting the BOLD responses associated with switch and repeat trials. Within this network, greater BOLD activity at the single timepoint immediately preceding the task cue predicted smaller costs of switching tasks; specifically, greater pre-trial activity led to a selective decrease in response time on switch trials. Using a data-driven approach, we then searched the whole brain for regions exhibiting this behavioral interaction with pre-trial activity, again finding only regions in the control network. Further analyses ruled out contributions of recent trial history, instead linking the result to gradual shifts in tonic states. We conclude that one's moment-to-moment capacity to mobilize attentional control is directly measurable in the neural activity within parietal and frontal regions, and this activity serves as a key predictor of control success.

Acknowledgement: Supported by NIH EY014193 (MMC) and MH070115 (ABL)

5:00 905 The Attentional Blink affects three aspects of selection: Delay, duration, and suppression.

Edward Vul[1, 2] (evul@mit.edu), Mark Nieuwenstein[1, 3], Brian Coffey[1], Nancy Kanwisher[1, 2]; [1]Dept. Brain and Cognitive Sciences, Massachusetts Institute of Technology, [2]McGovern Institute for Brain Research, Massachusetts Institute of Technology, [3]Dept. Cognitive Psychology, Vrije Universiteit

The attentional blink is a deficit in reporting the second of a pair of items when they are separated by 200-500 msec. Recent findings demonstrate that the AB is due to a disruption of attentional selection, rather than memory encoding. Here we asked which properties of attentional selection are affected by the AB: its delay, amplitude, and/or duration. We presented an RSVP sequence of letters with two annulus cues surrounding the location of the letters occurring for 58.3 msec each at two different times in the sequence. The letters occurring after the cues were targets while the other letters were distracters. By recording which letters from the stream were reported, we could compute (a) the “center of mass” of reports around the second cue (i.e. the delay), (b) the overall reduction in the proportion of letters that were reported from an interval around second cue, rather than elsewhere in the letter stream (i.e. the suppression), and (c) the variance of the distribution of reports around the second cue (i.e., the duration). We found that each of these effects of the attentional blink are dissociable by their time course (i.e., how they vary with delay after T1). The duration of selection returns to baseline (T1) levels first; suppression takes some 100 msec longer; and delay of selection takes longer yet to reach baseline. We further dissociate the delay of selection from suppression and duration by showing that a cueing manipulation alters delay without affecting either suppression of duration. These data show that all three effects exist and are dissociable; this new evidence may be problematic for current accounts of the blink that rely on only one of these effects as the basis of the AB deficit.

Acknowledgement: EY13455 to NK

5:15 906 Continuous target input overrides the attentional blink in rapid serial visual presentation

Mark Nieuwenstein[1] (MR.Nieuwenstein@psy.vu.nl), Mary Potter[2]; [1]Department of Cognitive Psychology, Vrije Universiteit, [2]Department of Brain and Cognitive Sciences, MIT

An attentional blink occurs when observers are asked to identify two targets embedded in an RSVP sequence of distractors: Performance is severely impaired for second targets that occur within less than 500 ms of the first target. Last year, we reported that this impairment does not occur when observers are asked to report all items in a sequence (Nieuwenstein & Potter, 2006). This whole-report advantage indicates that performance in dual-target partial report tasks is primarily constrained by the requirement to select the targets and little affected by the processing that occurs following their selection.

To further examine which task differences are critical to the selection cost, we contrasted the effects of first-target selection and distractor filtering on recall of subsequent items. RSVP sequences consisted of six characters and observers were instructed to report either as many items as possible (whole report), only two items designated by color or category (partial report), or all items starting with a designated item (mixed report). The comparison of second-target recall in partial report with recall of nominally the same items in mixed report revealed that the attentional blink is specific to partial report, and thus to the requirement to filter out inter-target items. Mixed report performance for items that matched the first target's color showed no indication of an attentional blink and closely resembled performance in whole report. The same comparison did show a mixed-report cost for items not matching the first target's color, replicating earlier findings (Weichselgartner & Sperling, 1987). Together, these results show that the requirement – or tendency – to suppress items directly following a first target is a critical determinant of the occurrence of an attentional blink effect in recall of ensuing items.

Nieuwenstein & Potter (2006). Psychological Science, 17, 471-475. Weichselgartner & Sperling (1987). Science, 238, 778-780.

Acknowledgement: This work was supported by NIMH Grant MH47432.

5:30 907 The behavioural temporal dynamics during a cueing task with partially valid cues

Steven Shimozaki[1] (ss373@le.ac.uk); [1]School of Psychology, University of Leicester, Leicester, UK

Introduction:

A cueing effect, in which valid cues lead to better performance than invalid cues, is commonly assumed be caused by limited attentional resources improving perceptability at the cued location, at a cost to the uncued location (i.e., Posner, 1980). However, an ideal observer, which assumes parallel and equal perceptability at both locations, can also predict cueing effects (Eckstein, et al., 2002). Classification images were employed in a cueing task to assess the dynamics of information use at the cued and uncued locations. Limited resource attention models might suppose a delay in information use at the uncued location (e.g., a serial ‘spotlight’), whereas a parallel model (e.g., ideal observer) would predict no such delays.

Method:

Two observers participated in a yes/no contrast discrimination task of vertical Gabors (1 cpd, 1 octave bandwidth, full-width, half-height). On each trial, two flickering Gabors appeared in the upper left and right, displaced 5° horizontally and vertically from central fixation (eccentricity = 7.1°). Half the trials contained two low-contrast (pedestal) Gabors (mean peak contrast = 23.4%); the other half contained one pedestal and one signal Gabor (mean peak contrast = 39.1%), and observers judged signal presence. The stimulus duration was 272 ms, divided into 12 intervals (23 ms/interval), in which the Gabor contrasts changed randomly on each interval (Gaussian-distributed, σ = 15.6% contrast). Dark square cues (4°) indicating signal locations (when present) with 80% validity appeared around one location simultaneously and continuously with the stimulus.

Results:

Both observers had modest cueing effects (valid hit rate – invalid hit rate: 0.183, 0.156). First evidence of information use at the uncued location was 92 ms, compared to 46 ms at the cued location. However, there was considerable overlap in the time courses at the two locations, and the time of peak information use did not differ (138 ms).

Binocular Vision: Rivalry and Mechanisms

Tuesday, May 15, 4:00 - 5:45 pm, Hyatt Ballroom North
Moderator: Paul Schrater

4:00 908 Binocular fusion can make two eyes worse than one.

Stuart Anstis[1] (sanstis@ucsd.edu), Brian Rogers[2]; [1]Psychology, UC San Diego, [2]Psychology, University of Oxford

In experiment 1, a digit (or oriented bar) was defined by dark grey dots embedded in surrounding light dots for the left eye, and by light grey dots embedded in surrounding dark dots for the right eye. With one eye open, the digits (or oriented bar) were clearly visible, but with both eyes open the light and dark dots fused binocularly into medium grey making the digit (or bar) no longer visible. A similar result was found in experiment 2 when a digit was defined by greenish dots embedded in reddish dots for the left eye, and by reddish dots embedded in greenish dots for the right eye (somewhat like an Isihara colour plate). In a third experiment, yellow dots defined the same digit to both eyes, but the surrounding dots were reddish to one eye and greenish to the other. With one eye open, the digits used in experiments 2 and 3 were clearly readable, but with both eyes open the red and green dots fused binocularly into yellow making the digit no longer visible. In a fourth experiment, the dots defining the digit moved upwards and the surround dots moved downwards, for one eye, while the digit dots moved downwards and the surround dots moved upwards, for the other eye. Common fate made the digits clearly visible with one eye open, but motion averaging between the eyes made the digits invisible when both eyes were open. These results show that luminance, colour and motion information that is clearly present in the visual system at an early stage can be discarded or suppressed by binocular fusion, making two eyes worse than one.

4:15 909 Perceptual memory of ambiguous figures survives spontaneous perceptual alternations

Jan Brascamp[1,2] (j.w.brascamp@bio.uu.nl), Tomas Knapen[3,2], Ryota Kanai[4], Raymond van Ee[3,2], Albert van den Berg[1,2]; [1]Functional Neurobiology, Utrecht University, The Netherlands, [2]Helmholtz Institute, The Netherlands, [3]Physics of Man, Utrecht University, The Netherlands, [4]Division Biology, California Institute of Technology

Introduction. The visual system displays memory for perception of ambiguous figures: Perceptual dominance following an interruption depends on the last dominant percept before the interruption. A common interpretation of this phenomenon is that the last preceding percept leaves some form of memory trace, which in turn determines perceptual choice following the interruption. Here we show that, on the contrary, the last preceding percept has no special importance in determining the content of memory. Rather, perceptual choice is determined by a minute-scale history of prior perception, which includes, but is not limited to, the last preceding percept.

Methods. We establish the content of memory by intermittently presenting an ambiguous stimulus until a subject consistently perceives the same percept for eight presentations in a row: Robust perceptual memory. Then we leave the stimulus on continuously, causing spontaneous perceptual alternations. Finally, we probe the content of memory following spontaneous alternations by assessing dominance during a renewed period of intermittent presentation.

Results. Perceptual choice following spontaneous alternations is influenced by the last percept during the alternations, but more strongly by the content of memory prior to the alternations. This long-lasting memory trace survives up to about one minute, or more than four perceptual alternations. This is evidence of unexpectedly complex memory behavior in ambiguous perception, indicating information integration over prolonged periods of time rather than straightforward storage of a single percept.

4:30 910 A Perceptual Inference Model for Bistability

Rashmi Sundareswara[1] (sundares@cs.umn.edu), Paul R. Schrater[1]; [1]University of Minnesota

In previous theoretical and empirical work (Schrater and Sundareswara, NIPS, 2006; Sundareswara and Schrater, VSS 2006), we showed how Bayesian models of perceptual inference could give rise to bistability when implemented via a sampling process. We also showed that flanking a bistable figure (Necker cube) with fields of similarly oriented background objects increase the time spent in the Necker percept matching the background. The dynamics of this context effect was in quantitative agreement with the predictions of the Bayesian model assuming that the statistics of the background act as a contextual prior that changes the relative heights of a bi-modal posterior distribution on the shape and orientation of the bistable figure. The goal of the present study is to test predictions of the proposed linkage between bistability and Bayesian inference. In particular, we tested for effects of background objects on Necker Cube switching dynamics for three context manipulations: 1) changing the orientation similarity between Necker percepts and background cubes in the context; 2) changing the spread of the orientation distribution of background objects 3) changing the shape of the background objects to minimize feature similarity to the Necker Cube, while maintaining orientation information. Perceptual states were recorded across time using a method similar to (Mamassian and Goutcher, 2005) and data was analyzed using a Markov Renewal Process (MRP) framework. The analysis generates empirical distribution functions for state-contingent first transition and survival probabilities. Our results show that increasing the match between Necker percept and background orientations and the spread of the background orientations parametrically decrease the context effect. These effects are weaker but similar when the background shapes are non-cuboidal. The results are in quantitative agreement with the predicted effects of our Bayesian model of bistability.

This work was supported by NIH-EY015261-01

4:45 911 Similarity in orientation triggers the unseen to be seen during dichoptic suppression

Mark L.T. Vergeer[1] (m.vergeer@nici.ru.nl), Rob Van Lier[1]; [1]Nijmegen Institute for Cognition and Information (Nici), Radboud University Nijmegen

While the amount of literature showing effects of interocular grouping in binocular rivalry is growing, relatively little is said about the integration of suppressed and visible information. Using the dichoptic suppression paradigm (Van Lier & De Weert, 2003) we demonstrate that the visibility of suppressed elements is influenced by similarity in orientation of the suppressed elements and an additional trigger element. This effect is irrespective of whether the suppressed elements and the trigger element are presented in the same eye or not. In dichoptic suppression, each element is suppressed by presenting a neutral high contrast element (i.e., suppressor) at the same location in the contra-lateral eye. In our experiment, we suppressed two gratings presented left and right of fixation (i.e., the flanking gratings); the gratings were either horizontally or vertically oriented. After suppression (600 msec) the suppressors were removed. Next, a grating was presented in the centre (i.e., the trigger grating), which' orientation was the same as the orientation of one of the suppressed gratings. This grating was presented in only one eye. Subsequently, participants had to indicate which of the suppressed gratings became visible first. Overall, gratings with the same orientation as the trigger grating became visible earlier than gratings with a different orientation. The effect of orientation was significant when the trigger grating was presented in the same eye as the flanking gratings ($p < .001$), as well as when the trigger grating was presented in the contra-lateral eye ($p < .01$). In a control experiment we demonstrate that this effect of orientation is not simply triggered by the collinearity of the gratings. Our results show that the activation of suppressed elements is influenced by their similarity with already visible elements.

Acknowledgement: MV is supported by a grant of NWO

5:00 912 **Action Can Influence Dynamics of Binocular Rivalry**

Kazushi Maruya[1,2] (kazushi.maruya@vanderbilt.edu), Eunice Yang[1], Randolph Blake[1]; [1]Department of Psychology, Vanderbilt University, [2]Department of Medicine, Jikei University

INTRODUCTION: It has been proposed that binocular rivalry and other forms of perceptual bi-stability are governed by distributed neural activity in multiple brain areas including those involved in motor action planning (Leopold & Logothesis, 1999, TiCS). This view is generally consistent with evidence pointing to strong links between perception and action (Knoblich & Flach, 2001, Psychol. Sci.). Inspired by this idea, we performed a series of experiments measuring sensorimotor influences in binocular rivalry dynamics. METHODS: Observers viewed dissimilar stimuli presented to the two eyes via a mirror stereoscope. One eye viewed a flickering, radial grating (RG) and the other eye viewed animations portraying dynamic 2D projections of a rotating sphere of dots (RS). While viewing these dichoptic stimuli, observers moved a hand-held mouse when they perceived one of two rival stimuli as dominant (RG or RS, depending on trial type). On some trials (manual: MAN), the concurrent mouse movement controlled the motion vectors of the dots defining the RS; on other trials, the RS dots were defined by motion vectors recorded from previous MAN trials, (i.e. the dot vectors were not controlled by the concurrent hand movements of the observers; AUTO). RESULTS: Rivalry dynamics varied dependent on motor control: average dominance durations of the RS rival target were longer during MAN tracking than during AUTO tracking, and suppression durations in MAN were briefer than suppression durations in AUTO. An additional experiment confirmed that observers varied in their ability to judge whether their concurrent mouse movements genuinely controlled the RS stimulus, but performance on this task was unrelated to the magnitude of control exerted on rivalry dynamics. CONCLUSION: These results indicate that sensorimortor signals can indeed bias perception of action-related stimulus under conditions of ambiguous stimulation.

Acknowledgement: Supported by NIH EY13358, KM is supported by JSPS

5:15 913 **Stereopsis at isoluminance**

Martin Banks[1,2] (martybanks@berkeley.edu), Bjorn Vlaskamp[1], James Hillis[3], Jonathan Gardner[2]; [1]Vision Science Program, UC Berkeley, [2]Department of Psychology, UC Berkeley, [3]Department of Psychology, University of Durham

In early visual processing, cone outputs are converted into achromatic and chromatic channels with different spatial and temporal properties. Some investigators have reported that stereopsis is deficient with isoluminant stimuli (Lu & Fender, 1972; De Weert, 1979), suggesting that chromatic channels do not support depth from disparity. Others found that stereopsis with chromatic stimuli is not deficient once the effective contrasts of isoluminant and achromatic stimuli are taken into account (Scharff & Geisler, 1992; Krauskopf & Forte, 2002). These disparate psychophysical observations might be reconciled by considering the binocular properties of cortical neurons. The ocular-dominance histograms of chromatically selective neurons do not differ significantly from the histograms of chromatically non-selective neurons (Peirce et al., 2003). However, chromatically selective neurons have low-pass spatial-frequency tuning. Thus such cortical mechanisms might support stereopsis, but only for half images with power at low spatial frequencies and for depth corrugations that are low in spatial frequency. To test this hypothesis, we measured disparity thresholds with isoluminant and luminance-varying stimuli while varying spatial-frequency content. The stimuli were random-dot stereograms with sinusoidal depth corrugations. The half images were gray backgrounds textured with Gaussian blobs that differed in luminance and/or hue. To determine if spatial frequency is an important determinant of stereopsis at isoluminance, we varied the frequency content of the half images and the spatial frequency of the corrugations. We also measured the perceptual salience of the half images for all experimental conditions. At high spatial frequency, we observed significant deficits with isoluminant stimuli compared to equally salient, luminance-varying stimuli. At low frequency, we observed no such deficit. Thus, the relative deficiency of stereopsis at isoluminance depends strongly on the spatial-frequency content of the stimuli. These psychophysical observations are therefore consistent with our understanding of the processing of binocular information in visual cortex.

Acknowledgement: NIH

5:30 914 **The role of extraretinal signals in egocentric depth estimation**

Gunnar Blohm[1] (blohm@yorku.ca), Aarlenne Z. Khan[2], Kai M. Schreiber[3], Lei Ren[1], J. Douglas Crawford[1]; [1]Centre for Vision Research, York University, Toronto, ON, Canada, [2]Smith-Kettlewell Eye Research Institute, San Francisco, [3]School of Optometry, University College Berkeley, Berkeley

To interact with an object in three-dimensional (3 D) space, the brain must construct the object's egocentric spatial location using binocular vision; both retinal images are merged to provide angular eccentricity (horizontal and vertical position) and retinal disparity provides information about distance. We have demonstrated theoretically that the reconstruction of egocentric distance from binocular retinal information requires 3 D eye and head position information in addition to ocular vergence in order to provide a unique depth position. Here, we tested whether subjects interpret identical retinal input as different depth positions depending on changing eye and head positions.

We first asked 5 subjects to fixate targets in different depth planes and under different head roll and head pitch angles. Recording the 3 D eye position from both eyes allowed us to determine each subject's binocular Listing's law and static VOR gains. These parameters were input into our theoretical model which provided us with different eye-head positions predicted to lead to different depth interpretations (with the same retinal stimulation and vergence). We then performed the actual experiment; first, we flashed a pointing target (ultra-bright LED which produced a retinal afterimage). Next we positioned the subjects' eyes and head into the predicted positions and asked subjects to align their finger tip with the recalled position of the target's retinal after-image. When comparing predicted and observed depth positions, we found significant correlations in all subjects, showing that depth was modulated in a way that could not be explained by fixation distance or vergence angle.

Our results demonstrate that extra-retinal eye and head position signals are indeed used by the human brain to compute depth from binocular visual information. Taken together with our theoretical findings, we suggest that extra-retinal signals in early visual areas encoding retinal disparity serve the purpose of depth reconstruction.

Acknowledgement: This work was supported by CIHR (Canada) and Marie Curie fellowships (EU).

Poster Session H

Tuesday, May 15, 8:30 am - 1:00 pm, Municipal Auditorium

Binocular Vision: Stereopsis and Fusion

Author Presents: 10:30 am - 12:15 pm

H1 915 A Multi-scale Model of Binocular Combination

Sean Lee[1] (hseanlee@uab.edu), Allan Dobbins[1]; [1]Dept. of Biomedical Engineering, University of Alabama at Birmingham

Anti-correlated random dot stereograms (AC-RDS) drive disparity-selective cortical neurons, elicit vergence eye movements, but fail to give rise to perception of depth (Cumming and Parker, 1997; Masson et al., 1997). Stimulation with AC-RDS elicits V1 disparity tuning curves and vergence movements that are inverted in sign, consistent with quasi-linear binocular combination. Recently, we have described a class of anti-correlated RDS that does give rise to a compelling sense of reversed depth. This stereogram is composed of local triads (two dots matching one, similar to the classical Panum's limiting case (PLC)), with one element having reversed contrast sign. We describe a model that accounts for the differences in perception observed with standard and PLC anti-correlated stereograms. The model uses standard binocular energy cells at several spatial scales in stage one, followed by within-scale inhibition between neurons differing by one half wavelength (pi) in disparity-tuning, followed by a disparity-specific weighted summation across scales. The within-scale inhibition greatly diminishes non-specific noise including the response to monocular inputs, and the multi-scale integration emphasizes features with multi-scale disparity consistency. In the case of standard AC-RDS, the stage one disparity estimates diverge with scale and the multi-scale model produces weaker responses. In contrast, in the case of the PLC AC-RDS, the stage one estimates show less divergence, and respond over a smaller range of scales. The output of the second stage, consistent with perception, is reversed. The model also responds suitably to transparent surface RDS and crisply represents depth discontinuities. Finally, the model predicts that a population of disparity selective neurons beyond V1, possibly in V2, which because of multi-scale integration, will be found that exhibits significantly broader spatial frequency tuning than is seen in disparity-selective V1 cells.

H2 916 Perceived Direction of Motion and Depth of Missing Fundamental Gratings

Jin Qian[1] (lucy_tsan@hotmail.com), Harold Bedell[1,2]; [1]College of Optometry, University of Houston, [2]Center for Neuro-Engineering and Cognitive Science, University of Houston

Purpose. The perceived directions of motion and stereoscopic depth were assessed for missing fundamental (MF) gratings, to compare the relative importance of energy and feature-matching processes. Methods. MF gratings were constructed by subtracting the fundamental Fourier component from a 1-cpd square wave. To assess motion processing, gratings were presented with successive quarter-cycle shifts for 1 s. The temporal frequency (TF) of motion was varied by changing either the duration of each frame or the inter-stimulus interval (ISI). Grating contrast ranged from 3 to 90%. If subjects reported motion in one direction, they then compared the speeds of the MF and a 3f grating, presented alone. If subjects reported transparent motion, they judged which direction of motion was faster. To assess stereo processing, pairs of counterphase flickering MF gratings were presented with a quarter-cycle disparity, or for various durations without flicker. Other procedures were analogous to the motion experiment. Results. When MF stimuli were presented with 0 ISI, subjects preferentially reported motion in the energy direction, regardless of the grating TF and contrast. As the ISI increased, subjects more often reported the direction of feature motion, particularly for high-contrast stimuli. Subjects also reported depth in the direction of MF feature disparity more frequently as the grating contrast increased, regardless of stimulus TF or duration. The perceived speed or depth of MF gratings was judged to be either greater than or equal to that of a 3f grating, when the perceived direction of motion or depth was consistent with the feature or energy directions, respectively. Conclusion. Energy computations account better for the perceived direction of motion and stereoscopic depth when stimulus contrast is low and feature matching accounts better when stimulus contrast is high. Overall, energy-based processing is more dominant in motion than in stereo processing.

Acknowledgement: NEI R01 EY05068, P30 EY07551 and a University of Houston, College of Optometry SVRSG award.

H3 917 Binocular depth discrimination and estimation beyond interaction space

Robert Allison[1,2] (allison@cse.yorku.ca), Barbara Gillam[2], Elia Vecellio[2]; [1]Centre for Vision Research, York University, Toronto, [2]School of Psychology, University of New South Wales

The benefits of binocular vision have been debated throughout the history of vision science yet few studies have considered its contribution beyond a viewing distance of a few metres. What benefit, if any, does binocular vision confer for distance vision? Elementary texts commonly assert that stereopsis is ineffective beyond modest distances despite theoretical analysis suggesting a much larger effective range. We compared monocular and binocular performance on depth interval estimation and discrimination tasks at and beyond 4.5m.

Stimuli consisted of a combination of: 1) the reference stimulus, a smoothly finished wooden architectural panel, mounted upright, and facing the subject, 2) the test stimulus, a thin rod that could be precisely moved in depth and 3) a homogeneous background. An aperture prevented view of the top and bottom of the stimuli. Subjects made verbal, signed estimates in cm of the depth between the test and reference stimuli. On each trial, the depth was set between ±100cm. Observers viewed the displays either monocularly or binocularly from 4.5, 9.0 or 18.0m. Depth discrimination at 9.0 m was also evaluated using adaptive staircase procedures.

Regression analysis provided measures of the scaling between perceived depth and actual depth (the 'gain') and the precision. Under monocular conditions, perceived depth was significantly compressed. Binocular depth estimates were much nearer to veridical although also compressed. Both raw precision measures and those normalized by the gain were much smaller for binocular compared to monocular conditions (ratios between 2.1 and 48).

We confirm that stereopsis supports reliable depth discriminations beyond typical laboratory distances. Furthermore, binocular vision can significantly improve both the accuracy and precision of depth estimation to at least 18m. We will discuss additional experiments to extend these results to larger viewing distances and to evaluate the contribution of stereopsis under rich cue conditions.

Acknowledgement: The support of an ARC International Fellowship (LX0667316), an ARC Discovery Grant (RM00362), and an NSERC Discovery Grant are greatly appreciated.

H4 918 Binocular orientation perception: the oblique effect occurs after binocular fusion

Tobias Borra[1] (t.borra@fss.uu.nl); [1]Helmholtz Institute, Experimental Psychology, Universiteit Utrecht

Meng and Qian (2005) have suggested that the oblique effect (the more precise perception of horizontal/vertical orientations compared to oblique orientations) is determined by the perceived orientation of a grating. Here, we make the distinction between retinal and perceived orientation after binocular fusion. The horizontal separation of the two eyes, make it possible to disentangle retinal orientation and perceived orientation. Using a mirror-stereoscope, observers were presented with a temporally separated dichoptic reference and test stimulus. They were instructed to adjust the orientation of the test stimulus to the reference stimulus. Three reference stimulus orientations were used: 1] 0° (presented to both eyes); 2] -8° (both eyes) and 3] -8° (left eye) and 8° (right eye). This led to the following perceived orientations, 0°, -8° and 0° respectively. We calculated the standard deviations (SDs) of the differences between the reference and the adjusted test stimulus. If the oblique effect is determined by the orientation of the retinal object image, we expect small SDs for condition 1 and large SDs for both conditions 2 and 3. However, if the oblique effect is determined by the orientation of the object representation after binocular fusion, that is the perceived orientation, we expect small SDs for conditions 1 and 3, and large SDs for condition 2.

We found that the SD for condition 3 was significantly smaller than for condition 2. This suggests that the oblique effect is primarily determined by the orientation of an object after binocular fusion, that is, the perceived orientation, and not the retinal orientation of the stimulus.

H5 919 Opposite Directions of Motion Enhance the Perception of Stereoscopic Depth

James Dannemiller[1] (dannemil@rice.edu), Bogdan Iliescu[1]; [1]Department of Psychology, Rice University

Previous studies have shown that oppositely directed motions enhance the perception of depth from disparity when the different directions are spatially intermixed as in a simulated rotating transparent cylinder defined by random dots. One argument for this enhancement is that opposite directions of motion help to solve the stereo correspondence problem. Is this enhancement observed when the opposite directions of motion are spatially segregated reducing or eliminating the ambiguity in stereo correspondence? Observers judged a step-change in depth in a small three-panel display with the motion direction in the middle panel opposite to that in the upper and lower panels (standard) against the depth in a simultaneously available display with the directions of motion the same in the three panels (test). Each panel was a window which contained a drifting grating of moderate contrast providing distinct features that should have simplified the solution of the correspondence problem. The disparity in the test display was varied to produce a forced-choice psychometric function from which we could estimate the point-of-subjective-equality at which the depths in the test and standard displays looked the same. For three observers, the PSE's indicated greatly enhanced depth in the standard display relative to the test display. Observers also judged the depths in both of these displays against a display with binocular disparity but no motion, and the results were consistent; displays with relative motion in opposite directions coupled with disparity always appeared to have more depth than displays with no relative motion coupled with similar amounts of disparity. Conclusion: the enhancement of stereoscopic depth provided by relative motion is not necessarily related its role in solving the stereo correspondence problem because it is also observed when the opposite directions are spatially segregated.

H6 920 Horizontal disparity gradient with vertical disparity in different depth planes

Céline Devisme[1,2] (devismec@essilor.fr), Björn Drobe[2], Annie Monot[3], Guillaume Girauret[2], Jacques Droulez[1]; [1]LPPA - Collège de France CNRS, Paris, France, [2]Essilor International, R&D Optics, Vision Science, Saint-Maur, France, [3]MNHN, CRCDG - Equipe Vision, Paris, France

Vertical and horizontal disparities can locally enhance or cancel each other depending on their depth sign (Matthews et al., 2003 Vision Research 43 85-99). The presence of vertical disparities modifies the sensitivity to horizontal disparity gradient in the peripheral visual field, relative to the depth sign of vertical disparity (Devisme et al., 2006 Journal of Vision 6 (6) 656a). In the present experiment, vertical disparities were computed to be always congruent in shape with concentric horizontal disparity gradients applied between 7 and 14 degrees of eccentricity. The stimulus consisted of a sparse random-dot display. The horizontal disparity gradients, crossed or uncrossed, produced respectively concave or convex shapes. However, whereas for horizontal disparities, the central disc (7° radius) of the shape was in the fixation plane, the central disc for vertical disparities could be in front of, behind or in the fixation plane. Horizontal and vertical disparities increased together from their fixation plane disparity, between the two eccentricities. The observers' task consisted in detecting the deformation of the frontoparallel plane. Results highlighted that the modifications of the sensitivity to horizontal disparity gradient, induced by vertical disparities, depended on the depth sign of the vertical disparities relative to both the fixation plane and the depth sign of horizontal disparities. Horizontal disparity allows to perceive the shape, concave or convex, and vertical disparity fixes the depth relative to the fixation plane.

H7 921 Relative Depth from Pattern Disparities and From Component Disparities

Bart Farell[1] (bart_farell@isr.syr.edu), Yu-Chin Chai[1]; [1]Institute for Sensory Research, Syracuse University, NY, US

Two simultaneously presented stimuli might appear at the same depth even though their disparities are very different. This happens when the two stimuli have very different orientations (Farell, J. Neurosci. 2006). Even for two-dimensional patterns that have no perceptually dominant orientation, the relative orientation of the patterns' Fourier components can affect the perceived stereo depth separation between the patterns (Chai & Farell, VSS2006). Thus component disparities carry relative depth signals.

Is the perceived depth of two-dimensional patterns determined only by independent component disparities? To answer this question, we examined perceived depth matches between a sinusoidal grating and a plaid made of two superimposed sinusoids. We varied the orientation of the grating relative to the orientation of the plaid's components and we varied the orientation of the grating relative to the disparity direction of the plaid as a whole.

The plaid was confined to an annular envelope and the grating probe was presented as a Gabor patch in the center of the annulus. The disparity of the plaid was fixed while the disparity of the grating varied across trials while the observer judged the grating as 'near' or 'far' relative to the plaid. We then determined the relative-depth PSE. If the grating had the same orientation as a plaid component, our observers perceived a depth match when the grating and the component had the same disparity. There was no independent effect of the plaid's disparity magnitude or its disparity direction on the depth match. However, if the grating differed in orientation from both plaid components, our observers perceived a match when the grating and the plaid had the same disparity magnitude and disparity direction. This result shows that two-dimensional pattern disparities are functionally distinct from component disparities and that both disparities support relative depth percepts.

Acknowledgement: NIH Grant EY 012286

H8 922 Biases in relative depth perception linked to configuration in the scene

Julie M Harris[1] (Julie.Harris@st-andrews.ac.uk), Paul B Hibbard[1], Joanna Brooks[1], Alasdair Anderson[1]; [1]School of Psychology, University of St. Andrews

When combined with information about distance, binocular disparity can be used to judge shape. It is usually assumed that disparity information is used veridically, with observed systematic errors attributed to mis-estimation of viewing distance. Here we present data that challenges this assumption, demonstrating perceptual biases that appear to be due to an object?s elevation in a scene.

Observers viewed a simple scene consisting of a pair of dots arranged one above the other, 5cm apart. Depth was conveyed via binocular disparity using a Wheatstone stereoscope. The dots were presented at different depths, on average 10cm apart (21 min arc at D = 1m). For example, in one configuration the upper dot was as far behind the fixation plane as the lower dot was in front. Using a 2AFC method, observers were asked in which interval the distance in depth between the dots was longer. We compared conditions in which a test stimulus was presented in the same configuration as the fixed standard stimulus (e.g. test and standard: upper dot far, lower dot near), with conditions in which the configurations were opposite (e.g. test: upper far, lower near; standard: upper near, lower far).

Points of subjective equality (PSE) were collected from fitted psychometric functions. When configurations were the same for test and standard, the PSE was close to the value of the standard, as expected. When the configurations were opposite, some observers showed biases consistent with target separation being perceived as relatively larger for the upper-far, lower-near configuration. These results suggest that relative distance perception can vary depending on whether the same disparity information is presented in the upper or lower part of the scene. This could be linked to the known bias in the distributions of disparities present in real scenes (Hibbard & Bouzit, 2005, Spatial Vision).

Acknowledgement: Funded by EPSRC (UK)

H9 923 Perceptual Distortions in Stereoscopic Photographs

Robert Held[1] (rheld@berkeley.edu), Martin Banks[1,2]; [1]Joint Graduate Group in Bioengineering, University of California, San Francisco & University of California, Berkeley, [2]Vision Science Program, University of California, Berkeley

Perceived 3d layout in stereoscopic photographs is often distorted relative to the actual layout. The distortions include the cardboard-cutout effect, puppet-theater effect, depth shearing, depth compression and expansion, and more. Creating the correct retinal images involves the capture parameters (how the photographs were generated) and viewing parameters (how the viewer's eyes are positioned relative to the photographs). For the retinal images to be geometrically correct, the capture and viewing parameters must be compatible: the viewer's eyes must be at the centers of projection of the photographs, a constraint that is rarely satisfied. Studies in the graphics, television, and cinema literatures have investigated how capture and viewing parameters affect the retinal images and have attempted to predict perceived layout when the center-of-projection constraint is not satisfied. Those analyses were generally limited to points in the horizontal (X-Z) plane. When the stimulus extends beyond that plane, the analysis is much more complicated. Sometimes there is no geometric solution for the depth specified by the photographs. We developed a general model that predicts perceived layout from stereo photographs for all capture and viewing parameters under the assumption that the visual system does not compensate for viewing from incorrect positions. To test the model (and the no-compensation assumption), we conducted an experiment in which observers viewed stereograms from correct and incorrect viewing positions. The stereograms depicted a plane, but we will examine more complex stimuli. Observers adjusted the plane's slant until it appeared frontoparallel. Their settings were quite similar to the model's predictions, which means that viewers do not compensate for the retinal-image distortions that occur when viewing stereo photographs from incorrect viewing positions. This finding is notably different from the case of conventional photographs, where viewers compensate for incorrect viewing position. The implications for creating and viewing stereo photographs will be discussed.

Acknowledgement: NIH EY014194 and NSF Graduate Fellowship

H10 924 Disparity Scaling in the Presence of Accommodation-Vergence Conflict

David M. Hoffman[1] (davidhoffman@berkeley.edu), Martin S. Banks[1,2,3]; [1]Vision Science Program, UC Berkeley, [2]Dept. of Psychology, UC Berkeley, [3]Helen Wills Neuroscience Institute, UC Berkley

To construct percepts from binocular information, the visual system must scale the retinal disparities with an estimate of fixation distance. Conventional 3d displays provide conflicting information about fixation distance: frequently, one distance is specified by the disparities, while another is specified by the display's physical distance. Simulated depth cues include the eyes' vergence, and horizontal and vertical disparities. Physical distance cues include focal cues which are retinal blur and accommodation. We have previously examined the influence of mismatches between simulated depth cues and focus cues on 3d percepts (Watt et al., 2005) using conventional displays. In that study, observers could have conceivably used high-level information such as knowledge of the monitor translation. We developed a fixed-viewpoint, volumetric display that allows one to present 3d images at three focal distances simultaneously (Akeley et al., 2004; Banks et al., 2005). Here we examine the utility of that display in minimizing the perceptual consequences of mismatches between simulated depth cues and focus cues. The volumetric display minimizes the contribution of high-level information. The stimulus was an "open-book" hinge textured with random dots. Observers indicated whether the hinge angle was greater or less than 90 deg. In one set of conditions, stimuli were presented on a conventional monitor at one of three physical distances and one of three simulated distances. In another set, the stimuli were presented on the volumetric display (Akeley et al., 2004). From the observers' judgments we determined the "equivalent distance", the distance estimate that appeared to be used to scale the disparities. Physical and simulated distance cues both affected judgments, indicating that focal cues influence depth percepts. The influence of physical display distance was less in the volumetric display suggesting that high-level cues also affect distance estimates used to scale disparities.

Acknowledgement: NIH EY007043 & EY014194

H11 925 Temporal property of contrast sensitivity for human stereopsis

Tasuku Ikemiyagi[1] (ike@l.u-tokyo.ac.jp), Takao Sato[1]; [1]Department of Psychology, University of Tokyo

Several past studies have examined temporal properties of stereopsis, and have proposed that there are at least two systems mediating human stereopsis. However, these arguments are based on the results using stimuli of limited spatio-temporal frequency ranges, although more general spatio-temporal characteristics of stereopsis are indispensable for such arguments.

In this study, thus, we measured contrast threshold of binocular depth detection with stimuli extending a wide range of spatio-temporal frequencies. We used spatially band-pass filtered random dot stereograms. Stimuli were generated by Gaussian filters that have one-octave half-height. There were 9 center spatial frequencies between 0.5 c/deg and 8 c/deg in half octave steps. Stimuli were static or temporally modulated (counter-phase) at 2, 4, 5, 10 and 20 Hz. It was found that, although contrast threshold at higher spatial frequencies increased as temporal frequency increased, threshold at lower spatial frequencies decreased for higher temporal frequencies. In the second experiment, we measured the reaction time for depth detection for contrasts near the detection threshold. Reaction times for lower spatial frequencies were shorter than those for higher spatial frequencies. These results are consistent with temporal property for detection of luminance modulations, and suggest a similarity between the detections of spatial modulations in disparity and luminance domain.

H12 926 Disparity averaging mechanisms

Simone Li[1] (simone.lan.li@gmail.com), Brad Motter[1,2]; [1]Dept. of Biomedical & Chemical Engineering, Syracuse University, [2]Veterans Affairs Medical Center, Syracuse

Purpose: We investigated the general mechanisms of disparity averaging. Methods: We employed a method of constant stimuli to measure the perceived depths for compound sine-wave gratings with two components placed at different depths. Observers compared perceived depths between two compound gratings: test and reference gratings. In each condition, both compound gratings contained the same spatial frequencies (SFs) and contrasts. Both components in the test grating were fixed at different disparities while the components for the reference grating had the same disparity. The reference disparity varied from trial to trial. The task was to indicate which grating was farther. Across conditions, component SFs and contrasts were varied independently and systematically. Results: At equal component contrast, the perceived depth is biased towards the disparity of the higher-frequency component. When the contrast of one of the components is reduced, the overall perceived depth moves towards the disparity of the other component. The rate of this change in perceived depth with respect to contrast differs for different SFs. The perceived depth as a function of contrast is systematically ordered with respect to ratios between the component SFs, independent of their absolute values. Conclusion: Both SF and contrast are significant factors in disparity averaging and they interact with each other. The general observation is that the greater the SF ratio, the greater the bias in perceived depth towards the higher SF.

H13 927 Disparity Statistics at Point of Gaze in 3D Natural Scenes

Yang Liu[1] (young76@mail.utexas.edu), Lawrence K. Cormack[2], Alan C. Bovik[1]; [1]Department of ECE, The Univeristy of Texas at Austin, [2]Department of Psychology, The Univeristy of Texas at Austin

A variety of measurements of the statistical properties of low level features at points of gaze in natural scenes have been published recently; measures such as luminance contrast, edge density, etc. at fixation loci are statistically different from those at randomly selected locations. In this study, we examined the disparity statistics of natural scenes at loci fixated by human observers. Surprisingly, we found that human fixations tend toward areas of relatively smooth scene depth. We computed dense disparity maps from 76 stereo images using a correspondence algorithm based on local correlation; the 48 image pairs yielding the lowest uncertainty in the disparity maps were used. The stereo pairs were presented on two calibrated monitors through a mirror stereoscope. The subjects were asked to free view each 20 x 15 deg. stereo image for 10 seconds during which eye movements were recorded, yielding a set of fixation maps paired with each disparity map. We then extracted patches from the disparity maps at the fixation loci from the corresponding fixation maps for analysis. For comparison, we ran a simulation that extracted the same number of patches uniformly distributed on each disparity map 100 times. By analyzing the different performances between human subjects and the 100 times random simulations, we found that disparity contrasts (standard deviation of the disparity map) and mean disparity gradients were generally lower at fixated patches than at randomly selected patches, and that this difference peaked at ~ 1 deg. This suggests that human gaze tends to seek regions where scene depth is changing smoothly. One possible explanation is that the disparity computation is better posed away from depth discontinuities. Since large disparity contrasts and gradients are often coincident with large luminance contrasts and gradients, it will be necessary to reconcile these findings with those based on luminance.

H14 928 Effect of wavelength on the nonius horopter

Jayasree Seshadri[1] (jayasree_seshadri@yahoo.com), Vasudevan Lakshminarayanan[2], Erwin Wong[1], Jerry Cristensen[1]; [1]College of Optometry, University of Missouri-St Louis, [2]Department of Optometry,Physics and Electrical Engineering,University of Waterloo

The Horopter is defined as locus of points in space with zero binocular disparity and having identical visual direction. Previous studies have shown that the perceived visual direction of the object in space varies as a function of wavelength. We have investigated if this change in directionality is due to chromostereopsis and the Stiles Crawford effect [SCE]. The nonius horopter was measured in three observers as function of four different wavelengths. For each observer and wavelength, the horopter was measured foveally for both photopic and mesopic conditions. The horopters were measured for all conditions while viewing through 2 mm and 6 mm pinholes. Chromostereopsis was also recorded. The results for the different luminance conditions show that SCE reduces the effects of aberration and modifies the curves under photopic conditions compared to mesopic condition where SCE effect is minimal. There was also a reversal in the direction of the chromostereopsis from positive to negative with the different pinholes. This corresponded to the reversals in the horopter curves for the blue and red wavelengths under the same conditions. Therefore we conclude that the changes in the horopter curves are due to both optical and neural factors.

H15 929 Anisotropy and individual differences in depth perception based on binocular disparity and motion parallax

Yasuaki Tamada[1] (c3305501@hibikino.ne.jp), Masayuki Sato[1], Sachio Nakamizo[2], Michiaki Kondo[2]; [1]Department of Infomation and Media Sciences, University of Kitakyushu, [2]Department of Human Relations, University of Kitakyushu

In order to investigate the anisotropy and individual differences in depth perception, we measured magnitude and direction of perceived depth based on disparity and motion parallax using a matching method. The stimulus was a random-dot pattern, subtended 20 deg by 20 deg, which was displayed on a monitor screen. The disparity or motion parallax was modulated sinusoidally with 0.05 c/deg along a horizontal or vertical meridian, simulating a concave or convex depth surface of 1, 4, or 10 cm peak-to-trough depth amplitude. An observer was required to adjust a curved line on the monitor screen so that its shape appeared to match that of the perceived depth surface. For the disparity-defined depth, five of ten observers perceived veridical depth. Two other observers significantly underestimated the magnitude of depth along the horizontal meridian. In that condition, the remaining three observers perceived depth in opposite direction to the geometrical prediction. For the motion parallax-defined depth, we did not find significant anisotropy or individual differences. These results suggest that there is a disparity-specific process which causes anisotropy although there might be common processes to produce depth for these cues.

H16 930 Surface orientation by indeterminacy: when stereoscopic surfaces with different simulated orientation appear similar

Carlo Fantoni[1] (fantoni@psico.units.it), Walter Gerbino[1]; [1] Department of Psychology and B.R.A.I.N. Centre for Neuroscience, University of Trieste, Italy

Two disparate views of a planar surface patch are consistent with an infinite number of (V, H, d) triplets; where V and H are inclinations around vertical and horizontal axes, and d the convergence angle. Such indeterminacy is conveniently described by two functions [V= É(K1, d); H= É(K1, K2, d)], with K1 and K2 derivable from the relation between two local features of projected surface markers: orientation disparity and average orientation.

We found that the perceived orientation of a stereoscopic surface depends on the shape of indeterminacy functions rather than on simulated (V, H, d) values. In a sequential 2AFC task observers discriminated which patch deviated more from the frontoparallel plane. Test and reference patches were specified by randomly-oriented intrinsic lines visible through a circular aperture. Keeping dref constant we selected three reference patches with different inclinations (Vref, Href= 50, 30; 30, 50; 50, 50) and generated nine test patches for each reference, combining three ds (dsmall< dref< dlarge) with three inclinations specified by indeterminacy functions.

In all reference conditions observers performed at chance when the simulated (V, H, d) values of the test were consistent with the pair of indeterminacy functions of the reference; while they accurately discriminated patches consistent with different indeterminacy functions. The probability of perceiving the test patch as deviating from the frontoparallel plane more than the reference increased as a direct function of the ratio between the areas subtended by the indeterminacy functions of the test and those of the reference.

A model that selects (V, H, d) values corresponding to the weighted difference between the areas below the indeterminacy functions explained data better than the weighted linear combination of simulated (V, H, d) values. We argue that humans recover surface orientation using the implicit knowledge of indeterminacy functions, without further assumptions on viewing geometry.

Acknowledgement: PRIN-COFIN 2005

URL: http://www.psico.units.it/users/fantoni/OrientationByIndeterminacy

H17 931 Precision of depth judgement from binocular disparity is heritable

Jeremy Wilmer[1] (wilmer@sas.upenn.edu), Benjamin Backus[1]; [1]Psychology Department, School of Arts and Sciences, University of Pennsylvania

One in three individuals is essentially blind to some range of stereoscopic depth for briefly presented stimuli (Richards, 1970). The relative contribution of genes and environment to these individual differences is unknown.

The degree to which identical twins are more similar for a given trait than fraternal twins indicates the genetic heritability of that trait. We used a recently developed stereo test of perceived depth by van Ee & Richards (2002) to test 90 identical and 20 fraternal twin pairs on a range of binocular disparities (13 levels from 2 deg crossed to 2 deg uncrossed) and at two durations (.2 or 1.5 sec). We computed the precision of each individual's depth judgements for near and far disparities, and for long and short durations.

Identical twins' depth estimation precision was more similar than fraternal twins' across the disparities and durations tested, suggesting heritability. This difference reached statistical significance (p=0.01) for the uncrossed, long duration stimuli, so performance over this spatial and temporal range may be particularly heritable. However, performance was generally poorer for crossed and short duration stimuli, so future testing may reveal heritability at other depths and display durations.

Our results suggest that one's ability to precisely determine depth from binocular disparity is heritable, at least for some spatial and temporal ranges, and they provide the first step toward identifying genes that influence depth perception.

Richards W. (1970) Stereopsis and stereoblindness. Exp Br Res, 10, 380-8.

van Ee R., Richards W. (2002) A planar and a volumetric test for stereoanomaly.

Acknowledgement: Support: NEI Kirschstein-NRSA postdoctoral fellowship to JBW and NIH RO1-EY13988 to BTB.

3D Perception: Shape and Depth

Author Presents: 10:30 am - 12:15 pm

H18 932 Perceived eccentricity difference is reflected by shifts in the spatial profiles of human V1 activity

Scott Murray[1] (somurray@u.washington.edu), Fang Fang[2], Huseyin Boyaci[2], Daniel Kersten[2]; [1]Department of Psychology, University of Washington, [2]Department of Psychology, University of Minnesota

Murray et al. (Nat. Neurosci., 2006) demonstrated that a distant sphere that appears to occupy a larger portion of the visual field activates a larger area in V1 than a sphere of equal angular size that is perceived to be closer and smaller. To assess whether this effect is due to an overall greater distribution of activity or due to a positional shift in the neural representation of spatial extent, we presented tori at close and far apparent depths in a rendered three-dimensional scene of a hallway and walls. When fixating its center of mass, the far torus appeared to be larger and occupy a more eccentric portion of the visual field, relative to the close torus. Using functional magnetic resonance imaging, we found that the spatial pattern of V1 activation induced by the far torus was also shifted towards a more eccentric representation of the visual field , while that induced by the close torus was shifted towards the foveal representation, consistent with their perceptual appearances. The peaks of the spatial profiles of V1 activation as a function of eccentricity induced by these two tori were at different positions. This effect was found not only when subjects attended to the torus, but also when they did a demanding fixation task (although weaker). Together with the previous study (Murray et al., 2006), these results strongly suggest that the retinal size of an object and the depth information in a scene are combined early in the human visual system resulting in positional shifts in V1 cortical activation. This is mainly a stimulus-driven process because it is largely independent of attention.

Acknowledgement: This work is supported by NIH grant EY015261. The 3T scanner at the University of Minnesota, Center for Magnetic Resonance Research is supported by NCRR P41 008079 and by the MIND Institute.

H19 933 Emmert's law cannot be generated by relative size cues even when these cues contain sufficient information

Rick Cai[1] (rcai@wisc.edu), Jerry Federspiel[1], Kerstin Priest[1], Mike Zenz[1]; [1]Dept. of Psychology, University of Wisconsin, Madison

In Emmert's law, the apparent size of an afterimage changes proportionally with the distance between the observer and the surface onto which it is projected (the 'projection surface'). In most cases in which the law was tested, relative size cues were available in addition to distance cues. For example, if an afterimage is projected onto a nearby chair, it may appear as a speck on the chair's fabric, but when the same afterimage is projected across a large room, several chairs can submerge into it. Such relative size cues contain sufficient information to scale an afterimage according to Emmert's law. It has been shown previously that distance cues alone, in the absence of any relative size cue, can lead to Emmert's law. Here, we tested the inverse condition to find out whether relative size cues alone can also generate Emmert's law. In Exp. 1, an object was presented on a computer monitor set at a fixed distance from the observer. The object's size changed smoothly, simulating the change in its retinal image as it moved closer or further away. An afterimage was projected onto the object. Thus, the relative size change between the two was achieved without any change in the apparent distance of the afterimage itself. The perceived size of the afterimage remained essentially the same. In Exp. 2, the changing object was placed within a virtual environment on the monitor, such that it was perceived as a looming or receding. The perceived size of the afterimage projected onto it remained unaltered. In Exp.3, the object' size was fixed on the monitor, but the monitor itself moved forward or backward. Emmert's law was obtained. Our results suggest that Emmert's law is due to a direct scaling of the afterimage itself by the size constancy mechanism.

H20 934 **Reconstruction of 3D symmetrical shapes by using planarity and compactness constraints**

Yunfeng Li[1] (li135@purdue.edu), Zygmunt Pizlo[1]; [1]Department of Psychology, Purdue University

It is known that a single orthographic image of a 3D symmetrical shape determines a one-parameter family of 3D symmetrical interpretations. We hypothesize that the subject's percept corresponds to the 3D shape from this family whose compactness is maximal. The 3D compactness is defined as the object's volume squared divided by the object's surface area cubed (V^2/S^3). Besides symmetry and compactness, our model also uses planarity of contours as a constraint. To test psychological plausibility of this model, we performed two experiments. In experiment 1 (preference), one 2D view of a 3D symmetrical shape was shown on the top. Two 3D rotating shapes (one was the original shape used to generate the view, and the other was a shape reconstructed by our algorithm) were shown in the bottom and the subject's task was to decide which of these two 3D shapes is closer to the 3D percept produced by the 2D view shown on the top. The subjects systematically preferred the reconstructed shape. In experiment 2 (reconstruction), the subject was shown one 2D view of a 3D symmetrical shape and a 3D rotating shape. The subject's task was to adjust the 3D shape so that it agreed with the 3D percept produced by the 2D view. The adjustment was done by setting the value of the free parameter determining the family of 3D symmetrical shapes consistent with the 2D view. The subjects' percept was always close to the 3D shape with the maximum compactness. In some cases, the perceived shape had less "depth" than the shape with maximum compactness. In order to account for these results, we use a Bayesian model in which the percept corresponds to the maximum of the posterior distribution.

Acknowledgement: Purdue Research Foundation

H21 935 **3D object completion develops through infants' manual exploration**

Kasey C. Soska[1] (kasey.soska@nyu.edu), Karen E. Adolph[2], Scott P. Johnson[2]; [1]Department of Psychology, New York University, [2]Department of Psychology and Center for Neural Science, New York University

As adults, we know that objects seen from a single viewpoint are most likely to have unseen surfaces that are occluded by the visible portions of that object. Previously, we found that infants 6 months and older achieved 3D perceptual completion of objects seen from limited vantage points in 2D displays. We hypothesized that infants with more sophisticated object manipulation skills would be more sensitive to the complete 3D form of objects, relative to infants with less experience handling objects.

Infants were habituated to a computer-generated 3D wedge that rotated back and forth through 15°, allowing only two faces of the object to be seen. Two displays were then shown in alternation, both rotating through 360°, one depicting a complete, solid wedge, and the other an incomplete, hollow wedge composed only of the two sides seen during habituation. A novelty preference for the hollow wedge test display was our measure of 3D object completion.

In further testing on the same day, infants were offered twelve graspable toys. Half of the toys had surfaces with congruent patterns on both sides, and half had different patterns on each side, to motivate infants to turn the objects over. We predicted that infants with more sophisticated exploration skills would examine the incongruent toys more thoroughly.

Infants younger than 6 months displayed more drops of the objects, $p<.05$, initiated contact with fewer objects, $p<.01$, and took longer to expose the other side of the objects in all postures, $p<.05$, compared to infants older than 6 months. Critically, only infants who were better at object manipulation were found to display a strong preference for the novel, incomplete 3D object following habituation, regardless of age. These results imply that emergence of sensitivity to the 3D form of a limited-view object may reside within action development.

H22 936 **Frames of reference for the light-from-above prior in visual search and shape judgements.**

Wendy Adams[1] (w.adams@soton.ac.uk); [1]University of Southampton

Faced with highly complex and ambiguous visual input, human observers must rely on prior knowledge and assumptions to efficiently determine the structure of their surroundings. One of these assumptions is the 'light-from-above' prior. In the absence of explicit light-source information, the visual system assumes that the light source is roughly overhead. A simple, low-cost strategy, would place this 'light-from-above' prior in a retinal frame of reference. A more complex, but optimal strategy would be to assume that the light source is gravitationally up, and compensate for observer orientation. Evidence to support one or other strategy from psychophysics and neurophysiology has been mixed. This study pits the gravitational and retinal frames against each other in two different visual tasks that relate to the light-from-above prior. Observers performed either a visual search task with shape-from-shading (SFS) stimuli, or made convex / concave shape judgments of simple SFS objects at various head orientations.

In both tasks the retinal frame-of-reference dominated.Visual search behaviour with SFS stimuli was modulated purely by stimulus orientation relative to the retina. However, the gravitational frame of reference had a significant effect on shape judgements, with a 30% correction for observer orientation. These results are consistent with current neurophysiological data on SFS if we re-frame compensation for observer orientation as a cue-combination problem.

Acknowledgement: Funded by EPSRC EP/D039916/1

H23 937 **Aging and the perception of slant from patterns of optical texture**

Charles Crabtree[1] (charles.crabtree950@wku.edu), J. Farley Norman[1]; [1]Western Kentucky University

A single experiment compared younger and older observers' ability to judge slant from natural patterns of optical texture. The observers monocularly viewed four differently textured planar surfaces that were presented at four different slants (20, 35, 50, & 65 degrees from frontoparallel). Three of the textures were flat (marble, granite, and a random array of circular elements), while the remaining pattern possessed solid texture elements (i.e., pebbles). The observers viewed the textured patterns through a circular occluding aperture. The resulting visible textures subtended 20 degrees of visual angle. Each of the 36 older (aged 61 to 78 years) and younger observers (aged 18 to 27 years) performed five judgments for each of the 16 combinations of slant and texture type. The observers made their judgment on each trial by adjusting the slant of a palm board until it matched the perceived slant of the textured pattern. In contrast to previous research with computer-generated textures (e.g., Rosas, Wichmann, & Wagemans, 2004; Todd, Thaler, & Dijkstra, 2005), our observers did not show underestimation in their slant estimates. In general, the observers' perceived slants were close to the actual slants (except for the circle texture where the observers overestimated by an average of 8.2 degrees). For two of the texture types (marble and granite) the younger observers perceived more slant than the older observers, whereas the two age groups performed similarly for the circle and pebble textures. The precision (i.e., reliability across repeated judgments) of the younger observers' judgments was the same for all texture types. The precision of the older observers' judgments, in contrast, was significantly better for the circle and pebble textures and poorer for the marble and granite textures. The overall results indicate that the ability to perceive slant from optical texture remains relatively intact with increases in age.

H24 938 **Perceived rigidity of rotating specular superellipsoids under natural and not-so-natural illuminations**

Katja Doerschner[1] (doers003@umn.edu), Daniel J. Kersten[1]; [1]Department of Psychology, University of Minnesota

Specular reflections provide potentially useful information about an object's 3D structure for the moving (Roth & Black, 2006) and stationary case, and it has been shown that human observers use reflections when estimating the 3D shape of an object (Fleming, Torralba & Adelson 2004). What happens when a specular object rotates rigidly in depth? Depending on the reliability of the shape information, a rotating ellipsoid can appear non-rigid. If we provide an observer with rich information as to the cause of the optic flow, namely the specular reflections of a natural vs. a not-so-natural environment, will the rotating ellipsoid vary in apparent rigidness?

We used five superellipsoids with decreasing degrees of corner roundedness, ranging from a near-ellipsoidal to a near-cuboidal shape. We also manipulated the perceived shininess that a given environment map elicits by: a) making the pixel histogram of the map Gaussian b) scrambling the map's spatial phase spectrum. Observers viewed short movie clips of rotating superellipsoids under different environment maps and rated rigidness of the object on a scale from 1(least) to 5 (most rigid).

A natural illumination map provides an optic flow pattern consistent with reflections flowing on a surface, whereas a less natural map suggests pigment changes (that might be incorrectly interpreted as stuck to the surface). We hypothesized that ellipsoids which are perceived as shiny, may appear more rigid than those which are perceived as matte and textured. Results show an effect of shape (roundedess) on perceived rigidity, the most roundish object appearing least and the most squarish appearing most rigid, but no effect of the environment map. Human observers were not able to use the specular cues to shape and the specular flow of the rotating roundish ellipsoids – even when they appeared very shiny.

Acknowledgement: R01EY015261

H25 939 Circles as ambiguous figures

Walter Gerbino[1] (gerbino@units.it); [1]Department of Psychology and B.R.A.I.N. Centre for Neuroscience, University of Trieste, Italy

Circles are deceptively simple stimuli. When the relative positions of two or more circles are manipulated, different perceived shapes emerge, depending on geometrical constraints that have not been clearly identified so far. Consider relative size and eccentricity of circles as critical variables. While isolated circles are preferentially perceived as flat frontoparallel disks, the composition of two circles, one surrounding the other, elicits the three-dimensional lampshade percept that Michotte, Thinès, and Crabbé (1967) labeled as a typical case of amodal complement "‡ decouvert" (i.e., without occlusion). The lampshade percept is robust enough to tolerate eccentricities that are incompatible with straight cone geometry, as demonstrated by the fact that observers easily perceive a lampshade with a concave mantle when the eccentricity is increased beyond the limits of inclusion of one circle within the other. Compositions of three or more regularly spaced circles are even more interesting, given that they are perceived as a set of overlapping disks only in the absence of a common axis. When their centers are collinear, circles are perceived as a structure of connected balls: a solution which is consistent with the "eggs" demonstration discussed by Tse (1999). Taken together, such phenomena suggest that the competition between alternative visual shapes is constrained by relatively local principles (unidirectional function of borders, minimal depth), as well as by global principles (view genericity at the level of the overall structure). In the absence of textural, kinetic, and shading information, volume perception can be supported by configural factors alone.

Acknowledgement: supported by MUR grant PRIN 2005119851

H26 940 3D Shape Perception in Real Stimuli: Combination of Motion and Stereo Information without Cues-to-Flatness

Rajesh Shah[1] (Rajesh_Shah@Brown.edu), Fulvio Domini[1]; [1]Department of Cognitive & Linguistic Sciences, Brown University

The most recent formulation of the Intrinsic Constraint (IC) Model of Domini, Caudek and Tassinari (in press) predicts that the perceived depth of a simulated 3D structure, specified by only one depth cue will be perceived as shallower than the same structure specified by two depth cues. While empirical evidence supports this hypothesis, the results may be confounded by presentation of stimuli using computer monitors. That is to say, simulated monitor viewing provides cues to flatness via pixilation, reduced blur gradient and accommodation which may contribute underestimations of depth. When depth-cues are seen in isolation, more weight may be given to flatness cues and therefore, the single-cue stimuli may appear flatter. To address this criticism textured real surfaces were employed in order to remove any contributions from flatness cues. These surfaces were slanted around the Y axis at a range of angles and viewed by observers in three experimental conditions: stereo-only, motion-only, and combined stereo and motion. In the stereo-only condition the surface was static and viewed binocularly. In the motion-only condition the surface was viewed monocularly while oscillating at a range of angular velocities about the vertical axis. Results were consistent with earlier findings by Domini (1999) where increases in angular velocity produced increases in perceived slant. In the combined-cue condition the surface was seen binocularly with oscillatory motion over the same range of velocities as in the motion-only condition. The results confirm those of Domini et al. and the predictions of the IC model in that the surface in the combined-cue condition was judged as more slanted than the surface viewed in the motion-only and stereo-only conditions.

H27 941 Perceptual elasticity in stereokinetic effect

Kenchi Hosokawa[1] (hskwk@l.u-tokyo.ac.jp), Yutaka Nakajima[1], Takao Sato[1]; [1]Depertment of Psychology, University of Tokyo

In the stereokinetic effect, rotated nested figures yield cone- or pyramid-like 3D impressions. We found that similar displays consisted of pseudo-concentric squares (squares with slightly shifted centers) induced elastic 3D object impression. This elastic impression systematically changes as the displacements between centers of squares are varied. In this study, we examined the relationship between the elasticity and the amount of shift between centers to explore the source of the elasticity. The stimuli were pseudo-concentric 15 squares of different sizes (edge size = 1 to 15 deg, in 1 deg steps). The center of each square was placed along a small circle according the size order with a fixed angular shift. They were moved simultaneously at a fixed angular velocity while keeping centers on the circle and the orientation upright. The shift size was varied between 0 to 64 degs and subjects were asked whether they perceived rigid or elastic 3D object, or no 3D impression at all. The solid 3D impression was perceived when the angular shift was less than 4 degs, but elasticity emerged for larger shifts up to 40 degs. Beyond this limit, 3D impression was completely lost. The shape of the lines connecting vertices is straight with zero shift, but it became sinusoidal when a shift was added. The sinusoid moves as a traveling wave and its spatial frequency increases as the angular shift was increased. This sinusoidal motion is a measure of display's violation from rigidity and is the source of elasticity observed in the present display. This suggests that 3D recovery and elasticity perception are independent. However, the disappearance of 3D impression when the frequency of the sinusoid increased beyond certain limit suggests some interaction between the two systems.

Acknowledgement: This research is supported by Japan Society for Promotion of Science.

H28 942 Shape Perception is Merely Ambiguous, Not Systematically Distorted

Young-lim Lee[1] (yl5@indiana.edu), Mats Lind[2], Geoffrey P. Bingham[1]; [1]Department of Psychological and Brain Sciences, Indiana University, Bloomington, [2]Department of Information Science, Uppsala University

Many studies have reported that perceived shape is systematically distorted (e.g., Johnston, 1991; Tittle et al., 1995). However, we have found that distortions vary with tasks and observers (Lind et al., 2002). Furthermore, using action measures (reaching and grasping), we found that shape cannot be calibrated (Bingham, 2005; Lee et al., 2005). These results imply that shape perception is ambiguous rather than systematically distorted and that systematicity is produced by contextual variables. We investigated this hypothesis under full information conditions by manipulating relevant context.

Methods: Actual cylindrical objects with different depth to width aspect ratios were viewed (at 50 cm) in two conditions: 1) frontoparallel elliptical cross section (2D); 2) elliptical cross section in depth (3D). The task was to adjust the aspect ratio of an ellipse on a computer screen to match the cross section of a target object. Two different ranges of aspect ratio were tested: 1) Large range (LR): .5, .67, 1.0, 1.53, 1.9 and 2) Small range (SR); .67, .83, 1.0, 1.24, 1.53. Three different groups of 8 observers were tested: 1) 2D:SR -> 3D:LR, 2) 2D:LR -> 3D:SR, 3a) 2D:SR -> 3D:SR and 3b) 2D:LR -> 3D:LR.

Results: Observers performed the 2D task accurately. This provided the context. If 3D aspect ratios are ambiguous, then Os might resolve the ambiguity by assuming the same range of aspect ratios as experienced in the 2D task. Plotting judged aspect ratios against actual aspect ratios should yield the following results: Group 3: accurate slope of 1, Group 1: low slope <1, and Group 2: high slope >1 or slopes ordered as Group 1 < Group 3 < Group 2. The results showed the expected slope orders.

Conclusions: Results confirmed the hypothesis that perception of shape is ambiguous and the systematicity of distortions is a function of contextual variables.

H29 943 Feature correspondence versus motion energy in 3-D shape perception

Xin Meng[1] (xmeng@sunyopt.edu), Qasim Zaidi[1]; [1]SUNY College of Optometry

Computer vision algorithms can estimate 3-D structure from image streams either by using feature correspondence across views, or patterns of motion signals. We ask whether feature correspondence is sufficient for human observers, or whether motion extraction is necessary. We measured the minimum velocity required to reliably identify 3-D shapes from monocular motion cues, and compared it to the minimum velocity at which the direction of motion-energy can be identified reliably. For 3-D shape identification, we presented a vertical sinusoidal corrugation translating for a half cycle across a central fixation. Observers had to indicate whether the half-cycle was concave, convex, right-slant or left-slant (4AFC). The corrugation was covered with a starry night texture which does not convey 3-D information in static displays (Zabulis & Backus, 2004). Measured by a method of constant stimuli, thresholds for three observers were between 0.44 and 1.02 deg/sec. For the identification of motion-energy direction, we presented a moving sinusoidal grating added to one of the component sinusoidal gratings of a static orthogonal plaid of the same spatial frequency. The grating could move in either direction along either of the two axes. The contrast of the plaid was three times the contrast of the moving grating, making accurate direction identification possible only when the motion energy of the grating can be extracted from the compound spatio-temporal spectrum (Lu & Sperling, 1995; Zaidi & DeBonet, 2000). Measured by a 4AFC method of constant stimuli, thresholds for direction of motion for three observers were between 0.65 and 0.78 deg/sec. Punctate spatially random sampling of the stimulus did not increase thresholds. Reliable identification of 3-D shapes thus occurs roughly at velocities at which motion energy is extracted. These results indicate that the human visual system uses motion signals per se to estimate 3-D shapes from image streams.

Acknowledgement: NEI EY13312 and EY07556

H30 944 Infants' Interpretation of Possible and Impossible Objects in Pictures

Sarah Shuwairi[1] (sms425@nyu.edu), Judy DeLoache[3], Scott Johnson[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Science, New York University, [3]Department of Psychology, University of Virginia

Previous research in our lab demonstrated that 4-month-old infants discriminate between 2D depictions of structurally possible and impossible object pairs. In an eye-tracking paradigm, infants showed longer looking times for impossible relative to possible object displays, and engaged in active comparison of critical regions in these cube stimuli, regions in which depth order of junction parts was reversed in impossible relative to possible displays. Sensitivity to the pictorial depth cue of interposition and detection of inconsistencies in global object structure, therefore, are available early and guide young infants' oculomotor behavior.

Here, we asked whether these perceptual skills would also guide reaching behavior in 9-month-olds. We reasoned that the degree to which infants manually explore depictions of possible versus impossible objects might provide an index of their interpretation of such displays. We measured differences in number of manual gestures attempted towards realistic photographic displays of objects, including possible and impossible cube stimuli. Infants directed a greater number of manual gestures (grasping, pinching, scratching, rubbing, patting) towards the impossible relative to the possible cube display (p < .001) and to images of real toys and non-pictorial images such as tree bark (p < .05). By 9 months, therefore, infants use the pictorial depth cue of interposition to guide manual investigation of 2D depictions of objects, and behave differently in response to images of possible and impossible objects. Specifically, anomalous depth information induces greater exploration of pictures of impossible objects.

These data suggest that the infant's visual system extracts structural information in 2D images in an attempt to analyze the projected 3D configuration, and this information serves to control both oculomotor and manual action systems. Our findings provide important insights into the development of mechanisms for processing pictorial depth cues and extracting 3D structure from pictures of objects.

H31 945 Is focal blur an absolute cue to depth?

Dhanraj Vishwanath[1] (dxvgss@rit.edu); [1]Department of Psychology, Rochester Institute of Technology

Accommodation and vergence are considered to be the main source of signals to absolute depth, since retinal visual cues are thought to signal only relative depth relations. Focal blur in the retinal image has been shown to be a reliable signal to unsigned ordinal depth relations. However, focal blur does contain information that signals absolute distance, since the rate of blurring around the fixated point varies systematically with change in absolute depth of fixation for a given pupil diameter. For example, the gradient of blur around a point of fixation between 10 and 30 cm is usually much higher than that for fixation beyond one meter. At distances much greater than a meter, the gradient of blur is significantly diminished. The gradient of blur should typically be greatest along the vertical meridian since the lower hemi field usually contains objects closer than fixation, while the upper hemi field typically contains objects further away. A curious visual effect, that has been recently exploited by photographers, makes objects in photographed scenes with a high degree of focal blur appear much smaller than reality. This suggests an effect on size constancy due to a change in perceived distance. Observers compared scenes (containing either circular patches or spheres) presented on two separate displays which had different degrees of simulated focal blur. The displays could be independently set at different distances from the observer. Observers matched the perceived size or distance of either a target patch or sphere in the displayed scenes. Settings showed a small effect of blur on perceived distance and size, where an object surrounded by higher blur appeared closer and smaller than one surrounded by elements that were in focus. We consider how a small but reliable signal to absolute depth could result in the vivid effects seen in pictorial images.

H32 946 Age-related differences in the ground dominance effect and perceptual organization of 3-D scenes

Zheng Bian[1] (bianz@ucr.edu), George Andersen[1]; [1]University of California, Riverside

Previously we have found a dominance effect of the ground plane over other environmental surfaces in determining the perceived relative distance of objects in 3-D scenes, and that this dominance effect was mainly due to the characteristics of the ground plane (Bian, Braunstein & Andersen 2006; in press). In the current study, we investigated whether the ground dominance effect varied with age. In Experiment 1, a scene containing a ground, a ceiling and two vertical posts were presented. Optical contact with the ground indicated that one post was closer, whereas optical contact with the ceiling indicated that the other post was closer. The scene was either in its normal orientation or rotated to the side. In Experiment 2, a blue dot was attached to each post with their location varied from bottom to top of the posts. In both experiments, observers judged which of the two objects (posts in Experiment 1 and blue dots in Experiment 2) appeared to be closer. The results indicated that both younger (mean age 21) and older observers (mean age 72) responded consistent with the ground dominance effect. However, the magnitude of the effect was less for older than younger observers. In order to examine if this age difference was due to differences in fixation we repeated Experiment 2 and measured eye movements. The results indicated no significant difference was found on the percentage of duration of fixation on either the ground plane or the ceiling plane between the two age groups. These results suggest a decreased reliance on ground surface information by older observers in the perceptual organization of scenes.

Acknowledgement: Supported by NIH AG13419-06

H33 947 Napoleon Paper Building Blocks

Keh-Ming Lu[1] (klu@asia.edu.tw), Alan S Tsaur[2], Mei-Fan Chen[1]; [1]Dept. of Computer Sciences and Information Engineering, Asia University, [2]Dept. of Information and Design, Asia University

A general concept of building blocks is of 3D geometric graphics presented by their different appearance. The shape of each individual building block is initially confined. Constructors must conceive the design pattern and then select different building blocks to construct the patterns. Therefore, converting a rhombic tessellation motif into a 3D tessellation model is an essential goal of paper building blocks. Reusability and capability of coloring are two specific features of paper building blocks. Combinations of building blocks including the prime models are reusable. These important features are irreplaceable by wooden or plastic building blocks.

This study starts with a description of the basics of Napoleon plane tessellation and a development of 8 basic building blocks such as Bowtie, Wing, Teardrop, Bar, Boat, Star, Chevron, and Carp that are made of a rhombic 32-iamond through four construction processes. In order to increase the number of types of building blocks, we developed two steps to create 54 types of primary, secondary, and derivative models. Since these models, topologically, are of polyhedral object that is comprised of faces, edges, and vertices of regular triangles, we can calculate their Euler characteristic that amazingly is equal to 2.

We also create innovative modules including through holes or handles by combining these building blocks. The topological name for the number of handles in an object is genus. Based on a polyhedron's numbers of vertices, faces, and edges, we developed two categories of applications of these modules: a) modules that connected building blocks by vertices and edges such as flip flop toy, rotation toy, and lantern spheres; b) modules that connected building blocks by faces such as a torus genus-1 donut and a genus-1 rhombus. For the modules of the second category, we developed a novel approach to calculate Euler characteristic and finally verify the genus-n modules.

H34 948 Size judgments of looming targets: Effect of speed, location and the utilization of eye movements.

Raiju Babu[1] (rjbabu@uwaterloo.ca), Susan Leat[1], Elizabeth Irving[1]; [1]University of Waterloo

Purpose: Judging the size of looming objects is important in many daily activities including driving and sports. The aim of the current experiment was to investigate the effect of speed, location, and the use of eye movements, in judging the size of looming targets.

Methods: Ten participants (mean age 27.7±4) observed a looming target (a vertical bar that appears to come towards the observer) projected on a screen, at a distance of 2m. Participants clicked a button when the size of the looming target matched a previously shown target. Responses for looming targets at five speeds were obtained in random order from one of the following: a central location (0 deg), a series of peripheral locations (-20,-10, 10 and 20 degrees) while fixating a central location or the same peripheral locations but with eye movements toward the looming targets. Eye movements were recorded with a video-based eye tracker. The effect of speed, target location and the use of eye movements on size match estimates was determined using a mixed design four factor ANOVA. A Tukey's post hoc was used for pair-wise comparisons.

Results: Higher speeds resulted in larger size match estimates for all target locations ($F[4,4935]=20.73$; $p<0.01$).The slope of subjects responses (in size) was significantly different from the rate of stimulus change. A size match main effect was found between central and peripheral locations both with and without eye movements ($F[4,4935]=25.23$; $p<0.01$).The interaction between target location and speed was not significant ($F[8,5485]=0.19$; $p>0.05$).

Conclusions: Looming speed and target location affect the ability to estimate the size of objects. Size judgments are generally seen to be overestimated but not with a constant reaction time. Location differences in responses cannot be explained by the differences in retinal motion cues as similar results were obtained with eye movements.

Visual Memory

Author Presents: 8:30 - 10:15 am

H35 949 Interactions Between Number and Resolution in Visual Working Memory

Brian Barton[1] (bbarton@uoregon.edu), Edward Awh[1]; [1]Department of Psychology, University of Oregon

Visual working memory enables the online maintenance of a limited quantity of information in an "online" or readily accessible state. Various paradigms have confirmed that this system is subject to relatively severe capacity limits. One influential paradigm for assessing these capacity limits is the change detection procedure, in which observers are asked to remember the content of a sample array for a brief period and then indicate whether any of the remembered items have changed in a subsequent test array. Multiple investigators have used this procedure and concluded that even with very simple objects, the number of items that can be maintained in working memory is limited to about four (e.g., Luck and Vogel, 1997; Pashler, 1988). Further work has shown that when more complex objects are presented, change detection performance declines even more (e.g., Alvarez and Cavanagh, 2004; Eng et al., 2005). We recently observed, however, that the influence of object complexity may be better explained by limitations in the resolution of representations in working memory rather than the number of items that are maintained (Awh et al., in press). This conclusion was supported by the observation that capacity estimates from a change detection procedure were equivalent for complex and simple objects when comparison errors were minimized by reductions in sample/test similarity. Here we extend these findings by describing a new analytic procedure for estimating the probability of comparison errors (i.e., the functional resolution of memory representations) while taking into account errors that result from limitations in the number of items that an individual can represent. This analysis coupled with new data demonstrates that the resolution of representations in working memory declines monotonically as the number of items increases, thereby clarifying how number and resolution interact during the maintenance of information in visual working memory.

H36 950 Dissociated Pattern of Neural Correlates for Verbal and Non-Verbal Coding Strategies in Visual Working Memory

Mark W. Greenlee[1] (mark.greenlee@psychologie.uni-regensburg.de), Christoph Rothmayr[1], Oliver Baumann[1,2], Roland M. Rutschmann[1], Tor Endestad[2], Svein Magnussen[2]; [1]Experimental Psychology, University of Regensburg, Germany, [2]Institute of Psychology, University of Oslo, Norway

Dorsolateral prefrontal cortex (DLPFC), parietal areas and extrastriate visual cortex have been identified as the neural correlates of visual working memory (WM). The involvement of DLPFC in the maintenance and/or manipulation of memory representations remains disputed, as is the issue of the cortical dissociation of verbal and non-verbal encoding strategies in WM, as well as how these processes depend on the delay period. We sought to explore the effect of explicit encoding strategies in a delayed discrimination task for grating orientation. Method: We used functional MRI in a 3-T head scanner to determine the neural correlates of the delayed discrimination of eccentrically presented Gabor stimuli differing in orientation. On each trial, subjects were cued to code the relative grating orientation either verbally (tilted left or right of vertical, covert speech) or non-verbally (visual discrimination between two oblique orientations) for short (2 s) or long (8 s) memory delay periods. They responded in a 2AFC whether the test and reference gratings had the same or different orientation. Results: Performance in the verbal encoding condition was significantly higher ($p < 0.01$) and reaction times were lower ($p < 0.01$) compared to the results of the non-verbal encoding condition. Blood-oxygen level dependent (BOLD) fMRI revealed significant activity bilaterally in prefrontal, anterior cingulate, posterior parietal, superior temporal and precuneus cortex. A random-effects analysis revealed that the right DLPFC was significantly more active in the non-verbal encoding condition for the long delay period, whereas the left superior temporal gyrus was more active in the verbal encoding condition for both short and long delays. Our results suggest that the coding strategy used by the subject has a significant effect on the resultant pattern of BOLD activation during delayed discrimination tasks requiring WM.

Acknowledgement: Funded by Bavarian Research Foundation

URL: http://www.psychologie.uni-regensburg.de/Greenlee/forschung/publikation.html

H37 951 **Does visual short term memory vary as a function of visual field location**

Leila Montaser-Kouhsari[1] (lmk306@nyu.edu), Marisa Carrasco[1,2]; [1]Department of Psychology, New York University, New York, NY, [2]Center for Neural Science, New York University, New York

Goal: It is known that visual performance differs across the visual field, even at isoeccentric locations. Performance is better at the horizontal than the vertical meridian, and is worse at the upper than the lower vertical meridian, a phenomenon referred to as vertical meridian asymmetry (Carrasco et al., 2001), which has a neural basis at the earliest stages of cortical visual processing (Liu et al., 2006). It is also known that performance in many visual tasks decays with delay. In this study we investigated whether visual short term memory (VSTM), as assessed by a spatial frequency judgment task, is affected by the location at which the stimuli appear.

Method: Eight observers performed a VSTM spatial frequency judgment at 4 different locations of the visual field (North, South, East and West). Each trial consisted of two intervals separated by either a short (1s) or a long (3s) delay. In each interval a vertical Gabor patch was presented at 6 deg of eccentricity for 100 ms. The test had a spatial frequency of either 6.5 or 7.5 cpd, and the probe had a spatial frequency of 7 cpd. Observers were asked to report which of the two Gabors, the former or the latter, had a higher spatial frequency.

Results: For all observers, performance was more accurate at short than long delays at all 4 locations. In addition, performance was equivalent at the East, West and South locations, and all three were superior to the North location in both the short and the long delays. These results indicate that visual short term memory varies as a function of the visual field location. The quality with which we encode information affects VSTM.

H38 952 **Object complexity does not reduce the number of representations that can be maintained in visual working memory**

Veronica Perez[1] (vperez@uoregon.edu), Edward Awh[1], Edward K. Vogel[1]; [1]University of Oregon

A central feature of visual working memory is that it is a highly capacity-limited system. Several studies have shown that, on average, subjects are highly accurate at maintaining about 3-4 simple objects in memory. Results such as these have been taken to suggest that memory capacity is primarily determined by a limit in the number of object representations (e.g., Luck & Vogel, 1997). Other research, however, has suggested that memory capacity may be best described as a flexible resource in which complex objects consume a greater amount of available memory capacity irrespective of the number of objects to be remembered (e.g., Alvarez & Cavanagh, 2004). Here, we recorded behavioral and electrophysiological data while subjects performed a change detection paradigm with simple and complex objects. Specifically, we examined the contralateral delay activity (CDA), which has been shown to be a highly sensitive online measure of the number of object representations that are maintained in memory during a given trial (e.g., Vogel & Machizawa, 2004). In a series of experiments, we found that change detection accuracy was considerably poorer for complex objects than for more simple objects. However, CDA amplitude was not modulated by the complexity of the objects despite being highly sensitive to the number of objects currently being held in memory. These results suggest that the total number of objects that can be held in memory is not determined by the complexity of the objects. Thus, poorer behavioral performance for complex objects may be the result of limited resolution representations that lead to errors in the comparison process at test rather than a reduction in the number of items that can be maintained.

H39 953 **Binding deficit in visual short-term memory reflects maintenance, not retrieval**

Jun Saiki[1,2] (saiki@cv.jinkan.kyoto-u.ac.jp), Hirofumi Miyatsuji[3]; [1]Graduate School of Human and Environmental Studies, Kyoto University, [2]PRESTO, Japan Science and Technology Agnecy, [3]Graduate School of Informatics, Kyoto University

Visual short-term memory (VSTM) has been claimed to maintain 3-5 feature-bound object representations. A few studies investigating memory for feature binding report significantly smaller capacity estimates (Saiki, 2003; Wheeler & Treisman, 2002), which have been interpreted as the effects of interference in memory retrieval, based on the finding that retrieval cues improve performance. However, change detection tasks may not properly evaluate feature-bound representations in VSTM, because observers can detect a change with other types of memory representations. To overcome this problem, we devised modified tasks, type identification and relevant-feature switch detection, to evaluate memory for feature binding more directly. With objects defined by shape, color, and spatiotemporal location, and changes being feature switches across objects as in previous studies on binding memory, the type identification task asked observers to identify the switch type among 4 alternatives (shape, color, shape-and-color, and no-switch). The relevant-feature switch detection required observers to monitor either color or shape alone, and to ignore the other. Both tasks need discrimination of different types of change, particularly between color- and shape-switch, not only detecting the presence of any change. Using a paradigm called multiple object permanence tracking (MOPT), where observers monitored a switch in feature combination between objects during an occlusion period, we manipulated memory retrieval by providing a cue right after a switch occurs. We found that retrieval cues revealed no facilitation with both type identification and relevant-feature detection tasks. In contrast, MOPT with the simple change-detection task showed significant facilitation, replicating previous findings. Additionally, object motion eliminated the cuing effect even with the simple change detection task. These results suggest that binding deficit in VSTM reflects memory maintenance, not retrieval, and that previous findings of retrieval effects are likely produced by memory unrelated to feature binding, such as saliency.

Acknowledgement: Support from 21st Century COE (D-10 to Kyoto Univ.), and PRESTO from JST.

H40 954 Repetition priming of appearance knowledge

Robyn T Oliver[1,2] (robyn@psych.upenn.edu), J. Stephen Higgins[1,2], Amy Baek[1], Sharon L. Thompson-Schill[1,2]; [1]Psychology Department, University of Pennsylvania, [2]Center for Cognitive Neuroscience, University of Pennsylvania

Possible multisensory acquisition of object shape and size knowledge (as proposed by Jeannerod; 1986), may result in distributed representations that are more overlapping with each other than either is with object color. In order to investigate this hypothesis, we evaluated the effect of repeated retrieval of object shape, size, and color knowledge on subsequent retrieval latencies for each of these attributes (i.e., repetition priming). Reaction times (RT) to primed test items were compared to RT's of items introduced during the test tasks in order to obtain a priming score for each prime and test task combination. Consistent with the hypothesis that shape and size knowledge are represented more similarly to one another than to color, priming shape knowledge had a greater facilitation effect on subsequent retrieval of size than color.

Acknowledgement: This research was supported by the National Institutes of Health RO1 MH60414.

H41 955 Is Visual Working Memory Consolidation a Continuous or Discrete Process?

Weiwei Zhang[1] (weiwei-zhang@uiowa.edu), Steven Luck[2]; [1]Psychology Department, University of Iowa, [2]Center for Mind & Brain and Department of Psychology, University of California

Perceptual representations fade rapidly unless transformed into durable working memory representations. This transformation process, called short-term consolidation, can be measured in change-detection tasks by using a mask at various times following the sample array to disrupt the perceptual representation before it has been consolidated (Vogel, Woodman, & Luck, in press). In this present study, we asked whether consolidation is (a) a continuous process that gradually produces a more and more precise representation, or (b) a discrete process in which the representation is lost unless it has reached a particular level of activation. To address this question, we developed a color recall task in which it is possible to independently estimate the probability that a representation was formed and, if so, the precision of this representation. We found that, as the amount of time between the sample and the mask array increased, the probability that an item was consolidated increased. However, increasing the time available for consolidation did not influence the precision of the working memory representation. These results are consistent with a model in which the activation level of a working memory representation must reach a threshold before the perceptual representation is masked in order to survive; if the working memory representation does not reach the threshold, it is lost entirely.

Acknowledgement: This research was made possible by grants R01 MH63001 and R01 MH076226 from the National Institute of Mental Health.

H42 956 Orientation-invariant perceptual memory

Yasuto Tanaka[1] (ytanaka@po.nict.go.jp); [1]Biological ICT group, National Institute of Information and Communications Technology

In investigating temporal cueing effects on contrast discrimination (Tanaka and Sagi, 2006), we found orientation-invariant perceptual memory. A double priming technique was used in which a temporal cueing signals (peripheral crosses to cue timing of prime temporal onset) followed by the presentation of high contrast Gabor primes (C=0.16, above threshold, sigma=lambda=0.25 deg) Onset asynchrony between cue and prime was optimized at 450ms. Memory trace for the prime was tested by the target Gabor that followed the prime with the onset delay of 900ms (Tanaka and Sagi 1998). Cue, prime and target durations were all 100ms. Detection threshold of target was measured by a temporal 2IFC paradigm with the interval between 1st and 2nd displays randomized by 700±500ms. We found detection facilitation with the high-contrast primes by 0.25±0.01 log units when prime and target orientation was identical. Facilitation was found with diagonal (45 deg) as well as orthogonal (90deg shift) primes, by 0.26±0.01, and 0.20±0.01 log units, respectively (2 observers). These results point to orientation invariant memory traces for high-contrast signals. Furthermore, phase dependency was examined by testing prime phase shifting either 45, 90, 135, or 180 degrees. Facilitation was limited within 90 degrees (0.21±0.04 log units, averaged across 0, 45, 90 deg) with estimation of the half-width of half height=0.l9 degrees of visual angle, corresponding to a perceptual receptive field. Taking the size of the RF as well as orientation invariance into account, we suggest high-contrast perceptual memory generated before cortical levels of processing, possibly in LGN.

References:

Tanaka and Sagi 2006, Improvement of contrast discrimination by temporally cued visual signals. Vis. Res. Submitted.

Tanaka and Sagi 1998, Perceptual memory for low-contrast visual signals. PNAS 95,12729-12733.

H43 957 Sleep affects adaptation

Bhavin Sheth[1,2] (brsheth@uh.edu), Murtuza Khan[3]; [1]Department of Electrical and Computer Engineering, University of Houston, [2]Center for NeuroEngineering and Cognitive Science, University of Houston, [3]University of Houston

Emerging evidence shows sleep plays a key role in the processes of learning and memory, which involve change at synaptic and cellular levels in the brain. Of importance, learning on the tasks used in sleep studies is guided by volitional, reward-driven, attentional and goal-directed behavioral processes. Is the role of sleep in synaptic plasticity confined to active, goal-directed processes alone or does sleep impact passive, more automatic forms of synaptic plasticity such as adaptation as well?

Adaptation is an alteration of synaptic strength resulting from sustained exposure to a sensory stimulus. Sustained association of two independent sensory features leads to a durable change in synaptic strength: visual inspection of a red horizontal grating for several minutes causes a post-inspection, achromatic horizontal grating to appear green for several days. Does sleep affect adaptation, a supposedly passive alteration in synaptic strength?

To address this, ten observers monocularly viewed an alternating sequence of red horizontal and green vertical gratings for a total of 5 min, and repeated the experiment a week later but on the previously closed eye. Published reports and our experiments find negligible interocular transfer of the afteraffect. Each observer was adapted twice: at 8 pm (re-tested at 8 am) following a night of sleep, and at 8 am (re-tested at 8 pm) with no sleep intervening. Condition and eye order were counterbalanced across observers. We compared the level of adaptation in the two conditions. Compared with the 8 am-8 pm condition, the re-tested aftereffect in the 8 pm-8am condition was significantly stronger ($p < 0.05$), indicating that overnight sleep caused more retention of the adaptation. Overnight sleep also had a modest effect on the initial acquisition of the aftereffect. Ongoing experiments are testing the impact of circadian rhythm and visual exposure.

Acknowledgement: BRS was supported in part by a GEAR grant (UH), MK was upported by a PURS fellowship (UH)

H44 958 Comparing the benefits of a nap, caffeine,modafinil and placebo on visual, visuospatial, motor and declarative memory.

Sara Mednick[1] (smednick@salk.edu), Jen Kanady[2], Kathy Resovsky[2], Sean Drummond[2]; [1]Salk Institute, [2]Psychiatry, UCSD Medical School

Naps enhance a wide range of learning, including visual perceptual, motor and declarative memory. However, napping is not as common a sleepiness-countermeasure as caffeine and modafinil. The extent to which these wakefulness promoters produce benefits equal to napping is unknown. In

Tuesday Posters

a double-blind study, we compared the effects of a 60-90min nap to 200mg of caffeine, 100mg of modafinil, and placebo on four different memory processes. 46 healthy volunteers were tested on four different types of learning: 1) perceptual: Texture Discrimination Task (TDT), visuospatial: Rey-Osterreith Complex Figure (RO) 2) motor: Finger Tapping Task (FTT), 3) declarative: Verbal Learning Task (VL). The first test session was at 9AM. At 12:30, all subjects were fitted with polysomnography monitors. Starting at 1PM, nappers slept up to 90 minutes but stayed in bed no later than 3PM, while non-nappers listened to a book on tape. Pills were administered at 2:30PM. Vitals signs were measured every half hour. At 3PM, all subjects retested. Task order was randomized across subjects, and each test session lasted 2 hours. Group differences were found on the four memory tasks. TDT: nappers showed improvement, there was no change in either drug group, and performance deteriorated in the placebo group. RO: nappers and modafinil groups showed improved visuospatial memory. FTT: The caffeine and modafinil groups showed slowed response times. HVLT: the modafinil group showed increased delayed recall, whereas the caffeine group showed decreases in most measures of declarative memory; nappers and placebo showed no change. We found differential memory enhancement and deterioration with the administration of a nap, caffeine and modafinil. Perceptual learning required a nap. Motor learning deteriorated with pharmacological intervention. Visuospatial memory improved with naps and modafinil. Declarative memory improved with naps and modafinil. These results have important implications for sustained performance applications in civilian and military operations.

H45 959 The role of short-term implicit memory in probability coding and associative learning

Paolo Martini[1] (pmartini@wjh.harvard.edu), Vera Maljkovic[1]; [1]University of Warwick

It is well known that choice reaction time decreases logarithmically with increasing probability of the stimulus (Hick's Law). In experiments and modeling we show that sequential dependencies in the response play a major role in eliciting this probability effect and that the implicit short-term memory mechanism of Priming of Pop Out (PoP) can be implicated in the genesis of probability effects on reaction times. By cross-correlating the responses with the stimulus series we characterize the first-order Wiener kernel underlying PoP. Assuming system linearity, we then show that the accumulation of memory traces over trials can induce large shifts in mean response times when the probability of the target is varied. However, this linear characterization of the memory-induced probability effect fails to capture the nonlinearity of Hick's law. We then discuss sources of nonlinearity and propose that an important function of PoP is to provide the basis for unconscious inferences that are essential in associative learning.

H46 960 Effects of saccadic eye movements on visual memory for natural objects

Gesche M. Huebner[1] (gesche_huebner@web.de), Barbara Gohlke[1], Karl R. Gegenfurtner[1]; [1]Abteilung Allgemeine Psychologie, Justus-Liebig-Universitaet Giessen

Our goal was to determine the benefit associated with saccadic eye movements for visual short term memory.

For different time spans between 50 ms and 3000 ms, participants viewed a display containing eight photographs of natural objects arranged on a circle. Memory for one object was tested subsequently using a partial report procedure: Participants either had to assign a previously seen object to the proper position on the circle or had to choose it out of an array containing the target object and seven distractors. Participants either had to fixate on the centre of the circle during stimuli presentation or were allowed to move their eyes freely after the trial had been started.

Accuracy in the memory task was not significantly different for the fixation condition and the eye movement condition. Performance also did not differ significantly for the different stimulus exposure durations. This indicates that prolonging the viewing time from 50 ms up to 3000 ms does not increase memory for the viewed material. In general, participants chose the right answer in about 48% of the cases in the memory test, both when having to indicate the correct position or the correct object. Given a chance rate of 12.5%, this yields a capacity estimation of about three items. Even though eye movements did not have an effect on memory capacity, they had a major impact on what items were stored. Previously fixated objects were remembered significantly better than the non-fixated items. There was a strong recency effect, meaning that a fixation only proved beneficial if the item was probed shortly after having been fixated.

Neither the different test modes nor the familiarity with the presented stimuli impacted upon performance.

We conclude that eye movements mainly affect what is stored in visual memory, but not how much is stored there.

H47 961 Visual chunking allows efficient allocation of memory capacity

Andrew McCollough[1] (awm@darkwing.uoregon.edu), Edward Vogel[1]; [1]Department of Psychology, University of Oregon

The ability to group information into "chunks" is a well know phenomenon in verbal working memory paradigms. However, the effects of chunking in the visual memory domain is not as well understood. Here, we investigate the effects of visual chunking on working memory capacity, by utilizing gestalt principles to bias subjects to group individual items into larger, virtual objects. Subjects were presented with groups of three "pac-men", elements of Kaniza figures, that were either coherently organized to form illusory Kaniza triangles or randomly oriented, and asked to remember the orientation of the individual pac-men. Subjects performed a change detection task on a single pac-man probe after a brief delay, indicating whether the pac-man probe was in the same or different orientation as the sample. We then measured change detection performance as a function of either the number of chunked objects or the number of individual elements in the display. Performance was greater in the Kaniza triangle condition than the random condition, which suggests that subjects were able to represent these illusory figures as single objects in visual working memory. ERPs were also recorded during the experiment. In particular, we examined the contralateral delay activity, which is an ERP component sensitive to the number of items held in memory during the delay activity of a visual working memory task. By examining the amplitude of this activity we will be able to further determine whether these grouping principles facilitated efficient allocation of memory capacity towards the "chunked" objects or whether the number of maintained representations in memory was set by the number of elements within the figure.

H48 962 Task-irrelevant attributes influence explicit and implicit memory for faces

Chris Oriet[1] (chris.oriet@uregina.ca), Pauline Pearson[2], Mitchell Jeffrey[2]; [1]University of Regina, [2]University of Winnipeg

We investigated whether task-irrelevant stimulus attributes of faces are encoded alongside relevant attributes. If so, repetition of an attribute present at study should facilitate performance when that attribute is repeated at test. In the study task, subjects classified faces along one dimension (emotion or gender) that was perfectly correlated with an irrelevant dimension (e.g., happy faces were always female for one group). At test, half of the faces were repeated from study (old) and half were new. Old faces were shown with the same emotion as seen during study (gender and emotion uncrossed) or with the opposite emotion (gender and emotion crossed) along with uncrossed and crossed foils. Subjects indicated whether the face was old or new (explicit task) or made a speeded judgment about the emotion or gender of the face (implicit task). Regardless of study condition, explicit recognition of crossed faces was at chance whereas recognition of uncrossed faces was demonstrated on 80% of trials. Crossing increased false recognition of new faces by about 10%, and this effect was somewhat larger when emotion was studied than when gender was studied. In the implicit memory task, emotion classification times were faster for old uncrossed items than for crossed items (a priming

Tuesday Posters

effect), and more priming was observed when emotion was studied, rather than gender. No priming was shown in the gender classification task. We found that: 1) explicit recognition is strongly affected by irrelevant attributes encoded at study; 2) encoding irrelevant attributes facilitates emotion classification (but not gender classification) and 3) implicit memory performance can be predicted from explicit memory performance suggesting that explicit recollection mediates the implicit memory contribution to the classification task.

Acknowledgement: This project was supported by a grant from the Natural Sciences and Engineering Research Council.

Auditory-Visual Interactions

Author Presents: 8:30 - 10:15 am

H49 963 Perceiving material properties of objects through sight or sound activates ventral occipitotemporal cortex

Stephen Arnott[1] (sarnott3@uwo.ca), Jon Cant[1,2], Melvyn Goodale[1,2]; [1]CIHR Group for Action and Perception, Department of Psychology, The University of Western Ontario, [2]Neuroscience Program, The University of Western Ontario

Knowledge of an object's material composition (i.e., what it is made of) alters how we interact with that object. Seeing the bright glint or hearing the metallic crinkle of a foil plate for example, confers information about that plate before we have even touched it. In a previous study (Cant & Goodale, 2007) it was shown that visually attending to an object's material properties as opposed to its shape or color, elicited greater hemodynamic activity in ventral occipitotemporal regions. In the present fMRI study, we investigated whether such areas are also sensitive to material properties of objects derived from sound only. Participants first completed a passive adaptation visual paradigm in which the material composition, shape or color of objects was manipulated in different blocks. In a separate series of blocks, participants were randomly presented with two-second normalized sound clips and asked to categorize them as either Material (crumpling styrofoam, plastic, tinfoil or paper), Noise (scrambled versions of each of the material sounds), or Human sounds (coughing, yawning, snoring or throat clearing). Replicating results from Cant & Goodale (2007), the visual task revealed a prominent area in the right parahippocampal region that was most selective for material as compared to shape or color properties. Although functional analyses of the auditory data within this visual material region did not reveal any discernable auditory modulation, expanding the region to include all of parahippocampal cortex revealed an area immediately adjacent to the visual material region that was highly selective for Material sounds as compared to Noise or Human sounds. Our findings point to an important multimodal role for the parahippocampal region in the analysis of material properties, and are in keeping with the notion that the medial aspect of the ventral pathway is specialized for processing the surface properties of objects.

Acknowledgement: Canadian Institutes of Health Research

H50 964 Auditory projections to visual cortex: synaptic basis for multisensory processing in 'unimodal' visual neurons.

Helen Ruth Clemo[1] (rclemo@vcu.edu), Giriraj Sharma[1], Brian Allman[1], Alex Meredith[1]; [1]Anatomy and Neurobiology, Virginia Commonwealth University School of Medicine

Neurophysiological studies in our lab have recently documented the multisensory properties of 'unimodal' visual neurons in the cat posterolateral lateral suprasylvian (PLLS) cortex, a retinotopically organized area involved in visual motion processing. These results showed that a large proportion (80%) of 'unimodal' visual neurons in the PLLS had their visual responses facilitated by the presence of an auditory stimulus. The present study used neuroanatomical methods to examine the cross-modal connectivity of the PLLS that may underlie this physiological effect. Adult cats (n=17) were anesthetized and, using sterile surgical techniques, biotinylated dextran amine (BDA) was injected into one of the following auditory cortical areas: AAF, AI, and PAF. Standard cytochemical procedures were used to visualize the transported tracer and a PC-based digitizing microscope was used to plot the location of labeled axon terminals. In each case, labeled boutons were identified in the region of the PLLS in a consistent pattern. Terminal label was the most concentrated at the outer lip of the sulcus, corresponding to the location of the auditory cortical area DZ. However, the label became progressively reduced with depth along the lateral bank, until few labeled axons were found near the fundus. This gradient among auditory terminals closely mirrors the distribution of bimodal and auditory-facilitated visual neurons, where bimodal neurons were primarily encountered in the transition between the visual PLLS and the auditory DZ, while the auditory-facilitated neurons were encountered at progressively deeper locations in the sulcal bank. Therefore, the gradient of projections from different auditory cortices to the PLLS may not only underlie the synaptic basis for multisensory processing here, but also the differential distribution of different forms of multisensory processing observed in this visual structure.

Acknowledgement: Supported by NIH-NS39460

H51 965 Dynamics of Crossmodal Interactions Between Corresponding Auditory and Visual Features

Karla Evans[1] (kevans@princeton.edu), Anne Treisman[1]; [1]Princeton University

Objects and events in the environment typically produce correlated input to several sensory modalities at once. There is mounting evidence that perceptual experiences that may appear to be modality-specific are also influenced by activity from other sensory modalities, even in the absence of awareness of this interaction. Using both behavioral and electrophysiological indices, we explored crossmodal interactions between non-speech auditory and visual stimuli on the basis of content correspondence between the stimuli. In a series of different psychophysical paradigms we found spontaneous mappings between the pitch of sounds (high or low) and the visual features of vertical location, size and spatial frequency. High pitch combined with visual high spatial position, small size or high spatial frequency gave better performance than the opposite pairings.

An EEG study using high-density mapping explored the time-course and scalp topography of this crossmodal interaction between pitch and spatial position in the vertical plane. Event-related potentials (ERPs) were recorded from 128 scalp electrodes while participants performed a one-back recognition task with unimodal auditory or visual stimuli or combined bimodal stimuli. Interaction effects were assessed by comparing the responses to combined stimulation with the algebraic sum of responses to the constituent auditory and visual stimuli when they were presented alone. The bimodal components were then also compared for congruent and incongruent pairings. Spatiotemporal analysis of ERP's revealed several audio-visual interaction components that were temporally, spatially and functionally distinct. The perceptual gains that we observe behaviorally correlate with amplification of the neuronal response in the participating sensory-specific and nonspecific cortices. Amplification of bimodal relative to summed unimodal responses was found within the time course of sensory processing, peaking at 120 and 190 msec poststimulus. A third component, peaking at 270 msec over parieto-occipital sites, was also modulated by congruency between the two features.

H52 966 Auditory noise can facilitate low-level visual processing

Jocelyn Faubert[1] (jocelyn.faubert@umontreal.ca), Eva-Maria Hahler[1], Rafael Doti[1], Eduardo Lugo[1]; [1]Visual Psychophysics and Perception Lab, Universite de Montreal

It has been shown that the Stochastic Resonance (SR) phenomenon occurs in different macro, micro and nano systems. From the cyclic recurrence of ice ages, bistable ring lasers, electronic circuits, superconducting quantum interference devices and neurophysiological systems such as receptors in animals. It has been extended to human sensory systems such as auditory, visual, proprioceptive and tactile mechanisms. Regardless of the demonstration of its presence in human sensory systems, there have been no direct demonstrations of cross-modal SR-based interactions in the human cortex. Here we report evidence of cortically based cross-modal effects of stochastically induced transitions. In previous experiments we demonstrated that introducing auditory noise significantly improved tactile sensations of the finger and EMG recordings of the leg muscles and the sweep area of stabilograms during posture maintenance. In the present experiments we presented different levels of auditory broadband noise while observers discriminated between vertical or horizontal luminance and contrast defined sinusoidal gratings. As in our previous auditory-tactile or auditory-proprioceptive experiments, the visual sensitivity profiles of the observers varied as a function of the different auditory noise levels demonstrating a typical SR function with zones of sensitivity values significantly different from baseline (no auditory noise condition). Our results show clear evidence that a stochastic synchronization-like phenomenon is present in the human cortex and that the added signals act upon the multisensory integration system creating a state that enhances functionality.

Acknowledgement: NSERC-Essilor Industrial Research Chair
URL: http://vision.opto.umontreal.ca

H53 967 Audiovisual Interactions in the Cat: Direct Cortical Projections from the Posterior Auditory Field to Primary Visual Cortex

Amee J Hall[1] (ahall57@uwo.ca), Jeffrey G Mellott[1], Stephen G Lomber[1]; [1]Departments of Physiology and Pharmacology, and Psychology, University of Western Ontario, London, Ontario, Canada

Sensory systems do not operate in isolation and must have the ability to influence each other. On a behavioral level, we have been examining the influence of auditory cortex on basic visual functions. Therefore, we are interested in identifying possible pathways that may serve to mediate these interactions. In adult cats (>6 months), sources of auditory cortical projections to primary visual cortex (areas 17 & 18) were studied using injections of wheat germ agglutinin conjugated to horseradish peroxidase (WGA-HRP) into areas 17 & 18. In each animal, multiple injections were made into representations of both the central and peripheral visual fields. In agreement with previous studies, characteristic patterns of cell body labeling were identified in extrastriate visual cortex (areas PMLS, PLLS, AMLS, 19, 20, & 21) and the visual thalamus (LGN, MIN, & LPl), thus confirming the efficacy of the tracer injections. Labeled neurons were also identified in the visual area of the anterior ectosylvian sulcus (area AEV). In auditory cortex, of the four tonotopically-organized regions, labeling was identified in the supragranular layers of the posterior auditory field (PAF). Little or no labeling was evident in the primary auditory cortex (AI), the anterior auditory field (AAF), or the ventral posterior auditory field (VPAF). Furthermore, little or no labeling was identified in the remaining nine generally-recognized regions of auditory cortex. Therefore, while no projections originating in AI could be found to terminate in primary visual cortex, projections were identified from non-primary PAF. Interestingly, PAF has been recently identified to play a significant role in the spatial localization of a sound source. Therefore, we propose that the PAF to primary visual cortex audio-visual pathway may serve to enhance or inhibit accurate spatial localization functions in primary visual cortex.

Supported by CIHR and NSERC.

H54 968 Cross-modal auditory and visual interactions and aftereffects – A comprehensive study

Anshul Jain[1,2] (anshuljjain@gmail.com), Sharon Sally[1], Thomas Papathomas[1,2]; [1]Lab of Vision Research, RuCCS, Rutgers University, Piscataway, NJ, [2]Department of Biomedical Engineering, Rutgers University, Piscataway, NJ

Goals: To study how perception of a stimulus in one modality (vision or audition) is influenced by the simultaneous presence of a stimulus in the other modality. To investigate whether such influences have perceptual or cognitive origins, we tested for aftereffects in one modality after adaptation in the other modality. **Methods:** We used three configurations: I. Approach/Recede (A/R): Visual stimuli were two low-contrast concentric counter-phase flickering sinusoidal (CPFS) gratings moving in opposite directions; their relative contrasts were varied to produce an expanding or shrinking stimulus. The loudness of auditory stimuli increased or decreased over time. II. Left-right (L/R): CPFS gratings moved right or left. Auditory stimuli moved right or left, by changing the relative loudness of two lateral speakers. III. Up/Down (U/D): CPFS gratings moved up or down. The pitch of auditory stimuli glided up or down. For each configuration, we studied both directions: visual stimuli influencing auditory stimuli and vice versa. For each combination of configuration and direction, we used simultaneous and cross-modal adaptation/test stimuli. **Results:** A/R and L/R: Visual stimuli influenced auditory perception in both simultaneous and adapt/test cases; this influence was larger in the A/R than the L/R case. This indicates perceptual origins for these effects. Some influence of auditory stimuli on visual perception was present only in the simultaneous case, indicating cognitive origins. U/D: The only strong crossmodal influence was in the auditory-to-visual direction for the simultaneous case [Maeda, Kanai, Shimojo 2004]. Very weak effects for the simultaneous case in the visual-to-auditory direction were observed. **Conclusions:** Cross-modal interactions between vision and audition are complex and do not follow a uniform rule. Most such interactions occur for simultaneous stimulation, and do not produce significant aftereffects, with the exception of auditory aftereffects following A/R visual adaptation [Kitagawa, Ichihara 2002], and weaker such aftereffects in the L/R case.

H55 969 Detecting Correlations between Auditory and Visual Signals

Pei-Yi Ko[1] (peiyiko@berkeley.edu), Carmel Levitan[2], Martin Banks[1,2]; [1]Vision Science Program, UC Berkeley, [2]Joint Graduate Group in Bioengineering, UCSF & UC Berkeley

In combining information from multiple sources, the brain must determine which signals correspond. For instance, in a crowded room, there may be many people speaking at once, but the brain correctly determines which speaker's lip movements match which sound. To examine the ability to detect correlations between auditory and visual stimuli, we presented auditory-visual stimulus pairs that contained correlated and uncorrelated changes over time. The visual stimuli were modulated in size and the auditory stimuli were modulated in intensity. We used a two-interval, forced-choice procedure to measure correlation-detection thresholds. In the signal interval, the amplitude modulations contained a correlated component. In the no-signal interval, the modulations were uncorrelated. Observers indicated which of two intervals on each trial contained the correlated modulations. To find the correlation-detection threshold, we varied the proportion of correlated and uncorrelated modulation in the signal interval. In one experiment, we varied the temporal frequency of the amplitude modulation by band-passing filtering the modulation waveforms. Correlation detection was good (threshold was ~0.2) for temporal frequencies of 0.5-2 Hz and then deteriorated at progressively higher frequencies. This suggests that the mechanisms involved in detecting auditory-visual correlations are sluggish. In another experiment, we presented broad-band stimuli and varied the temporal lag between the auditory and visual stimuli. Correlation-detection threshold was roughly constant for lags of +/-200 msec and was elevated about two-fold for lags of +/-400 msec. There was no obvious asymmetry in this lag effect. Thus, the mechanisms involved in detecting auditory-visual correlations tolerate fairly substantial time offsets. In analogy to models of stereo correspondence, we developed an auditory-visual cross-correlator and found that its properties are similar to those observed experimentally.

Acknowledgement: NIH EY014194

H56 970 How audio and visual cues combine to discriminate tempo of swing groove drumming

Scott Love[1] (s.love@psy.gla.ac.uk), James M. Hillis[1], Carl Waadeland[2], Davide Rocchesso[3], Federico Avanzini[4], Sofia Dahl[5], Frank E. Pollick[1]; [1]Department of Psychology, University of Glasgow, [2]Department of music, Norwegian University of Science and Technology, [3]Department of Computer Science, University of Verona, [4]Department of Information Engineering, University of Padova,

Tuesday Posters

[5]Cognitive and Systematic Musicology Lab , School of Music , Ohio State University

When multiple sources of sensory information about a single environmental property are available, more precise estimates of that property can be formed by combining the different sources. To maximize the precision of the combined estimate each cue must be weighted in proportion to its reliability. For physical dimensions such as object size (Ernst & Banks, 2002), surface slant (Knill & Saunders, 2004) and object location (Alais & Burr, 2005), studies show that humans integrate different sensory sources in a statistically optimal fashion. We investigated the integration of auditory and visual cues for a more complex physical property: beat tempo. Stimuli were created from 3D motion capture data (240 Hz) of a drummer performing swing groove drumming at 90BPM. This movement data was converted into visual point light displays with points at the shoulder, elbow, wrist, hand and two drumstick points. The movie sample rate was 60Hz. Sounds were obtained by a simulation of the first 25 modes of a circular membrane. Parameters for the sound model were the physical parameters of the membrane and the time and impact velocity of a strike. There were three main conditions in the experiment: audio-alone, vision-alone and audio-visual combined. For each of these conditions, we measured tempo discrimination performance in a 2IFC task. One of our three observers, discrimination performance improved in the two-cue case as predicted by the statistically optimal cue combination model. However, the other two observers do not show the predicted improvement. These differences in performance may be a result of the practice in audio-visual tempo discrimination. We are currently investigating the effect of expertise and practice on the integration of audio-visual information in this tempo discrimination task.

Acknowledgement: ESRC, British Academy

H57 971 Audio-Visual Synchrony in an Apparent-Motion Discrimination Task

David McCormick[1,2] (david.mccormick@univ-paris5.fr), Pascal Mamassian[1,2]; [1]CNRS, France, [2]Université Paris 5

We present a new method designed to study the effect of audio-visual synchrony on visual contrast sensitivity. We displayed a two-frame apparent-motion stimulus composed of square-wave bar trains. The bars in a given frame spanned 30 arcmin and were separated by 6 degrees of arc. They were shifted by 90 arcmin left or right between frames. The first frame contained a suprathreshold bar train while the second comprised a low contrast bar train. Each set of bars was displayed for 33.3ms with four stimulus onset asynchronies (SOAs) varying between 100 and 300ms. Each trial contained an auditory beep of 33.3ms duration, temporally concomitant with either the first or second set of bars. When the second frame was visible, apparent-motion was seen. Observers were required to indicate the direction of the motion on each trial; data were analysed according to the temporal location of the beep, at each of the low contrast values. The data show a trend toward improved performance when beeps were synchronous with the low contrast frames. The efficacy of this method is that the required response (left/right motion) is on a dimension orthogonal to the point of interest (contrast sensitivity). We are therefore able to reject cueing and attentional based accounts and we discuss the attribution of this effect to a cross-modal integration of the visual and auditory systems.

H58 972 Visual-auditory motor remapping within and between the hemispheres: A state-of-the-art theoretical overview of visuomotor functioning across-domains

Simon M. McCrea, Ph.D.[1] (simonmccrea@yahoo.com); [1]University of British Columbia

In a 1967 symposium Luria proposed that specific cortical and non-specific subcortical cortical systems interacted in the regulation of behaviour according to "geographic principles". The adaptive nature of 'dominating foci' elicited transmission, selection, amplification, and inhibition of the required information from objects and scenes. A less static, more dynamic, and contemporary approach to the study of consciousness has been advocated by Kinsbourne (1996). This "integrated field model" posits that consciousness is embodied in "intermediary representations", not in sensory primitives, nor in those representations pertaining to the highest levels of abstraction. Therefore in an adaptive field comprising scenes and objects subsidiary clusters of entrained representations co-exist across the whole brain through volume oscillation. Distinct representations can fire synchronously or in joint oscillation for potential inclusion into the dominant focus. Through analysis of blindsight and neglect phenomenon preserved gestalt completion of incomplete figures must then occur through the activity of expectancy set or motor attention. Amelioration of neglect through various means of stimulation suggests that a hemifield loss of part of a representation that was initially insufficiently activated can then become integrated into the conscious field and thus that the initial representations were intact. Effective opponent-processing between or within the hemispheres is necessary for equilibrating representations across a plane and therefore to represent an object one must have access to the requisite spatial domain. In order for a representation to activate or conversely inhibit a hemisphere it must be of sufficient magnitude, completeness, precision, and longevity and it must not make incompatible demands on output mechanisms. I will synthesize findings from cases of pure word deafness, atypical localization of language, subcortical processing, fMRI study of localization of vowels and vestibular functions, lesion study of gaze direction and sound localization, and akinetopsia into a synthetic review of audiovisual motor remapping

Acknowledgement: Funded by NIMH grant #R01-MH069898 awarded to Jason J.S. Barton, MD., Ph.D.

URL: http://www.neuroophthalmology.ca/UBCNeuroOp/JBarton/labstaff/McCrea.html

H59 973 'Unimodal' visual cortical neurons are influenced by auditory inputs.

Alex Meredith[1] (mameredi@vcu.edu), Brian Allman[1]; [1]Anatomy and Neurobiology, Virginia Commonwealth University School of Medicine

Visual neurons with multisensory responses have been identified in many cortical areas. These bimodal (or trimodal) neurons are excited by inputs from different sensory modalities and often integrate their responses to multisensory stimuli. However, the behavior of non-bimodal (e.g., 'unimodal') neurons in the presence of multisensory stimulation has largely been overlooked. The present experiments used extracellular recording techniques to systematically examine the activity of all neurons encountered within the posterolateral lateral suprasylvian (PLLS) visual area of the cat in response to visual, auditory and combined visual/auditory cues. A total of 360 neurons were examined, of which 49 bimodal neurons responded both to visual and to auditory stimulation, and integrated those inputs when combined. In contrast, 196 visually-responsive neurons showed no response when presented an auditory stimulus alone. However, 37 of these same apparently 'unimodal' neurons had their responses to visual stimulation significantly facilitated ($P<0.05$, paired t-test) when visual and auditory stimuli were combined. Furthermore, while the overwhelming number (n=159) of visual neurons was not significantly influenced by auditory stimulation, they were, as a population, significantly more active in response to the combined stimuli than to the visual stimulus alone. In fact, when the multisensory response generated by all the neurons was calculated, the overwhelming proportion (69%) of the multisensory signal was carried by the neurons that would otherwise have been considered 'unimodal.' These data show that 'unimodal' visual cortical neurons can be significantly influenced by auditory stimuli at the neuronal as well as the population level, and that the behavior of bimodal neurons cannot adequately represent the multisensory processing capacity of the visual cortex.

Acknowledgement: Supported by NIH-NS39460.

H60 974 Audiovisual Congruence and the Processing of Synchrony in Swing Groove Drumming

Melanie Russell[1] (Melanie@psy.gla.ac.uk), Karin Petrini[1], Phil McAleer[1], Davide Rocchesso[2], Sofia Dahl[3], Carl Haakon Waadeland[4], Federico Avanzini[5], Frank

Pollick[1]; [1]Department of Psychology, University of Glasgow, [2]Department of Computer Science, University of Verona, [3]Cognitive and Systematic Musicology Lab, School of Music , Ohio State University, [4]Department of Music, Norwegian University of Science and Technology, [5]Department of Information Engineering, University of Padova

Single cell data from macaque suggest special processing of the sights and sounds of biological actions (Kohler, Keysers, et al, Science 2002). Recently Arrighi, Alais & Burr (JOV, 2006) have examined this hypothesis using judgments of perceptual synchrony of audio and visual streams of conga drumming as well as with synthetic audio and visual streams. The perception of audiovisual temporal synchrony provides a window on how these two different sensory modalities are integrated. To further investigate the perception of audiovisual synchrony from human movements we first obtained 3D motion capture data (240 Hz) of a drummer performing swing groove drumming with an accent on the first beat at 60, 90 and 120 BPM. This movement data was converted into visual point light displays with points representing the shoulder, elbow, wrist, hand and 2 points on the drumstick and output as 60 Hz quicktime movies. Matching synthetic sounds were obtained by a simulation of the first 25 modes of a circular membrane that took as input the time and impact velocity of a strike and output the resulting audio signal. In one experimental condition the estimated impact velocity was provided to the algorithm and in the other condition the average impact velocity of all strikes was used. This allowed production of one audiovisual stream with a natural covariation of drummer motion and sound present, and another audiovisual stream with this covariation absent. For both the covariation present and absent conditions we presented observers with audiovisual displays of varying levels of positive and negative asynchrony between audio and visual streams and collected forced-choice judgments of synchrony. Our preliminary results indicate that the novel manipulation of eliminating the natural covariation between physical movement and audio signal influences observers' integration of sight and sound.

Acknowledgement: Wellcome Trust, British Academy

H61 975 Patterns of cross-modal plasticity in the visual cortex of early blind human subjects across a variety of tasks and input modalities

Lindsay Lewis[1,2] (lblewis@psy.ucsd.edu), Melissa Saenz[3], Ione Fine[2]; [1]Department of Psychology, University of California, San Diego, [2]Department of Ophthalmology, University of Southern California, [3]Computation and Neural Systems, California Institute of Technology

A number of studies have demonstrated cross-modal responses within visual cortex of blind subjects. However, to date, cross-modal plasticity has not been compared across a variety of tasks and modalities. If cross-modal plasticity is driven by anatomical connectivity, similar activations might be expected for a given modality, regardless of task. If cross-modal plasticity is driven by functional role, similar activations might be expected for a given task (mapped onto normal specializations of visual cortex), regardless of modality.

FMRI responses to a variety of tasks were measured in early blind, sighted, and sight recovery subjects. Auditory tasks included frequency, motion, and letter trigram discrimination. Tactile tasks included orientation, letter trigram, and plastic animal discrimination. In sighted and sight recovery subjects, visual tasks included orientation, letter trigram, and animal picture discrimination, as well as a motion stimulus. Data were collected with a GLM design using a sparse pulse sequence. Sight recovery and tactile data are still being analyzed.

In blind but not in sighted subjects, cross-modal responses were found within MT+ across all auditory tasks. This general response to auditory stimuli within MT+ suggests that in visually deprived subjects an anatomical route between MT+ and auditory areas may exist. However, MT+ responses were stronger for the auditory motion (see also Saenz et al. VSS 2007) and letter task than for the frequency task, with a lateralization asymmetry between the two tasks (motion: right dominance, letters: left dominance), suggesting that functional demands also modulate cross-modal plasticity. In addition to MT+, the auditory letter task also activated left fusiform areas. In sighted subjects, comparable areas within left fusiform and MT+ were activated by the visual letter task. This selective cross-modal response to auditory letters within left fusiform areas is therefore likely to be primarily driven by functional demands.

Acknowledgement: Funding provided by NEI-014645 and RPB.

H62 976 Perceivedtime is dilated by modulation of visual and auditory stimuli

Gijs Plomp[1,2] (gplomp@brain.riken.jp), Sergei Gepshtein[2], Cees van Leeuwen[2]; [1]Lab for Psychophysics, Brain Mind Institute, École Politechnique Féderale de Lausanne, [2]Lab for Perceptual Dynamics, Brain Science Institute, RIKEN

We examined the effect of temporal articulation of sensory events on the perceived duration of visual and auditory stimuli. There were three experiments: visual and auditory within-modality experiments and a visual-auditory experiment. In the visual task participants viewed two sequential stationary stimuli, and in the auditory task they listened to two sequential tones. In both cases the stimuli were suprathreshold. Participants reported which of the two stimuli appeared to last longer. In the vision-only experiment we modulated brightness of one of the two stimuli. In the audition-only experiments we modulated the amplitude of one of the two tones. In the visual-auditory experiment participants discriminated duration of visual stimuli while we played amplitude-modulated tones concurrent with one of the visual stimuli. In all experiments modulations were not informative of stimulus duration. In both visual and auditory experiments duration discrimination followed Weber's law. Brightness modulation monotonically increased perceived duration of visual stimuli: the effect was larger for longer stimuli and it increased with the frequency of modulation. Auditory modulation also increased the perceived duration of tones, but this effect was much smaller than in the visual experiment. In contrast to the strong effect of the frequency of visual modulation on perceived duration of visual stimuli, the frequency of auditory modulation affected duration of neither visual nor auditory stimuli. These results appear to support the view that there exist peripheral, sensory-specific mechanisms serving perception of time (e.g., Johnston, Arnold, & Nishida, 2006) in contrast to a single central mechanism. But we cannot exclude the possibility that the results reflect variable strengths of sensory signals that are fed to the central mechanism.

H63 977 Specificity of Crossmodal Links in Exogenous Covert Orienting

Melissa Batson[1,2] (melbats@bu.edu), Anton Beer[2,3], Takeo Watanabe[1,2]; [1]Program in Neuroscience, Botson University, [2]Vision Sciences Lab, Boston University, [3]Institut für Experimentelle Psychologie, Universität Regensburg

An auditory cue improves perception of subsequent visual stimuli that are spatially aligned with the cue as long as the stimulus onset asynchrony (SOA) is short (<300ms). Plasticity in these crossmodal links has been shown to persist into adulthood and to be independent of focused attention (Batson, Beer & Watanabe, VSS 2006). Although crossmodal links have been shown to remain vulnerable to perceptual manipulations using a task-irrelevant training paradigm on a mature population of subjects, the location of this crossmodal facilitation remains unclear. We tested the effects of crossmodal cuing before and after task-irrelevant training where target shapes at a visual location proximal to the sound source are weighted to valid (same-side) auditory cueing during training sessions. Test targets were oriented Gabor patches that appeared either at the same or proximal locations to the sound source, all equidistant from fixation, at one of three SOAs; 150, 300 or 1000ms. To investigate the location of this plastic facilitation, the same experiment was repeated with monocular training of one eye and testing on the untrained eye. After training in the binocular condition, discrimination of validly cued targets improved at the newly associated location while discrimination at the location of the sound source shows a decrease in performance compared to the pre-test. Changes in validity effect are statistically significant at the shortest SOA, 150ms. Proposed sites of crossmodal integration extend from primary sensory cortices up to extrastriate and association cortices known to respond

Tuesday Posters

to multimodal stimulation. Complete interocular transfer in the monocular condition would suggest that only binocular processes are involved in the observed crossmodal plasticity, while incomplete transfer would imply that monocular processing, such as that of monocular cells in primary visual cortex, is involved. Additional results from tests of object/spatial transfer and retention of these new associations will also be reported.

Acknowledgement: Supported by: NSF BCS-0345746, NIH R01 EY015980

H64 978 Limited cross-modal capacity revealed by selective attention in repetition blindness with sounds

Yi-Chuan Chen[1] (r91227006@ntu.edu.tw), Su-Ling Yeh[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

The perceptual load model in selective attention (Lavie & Tsal, 1994) suggests that selection locus depends on perceptual load. We extend this idea to cross-modal processing and investigate whether vision and audition share the same limited source of attention by using the paradigm of repetition blindness (RB; Kanwisher, 1987) with task-irrelevant sounds. RB is a phenomenon that the observer fails to detect the second occurrence of a repeated item in a rapid serial visual presentation (RSVP). We manipulated perceptual load in the temporal dimension and examined whether the effect of irrelevant sounds on RB varies with perceptual load. The two critical items (C1 and C2) embedded in each RSVP were either accompanied by two sounds with the same pitch or with different pitches, and a no-sound control condition was used as the baseline. The stimulus onset asynchrony and lag between C1 and C2 were manipulated to lead to a high-load or a low-load condition. Results show that the facilitaroty effect of sounds on character identification varies with perceptual load. However, only those who are aware of the difference in sounds are affected by them, and this participant group also performs more accurately for the repeated control condition than the other group. Together, these results suggest that visual-auditory processing share a common limited resource to execute selection.

Acknowledgement: Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020

Face Spaces and Adaptation

Author Presents: 10:30 am - 12:15 pm

H65 979 The Philadelphia Face Perception Battery

Amy Thomas[1] (thomasam@mail.med.upenn.edu), Kathy Lawler[1], Ingrid Olson[2], Geoffrey Aguirre[1]; [1]Department of Neurology, University of Pennsylvania, [2]Department of Psychology, University of Pennsylvania

Several neuropsychological tests that ostensibly assess performance with face stimuli rely upon cognitive abilities not related to facial perception (Duchaine & Weidenfeld, 2003). Although recent efforts have provided better alternatives (Duchaine & Nakayama, 2006), we sought to develop a battery of face perception tests that could be used easily with a clinical (brain damaged) population. Our design goals included minimization of sensitivity to memory loss, and simplification of instructions and requirements for motor response. Additionally, the set of tests would include assessment of several aspects of internal face perception to provide for improved test stability. Four tests were created using computer-generated faces to assess discrimination performance for four face attributes: similarity, attractiveness, gender, and age. Each test presented between 166 and 197 trials and was completed by 62 to 117 subjects ranging between 18 and 81 years of age. The test trials were then narrowed to include the 75 trials for which between-subject agreement (across demographic populations) for each trial was greater than 80% and as a set provided average subject performance of 90%. Performance on the similarity, beauty, and age components was correlated across subjects (adjusted r2=0.45, 0.27, 0.49 respectively). The gender test performance was not correlated with the other subcomponents (adjusted r2=0.01). Performance was not significantly predicted by subject age, gender, race, or handedness. Years of education was positively related to performance on the similarity and age subtests, but not the gender or beauty components. We are now examining the test-retest reliability of scores within subject, and will assess the sensitivity and specificity of the test battery for perceptual deficits in brain damaged patients.

Acknowledgement: Burroughs-Wellcome Trust, NIMH

H66 980 When stability means flexibility! Familiar faces under permanent adaptation

Claus-Christian Carbon[1] (ccc@experimental-psychology.com); [1]Department of Basic Psychological Research, Faculty of Psychology, U Vienna

A central problem of face identification is to form stable representations from entities that vary, both in a rigid and non-rigid manner, over time, under different viewing conditions and with altering appearances (Bruce, 1994). Four experiments investigate the underlying mechanism that is more flexible than has often been supposed. All experiments used highly familiar faces that were first inspected in a configurally or locally manipulated way. When participants had to select the veridical version (known from TV/media/movies) out of a series of gradually altered versions, their selections were biased toward the previously inspected manipulated versions. This adaptation effect (face identity aftereffect; Leopold, Rhodes, Mueller, & Jeffery, 2005) was demonstrated even for a delay of 24 hours between inspection and test phase. Moreover, the inspection of a specific image version of a famous person not only changed the veridicality decision of the same image but transferred to other images of this person as well. Thus, this adaptation effect is apparently not based on simple pictorial grounds but appears to have a rather structural basis. Importantly, the adaptation effect was not based on a simple averaging mechanism but on identity-specific information.

URL: www.experimental-psychology.com

H67 981 Face distortion aftereffect activates motion and face sensitive areas: an fMRI study

Daniel Kaping[1] (dkaping@gwdg.de), Carmen Morawetz[2], Juergen Baudewig[2], Stefan Treue[1], Michael A. Webster[3], Peter Dechent[2]; [1]German Primate Center, Goettingen, Germany, [2]MR-Research in Neurology & Psychiatry, Medical Faculty, Georg-August University Goettingen, Germany, [3]University of Nevada, Reno

After adapting to a face image that has been distorted (e.g. locally contracted), the original face appears distorted in the opposite direction (e.g. expanded) (Webster & MacLin, 1999). Several lines of evidence suggest that this face distortion aftereffect (FDA) includes response changes at a high level of visual processing, but the sites and nature of these changes are not well established. We examined neural activity during the FDA using an fMRI adaptation paradigm. Face images were presented in an even block design with 17x18 sec cycles that alternated between a contracted face (adapting image, 18 sec) followed by a normal face of the same or different identity (test image, 18 sec). Contrasting the switch from the distorted to the normal face (with an FDA) to the switch in the other direction (normal to contracted / without FDA) revealed higher activity in response to distorted faces within the fusiform face area, superior temporal sulcus, and superior temporal gyrus. Surprisingly, significant activation (during the FDA) was also revealed in the motion-sensitive area MT+, suggesting that the FDA may induce a form of "motion aftereffect" even though the adapting and test images were static. This subjective motion could result from the decay of the FDA, during which the perceived distortions in the physically normal face image visibly dissipate over time. Conversely, adapting to the normal face does not bias the appearance of the distorted face and thus does not induce a temporal change. Our results are consistent with the hypothesis that individual faces are encoded as deviations from an average face and of a motion system that is activated by dynamic image distortions even if they are illusory.

Acknowledgement: This study was supported by the SensoPrim EU Marie Curie Early Stage Training Program

H68 982 **The contribution of configuration, facial features and low-level properties to the adaptation of facial expression**

Andrea Butler[1,2] (andebutler@gmail.com), Ipek Oruc[1,2,3], Christopher Fox[1,2,4], Jason Barton[1,2,3]; [1]Department of Ophthalmology and Visual Sciences, University of British Columbia, [2]Division of Neurology, University of British Columbia, [3]Department of Psychology, University of British Columbia, [4]Graduate Program in Neuroscience, University of British Columbia

Adaptation aftereffects to expression in faces have been reported by Webster, Kaping, Mizokami, & Duhamel (2004) and Fox & Barton (2006). Here we investigated which aspects of facial stimuli contribute to these aftereffects. In Experiment 1 we examined the role of low-level image properties such as curvature, shape and orientation, independent of expression, by using hybrid faces constructed from either the same or opposing expressions. While hybrid faces made with consistent expressions generated adaptation effects as large as those generated by normal whole faces, there were no aftereffects from hybrid faces made from conflicting expressions. This suggests that adaptation to low-level properties does not make a significant contribution to expression aftereffects in our paradigm. In Experiment 2 we examined the role of facial features independent of the normal facial configuration, by contrasting adaptation with whole faces to that with scrambled faces. We found that scrambled faces also generated significant aftereffects, indicating that features in the absence of a facial configuration could generate expression adaptation. In Experiment 3 we examined the role of facial configuration, by using stimuli made from line elements (e.g. curved segments and straight lines) that in isolation do not carry expression-related information, but that convey a coherent expression when arranged in the configuration of a face. We obtained a significant aftereffect for facial configurations but not scrambled configurations of these line elements. We conclude that face expression aftereffects are due to adaptation of neural representations of expression involving facial configuration or facial features alone, but are not due to adaptation of low-level image properties.

Acknowledgement: This work was supported by NIH grant 1R01 MH069898 and CIHR grant MOP 77615. CJF was supported by a Michael Smith Foundation for Health Research Junior Graduate Studentship and a CIHR Canada Graduate Scholarship Doctoral Award.

H69 983 **Gender aftereffects in face silhouettes depend on face-specific processes**

Nicolas Davidenko[1] (ndaviden@psych.stanford.edu), Nathaniel Witthoft[2], Jonathan Winawer[2]; [1]Psychology Department, Stanford University, [2]Brain and Cognitive Sciences Department, MIT

We recently reported that gender aftereffects, similar to those observed with front-view face images (e.g., Webster, Kaping, Mizokami, & Duhamel., 2004), also occur with face profile silhouettes (Davidenko, Winawer, & Witthoft, VSS 2006). Here we tested the extent to which these aftereffects are sensitive to differences in image properties between adapting and test faces. Because the silhouettes are defined by a single contour, it is important to determine whether aftereffects result from face-specific adaptation or are just due to general properties of the contours, such as tilt and curvature. In a brief implicit adaptation paradigm, subjects classified 8 male (or 8 female) face silhouettes on non-gender characteristics and then made a gender classification on a 9th, gender-neutral face silhouette. The nine faces were arranged in three rows on a single sheet of paper. Judgments were considered aftereffect-consistent if the 9th face was classified with the gender opposite the gender of the 8 previous faces. Gender aftereffects were undiminished by a reversal of left-right orientation (Study 1) or a reversal of contrast polarity (Study 2) between the 8 adapting silhouettes and the 9th test silhouette. The percent of aftereffect-consistent judgments was 84±12% (Study 1) and 83±8% (Study 2), not significantly different from a previous study with neither transformation (79±7%; means ± 95% CIs). Invariance to these two image transformations suggests that face aftereffects occur at a relatively high level of representation. In Study 3, adapting to upside-down face silhouettes did not lead to significant aftereffects on the test silhouette (58±11% aftereffect-consistent judgments). Although all three manipulations modify the silhouette contours, only vertical inversion, which significantly reduces the face percept (Davidenko, 2007), eliminates aftereffects, suggesting that face-specific processing is necessary to induce face-aftereffects in silhouette profiles. We discuss the implications of these findings with respect to a face-space framework.

H70 984 **Transfer of adaptation after-effects between simple visual forms and faces**

Vaidehi Natu[1] (vnatuwasson@utdallas.edu), Kai-Markus Mueller[2,3], Fang Jiang[1], Alice O'Toole[1]; [1]The University of Texas at Dallas, [2]National Institute of Mental Health, [3]International Max-Planck Research School, Tuebingen, Germany

Adaptation to simple shapes and forms can produce shape-contrast after-effects (Suzuki and Cavanagh, 1998). Adaptation to complex visual stimuli such as faces can likewise produce contrastive figural after-effects (Webster and MacLin, 1999). Here, we examine the transfer of adaptation from simple visual forms to human face stimuli (Exps. 1 and 2) and vice-versa (Exp. 3).

In Experiment 1, observers adapted to a vertical ellipse, a horizontal ellipse, or a perfect circle. Normal faces were judged to be horizontally elongated following adaptation to a vertical ellipse and vertically elongated following adaptation to a horizontal ellipse. Adaptation to the circle did not distort the perception of faces.

In Experiment 2, observers adapted to pairs of convex and concave arcs, e.g., ( ) and) (respectively. We varied the aspect ratio of the arcs pairs, changing the height of the arcs and the width between the arcs, so that they appeared vertically or horizontally elongated. Following adaptation to narrow convex and concave arcs, observers judged faces as wider. An opposite after-effect occurred with widely spaced arcs. When observers adapted to a convex arcs with the average aspect ratio of normal faces the subsequent face perception remained unaltered. Combined, these results are consistent with Experiment 1 and further confirm that adaptation to simple visual forms can alter perception of faces.

In Experiment 3, observers adapted to faces that varied in their aspect ratio and were tested with circles. We found little evidence that face adaptation can alter the perception of the circle.

The present study suggests an asymmetric relationship in the transfer of adaptation aftereffects between high and low level visual stimuli. These findings are partially consistent with O'Leary and McMahon (1991) and lay a foundation for using adaptation to explore the organization of neural codes at different levels of visual abstraction.

H71 985 **Saving face: Extracting summary statistics from a set of faces**

Jason Haberman[1,2] (jmhaberman@ucdavis.edu), David Whitney[1,2]; [1]Center for Mind and Brain, [2]Department of Psychology, UC Davis

Our effortless interaction with our visual world leaves us with the impression that we have an accurate and complete representation of all that we see. However, examination of the textures in our environment reveals that this is not reality: often we perceive a bed of roses or a crowd of faces, not the individual rose or singular face. This loss of information is by design, as it is more efficient to represent summary statistics about crowds of items than it is to code each individual item. Here, we report that statistical representation occurs at both low and high levels of visual processing. We found that observers precisely extracted the 'mean emotion' of a set of faces, even when it was impossible to code every member of the set. Specifically, participants were more likely to identify a test face as a member of the previously displayed set as it approached the mean emotion of the set. Despite this implicit knowledge of the mean, participants were unable to correctly identify which of two test faces was a member of the previously presented set, suggesting they lacked individual item representation. When explicitly asked to indicate whether a test face was happier or sadder than the mean of the set, observers were remarkably precise. Statistical set representation was quite stable, as it occurred regardless of set size or duration, up to 16 items displayed for as little as 500 ms. When observers viewed sets of inverted faces and fractured faces, patterns of performance paralleled that of upright faces, but overall thresholds were significantly higher. Thus, while statistical representation of inverted and fractured faces is possible, the strategy employed is distinct from and less efficient than that used for upright faces. The results demonstrate that statistical extraction occurs at multiple stages of visual processing.

Acknowledgement: Faraz Farzin, David Horton

H72 986 Abstract withdrawn

H73 987 On Creating Facial Similarity Spaces

Alex Holub[1] (holub@caltech.edu), Yun-hsueh Liu[1], Pietro Perona[1]; [1]Computation and Neural Systems, California Institute of Technology

Humans naturally perceive the similarity between different objects. Humans are especially sensitive to facial similarity and it has been suggested that individuals seek partners with similar facial attributes. The goal of this work is to place facial similarity on a solid computational footing by developing algorithms which map measured facial features to metric spaces that conform to human notions of facial similarity.

While there is a vast literature devoted to facial recognition, judging facial similarity is a more subtle and difficult topic and presents numerous challenges. One challenge is obtaining a large number of reliable facial similarity judgments with which to learn an appropriate metric space for faces. We compare the efficiency of several different similarity rating techniques using both information theoretical analysis and synthetic simulations based on subject data. Using these analyses we are able to identify the most promising rating method. Another challenge is developing objective approaches for measuring facial similarity, and acquiring data-sets which can supplement similarity information obtained from human ratings. For this purpose, we utilize a variety of data-sets, including facial morphs and sets of images of the same person under different poses and lighting conditions. Finally, we outline a computational framework which automatically maps measurements on faces into a new space which conforms to notions of facial similarity. Our system exhibits a surprising ability to generalize similarity information learned from different data-sets and the perceptual maps show significant improvement over baseline techniques in predicting human similarity judgments.

H74 988 fMRI and behavioral evidence against a "norm-based" face representation

Xiong Jiang[1] (xj9@georgetown.edu), Volker Blanz[2], Maximilian Riesenhuber[1]; [1]Department of Neuroscience, Georgetown University Medical Center, [2]University of Siegen, Germany

We recently proposed a shape-based computational model of face discrimination in the FFA, in which a particular face is represented by a sparse population code over highly selective face neurons tuned to different face shapes. This model has been quantitatively supported by data from both behavioral and fMRI adaptation experiments (Jiang et al., 2006). In contrast, recent human fMRI (Loffler et al., 2005) and monkey electrophysiology studies (Leopold et al., 2006) have suggested an alternative conceptual "norm-based" model, in which face perception is mediated by neurons that are tuned around an "average" face. However, by design such studies involve the repeated presentation of stimuli similar to the "average" face, which could lead to the selective adaptation of neurons selective for the "average" face, creating the impression of a neuronal population that responds little to the "average" face and increasingly more to faces different from the "average". To directly test this hypothesis, we created four different faces spaces, centered either around an average face (as in Leopold et al., 2006), or around a specific individual face (i.e., belonging to a particular individual instead of the "average"), for both genders. This design equalized adaptation effects in both cases, allowing us to test if the "average" face had a special status, as predicted by the "norm-based" theories. For all four face spaces, we then tested discrimination performance with a 2AFC behavioral paradigm (n=10), and the selectivity of FFA neurons with a short-block fMRI adaptation paradigm (n=5). The data from both experiments revealed a significant effect of face shape difference ("morph steps", M2/4/6/8/10 for behavioral, M0/3/6/9 for fMRI testing), but no significant difference between the "average" and the "individual" face spaces, and no interaction, suggesting that prior reports of a "norm-based" face representation might have been confounded by adaptation effects.

Acknowledgement: This study is supported by NIMH grant R01 MH076281

H75 989 Navigating the boundary of face space: What kind of stimulus is a face?

Jessica Taubert[1] (jess@galliform.bhs.mq.edu.au), Darren Burke[1], Simone Favelle[2], Elinor McKone[3]; [1]Macquarie Univeristy, [2]University of Wollongong, [3]Australian National University

The processing that underlies the subordinate level recognition of faces is a point of great debate in cognitive neuroscience. However, arguments derived from investigations attempting to discriminate between processing strategies assume a controversial premise, because it is not known what categories of stimuli are face-like. One theoretical model used to explain face recognition is the heuristic concept of "face space". Face space presumes that identity judgements are based on the distance between an exemplar and the average of all faces experienced. The 'average' face sits in the centre of an array of dimensions that span out in an infinite number of directions towards a boundary that has seldom been tested. In a series of three experiments the faces of nonhumans were used as stimuli to probe the limits of face space, using both the inversion and composite effect as behavioural indices of configural/holistic processing. Since the initial data suggested that primate, but not avian faces were being processed configurally, we tested the idea that the boundary of face space might fall between different face categories, classed by species. The final experiment examined more precisely where evidence of face-like processing disappeared along a continuum of face categories that were chosen as a function of relative phylogenetic distance, to represent departures from typical human face morphology.

H76 990 Human Face Matching Performance is Robust to Task-Irrelevant Image Changes

Danelle Wilbraham[1] (wilbraham.1@osu.edu), Aleix Martinez[2], James Christensen[1], James Todd[1]; [1]Department of Psychology, Ohio State University, [2]Department of Electrical and Computer Engineering, Ohio State University

A popular conception of face representation is that faces are represented in a multidimensional face space with the "mean face" at the origin [Valentine, Q. J. Exp. Psych. 43(2), 1991]. Several studies have hypothesized that appearance-based features may account for many of the dimensions of this face space. We examined the relationship between appearance-based dimensions and judgments made by human observers in two experiments. In the first experiment, a match-to-sample paradigm was used where observers saw a sample face followed by two alternative faces which varied from the sample in expression or illumination. Observers indicated which of the alternatives shared the same identity as the sample. The second experiment employed a sequential matching paradigm in which the standard face was partially occluded by a checkerboard grid of small black squares. The comparison face was occluded by the same checkerboard as the standard, a reversed checkerboard, a checkerboard shifted in phase by 90 degrees, or no checkerboard. Observers indicated if the two faces were of the same or different identities. Presentations in both experiments were masked by a full screen pattern.

Several computational appearance-based algorithms were investigated. Both the pixel intensities and the outputs of Gabor filters were used as input. Euclidean distances were calculated between the inputs for the pairs of images in the experiment. In addition, both intensities and Gabor filter outputs were subjected to several variations of Principle Components Analysis. The results revealed that though these techniques produced reasonably accurate performance in many of the conditions tested, the correspondence between the appearance-based algorithms and the observers was poor. This was especially true in the checkerboard experiment, and remained true even after a filling-in algorithm was applied to remove the occlusions. These results demonstrate that appearance-based dimensions alone cannot adequately parameterize the face space used by human observers.

Acknowledgement: Supported in part by a grant from NIH.

H77 991 Perceived Facial Attractiveness as a Function of Age and Clinical Vision Diagnosis

James Nolan[1] (james.nolan@envisionus.com), Mark Sai Leong Chan[2]; [1]Envision, [2]University of Kansas

It is believed that attraction does not change throughout a lifetime as attractiveness is closely linked to the average or prototypical face (Langlois & Roggman, 1990; Chan, Schnackenberg, Bement & Nolan, 2005). The purpose of this project is to follow up on previous research conducted on facial attractiveness and age by testing the effects of the age of stimuli on the perception of attractiveness and also to address whether or not a clinical vision diagnosis (such as AMD- Age Related Macular Degeneration) has an impact on ones perceived level of reported facial attractiveness. Research by Zebrowitz, et al (1993) has shown that raters from a single age group are able to rate faces from different age groups similarly based on attractiveness. This is known as Differential Stability, which is defined as "consistency of individual differences within a sample of individuals over time" (Caspi & Bem, 1990). But this does not fully support the prototypical or averaged face as described by Langlois & Roggman (1990), as an averaged face was not included in the 1993 study conducted by Zebrowitz et al. It is further understood that averageness is a factor that has a role in facial attractiveness. We tested individuals from 6 age groups with standard vision (n=60) including children, adolescents, young adults, middle adults, late adults, and senior adulthood. We further tested individuals who had clinically diagnosed conditions (such as AMD, Diabetic Retinopathy, and Cortical Vision Loss) with the same testing procedure. Subjects were asked to rate both individual and morphed composite exemplar faces for level of attractiveness via a likert-type scale. Our results further support the averageness hypothesis of Langlois & Roggman (1990). Our results indicate a possible qualitative difference between perceived level of attractiveness regarding averaged and non-averaged faces, regardless of age and diagnosed visual condition.

Multiple Object Tracking

Author Presents: 8:30 - 10:15 am

H78 992 The Tracking Trade-off: Sacrificing Time for Smooth Movements of Attention

Hinze Hogendoorn[1] (j.h.a.hogendoorn@fss.uu.nl), Thomas A. Carlson[1,2], Frans A.J. Verstraten[1]; [1]Helmholtz Institute, Experimental Psychology Division, Universiteit Utrecht, Utrecht, The Netherlands, [2]Vision Sciences Laboratory, Harvard University

The temporal characteristics of attentive tracking were studied in two experiments in order to evaluate two models of selective attention. Episodic models of spatial attention state that attention can be resolved into discrete attentional episodes, whereas continuous models state that attention moves continuously and smoothly across visual space. We use an apparent motion stimulus consisting of an array of 10 running analog clocks, which are sequentially cued such that observers can track the cue with their attention. In an adaptation of the method used by Carlson, Hogendoorn & Verstraten (JOV, in press), observers report the earliest and latest time they can read off the tracked clock, allowing us to directly measure attentional dwell time and shift time during attentive tracking. Contrary to what might be expected from episodic models of spatial attention (e.g. Weichselgartner & Sperling, 1995), we show that the time required to shift attention is inversely related to tracking rate. This is remarkable because it means that more time is lost shifting attention at lower tracking rates than at higher tracking rates: in other words, tracking slowly is less efficient than tracking quickly. In a follow-up experiment, we manipulate the duty cycle of the tracking cue and find that during tracking, attentional dwell time is unaffected by the veridical duration of the tracking cue. Instead, the temporal dynamics remain dependent on the tracking rate, as would be predicted by a continuous model of attention. Together, our results indicate that the attentional system sacrifices temporal resolution to accommodate a smooth percept during attentive tracking, thus supporting a continuous model of attention.

H79 993 How to kill a fly: on the difficulties of tracking a smooth and sometimes saccadic moving target.

Alejandro Lleras[1,2] (alleras@uiuc.edu), Michael Ambinder[1,2]; [1]Psychology Department, [2]Beckman Institute, University of Illinois at Urbana-Champaign

Myriad studies have investigated the ability of human observers to track smooth moving objects under both free-viewing and fixation-controlled conditions and shown that observers are generally good at this task. However, no research to our knowledge has investigated humans' ability to track smoothly moving targets that can sometimes abruptly shift direction and speed, such as flies do in a natural environment. Unlike the multiple-object tracking task where observers can typically track four smooth-moving targets, in our daily life we usually experience great difficulty in tracking the motion of a single fly. Indeed, we often experience the fly "flying out" of awareness. In the current set of experiments, we investigated observers' ability to track a simulated fly in a computer display. A single pixel moved around the display, randomly alternating between slow-and-smooth ("continuous") and fast-and-jerky ("jump") motions, simulating abrupt changes in speed and direction normally observed in a fly's flight. The observers' task was to detect brief luminance increments in the "fly" that occurred four times during each 20-second trial. In Experiment 1, participants observed the fly under free-viewing conditions. Detection of flashes during continuous motion was significantly greater than detection during jump motions, which might be expected due to saccadic suppression. Interestingly, this difference was substantially increased when participants were asked to maintain fixation (i.e., not move their eyes), even though one might have expected the sudden onset of the luminance increment in the jump condition to capture attention. We take this decrement during jump motions to reflect more than just a reduction in stimulus visibility; in fact, we believe it stems from the actual phenomenal disappearance of the fly during this type of motion, which would be consistent with reports from post-experimental interviews. Is this a form of saccadic camouflage? Current experiments are aimed at further testing this phenomenon.

H80 994 Attending to Moving vs. Static Stimuli: A Surprising Dissociation in Multiple Object Tracking

Jonathan Flombaum[1] (jonathan.flombaum@yale.edu), Brian Scholl[1]; [1]Department of Psychology, Yale University

Most experimental paradigms used to study attention require brief unitary shifts to single objects or locations, whereas everyday experience requires sustained attention to multiple dynamic objects and events. Such dynamic attention has often been studied using multiple object tracking (MOT): observers track several featurally identical targets that move haphazardly and unpredictably among identical moving distractors. But how and where is attention allocated during MOT? Here we present a deeply counterintuitive answer to this question: though targets are prioritized over distractors, as expected, attention prioritizes static stimuli over moving stimuli -- including moving targets. In addition to tracking, observers had to detect small probes that appeared sporadically on targets, distractors, or various regions of empty space. There were no visual differences between these conditions, since all objects were patches of random visual noise moving on a background of random visual noise -- such that the objects were invisible on any given static frame. We used probe detection as a measure of attention, and consistently observed several surprising effects. First, probe detection in static empty space was always better than on moving targets. Second, probe detection was worse for moving targets compared to targets that were momentarily stopped. Third, the attentional deficit for moving objects relative to the background disappeared when the entire noise-defined background was itself constantly translating. We will describe and demonstrate these and several other results which all fuel the same conclusion: attention treats dynamic and static information differently, and there appears to be a severe cost involved in attending to dynamic information. This could reflect the depletion of attentional resources on moving objects due to motion processing itself. These results are also consistent with the idea that moving objects are represented on a visual map -- the 'motion map' -- that is independent of global salience maps.

URL: http://www.yale.edu/perception/

H81 995 Multi-object Tracking in a Realistic 3D Environment

Gregory Zelinsky[1] (Gregory.Zelinsky@sunysb.edu), Mark Neider[2], Andrei Todor[1]; [1]Stony Brook University, [2]Beckman Institute, University of Illinois at Urbana-Champaign

Multi-object tracking (MOT) has traditionally been studied using simple patterns moving in two dimensions. We explored MOT using more realistic objects moving in three dimensions. Our stimuli were 9 sharks in a rendered 3D underwater scene. The sharks started each trial arranged in a ring, with 1-4 marked for tracking. All of the sharks then swam throughout the scene for 20 seconds, after which one of the sharks was probed. The task was to indicate whether the probed shark was one of the marked sharks. We manipulated whether the probed shark intersected another shark during its movement, and whether it appeared near or far in depth at the time of probe onset. Consistent with the 2D MOT literature, accuracy declined non-linearly with the number of objects to track. Tracking was near perfect (>95%) with 1-2 sharks, still good with 3 sharks (87%), and quite poor with 4 sharks (62%). Tracking was relatively unaffected by intersecting trajectories or depth of the probed shark on the final frame. Fixation analyses revealed that the proportion of gaze and the maximum dwell time on any one shark decreased as the number of tracked sharks increased. This suggests that observers tended to look back-and-forth between sharks in the track-two condition, but not when tracking more objects, and that gaze was not being held on any one shark when multiple sharks were being tracked. Instead, observers appear to have adopted a centroid tracking strategy, choosing to fixate an average location from which to peripherally track multiple sharks. We conclude that tracking benefits from the periodic fixation of objects, which may serve to maintain track on an object during moments of potential confusion. As the number of tracked objects increase and observers shift to a centroid tracking mode, such "foveal rescues" become infrequent and tracking performance suffers.

Acknowledgement: This work was supported by a grant from the National Science Foundation (IIS-0527585)

H82 996 Multiple object tracking disrupts feature binding in visual working memory

Daryl Fougnie[1,2] (d.fougnie@vanderbilt.edu), René Marois[1,2]; [1]Vanderbilt Vision Research Center,, [2]Center for Integrative and Cognitive Neuroscience, [3]Department of Psychology, Vanderbilt University

One important aspect of visual perception is the ability to bind together different visual features into a coherent object percept. We are also able to maintain a limited number of such bound objects in visual working memory (VWM). While it is widely believed that attention plays a necessary role in perceptual feature binding, it is unclear whether attention also plays a role in maintaining bindings in VWM. Contrary to the view that attention is necessary for VWM binding (Wheeler & Treisman, 2002), studies that have combined VWM and attention in a dual-task procedure have failed to show that engaging attention disrupts binding (Allen, Baddeley, & Hitch, 2006; Yeh, Yang, & Chiu, 2005). However, previous work may not have used sufficiently demanding visual attention tasks. To further test the attentional requirements of VWM binding, we gave participants a 6 second long attentive tracking (multiple object tracking, MOT) task during a VWM retention interval. The effect of the MOT task on VWM performance was assessed in different blocks of trials that required either color, shape, color or shape (Unbound), or color and shape (Bound) VWM. The results revealed that MOT severely disrupted binding in VWM: Dual-task costs in VWM performance were significantly larger in the Bound condition than in all the other conditions, including the Unbound condition. A second experiment indicated that the disruptive effect of the MOT task originated from the attentional demands of tracking: When participants performed a secondary task similar to the MOT task except that the items remained static, Bound VWM was not significantly impaired. These results suggest that attention plays a role in maintaining binding in VWM.

H83 997 The attentional tracking system in each hemifield cannot move toward the other hemifield

Boyoung Won[1] (boyoung.won@yonsei.ac.kr), Min-Shik Kim[1]; [1]Department of Psychology, Yonsei University

Alvarez and Cavanagh (2005) have reported that there are independent attentional resources for multiple object tracking (MOT) in two hemifields. Twice as many targets could be successfully tracked when they were distributed between hemifields as when they were all presented within a single hemifield. We investigated whether the attentional tracking system for one hemifield could track the targets that were presented initially in that hemifield, but later moved to the other hemifield. In our experiments, the participants tracked four objects among eight objects. The four targets were divided equally between the left and right hemifields. In one condition, targets moved only within each hemifield in which they were initially presented (Bilateral-to-Bilateral condition). In the other condition, two targets in one hemifield moved toward the other hemifield, while the other two targets remained moving in the initial hemifield, resulting in four moving targets within a hemifield (Bilateral-to-Unilateral condition). Our main interest was comparison between these two conditions, measuring the accuracy of MOT. The results showed that performance in the Bilateral-to-Bilateral condition was better than that in the Bilateral-to-Unilateral condition. In other words, when the initial targets presented in one hemifield moved across to the other hemifield, the attentional resource in each hemifield did not move cross the other hemifield along with the moving targets. This finding suggests that attentional tracking system could be object-based only within each hemifield.

Acknowledgement: This research was supported by a grant (M103KV010017-06K2201-01710) from Brain Research Center of the 21st Century Frontier Research Program funded by the Ministry of Science and Technology, the Republic of Korea.

H84 998 Effects of Task Difficulty on Multiple Object Tracking Performance

Katherine Bettencourt[1] (kcrum@bu.edu), David C. Somers[1,2]; [1]Boston University, Department of Psychology, [2]Boston University, Program in Neuroscience

Multiple object tracking (MOT) experiments have suggested that the capacity limit for attention is approximately four objects (Pylyshyn and Storm, 1988; Yantis, 1992; Cowan 2001; Scholl and Xu, 2001). However, accuracy in these paradigms has ranged from 65% to over 90% for four objects. This variation may be due to differences in the MOT paradigms used, which may have affected the difficulty of the task.

Subjects performed a basic MOT task, tracking five out of ten balls. Subject performance was analyzed as speed, size, or total number of objects was varied. This allowed us to explore the manner in which each affected task difficulty and the concurrent effect that had on the capacity limit of attention.

As both the speed of the balls and the number of distractors increased, performance decreased. Performance as ball size varied showed an inverted U shape, with peak performance at a ball size of 1.5°. Performance for both smaller (0.5° or less) and larger balls (2.75°), was significantly worse.

These results demonstrate that increasing the task difficult, by either increasing the speed of the objects, number of distractors, or by using smaller or larger objects, will have a significant effect on an individual's performance on the MOT task. These data support the view that capacity limit for the number of attended objects is not simply a fixed number, but instead varies with the attentional demands of the objects.

Acknowledgement: National Science Foundation BCS-0236737

H85 999 Multiple Object Tracking in the Periphery Does Not Show Hemifield Independence

Justin Ericson[1] (justin.ericson@vanderbilt.edu), Jeff Nyquist[1], Joe Lappin[1], Adriane E. Seiffert[1]; [1]Department of Psychology, Vanderbilt University

Attention can be divided amongst several spatial locations, allowing people to track several objects moving independently. Alvarez and Cavanagh (2005) have shown that participants were able to track twice as many targets when they were presented in the left and right hemifields as when they were all presented within the same hemifield. This result suggests that there is hemifield independence in attentional tracking. Our experiment was designed to test this hypothesis by examining attentional tracking in the far periphery to determine if hemifield independence holds when attentional foci are farther apart. Observers maintained fixation in the center of the screen while viewing two square display boxes (11.3° visual angle to a side) in one of two configurations. Boxes were aligned either vertically (unilaterally in either the left or right hemifield), or horizontally (bilaterally to the left and right of fixation) close to fixation with 1.25° to the nearest edge. A third condition extended the horizontal configuration into the far periphery (20.1° to the nearest edge) with larger display boxes (17.7° to a side). Each display box contained 4 dots (dot diameter: 0.64° for the close condition and 1.27° for the far condition) moving randomly at approximately 15° per second such that no two dots overlapped. Participants attentionally tracked either 2 target dots in a single box or 4 target dots (2 in each box) for 5 seconds. Replicating Alvarez and Cavanagh (2005), participants were able to track twice as many targets when presented bilaterally close to fixation than when targets were displayed unilaterally. However, participants could not track twice as many targets when displays were presented bilaterally farther in the periphery. This suggests that attentional resources used in tracking are not completely hemifield independent, and attentional tracking becomes more taxing farther in the periphery.

Acknowledgement: NIH EY014984
URL: http://www.psy.vanderbilt.edu/faculty/seiffert/

H86 1000 Size differences improve tracking in MOT, but only when the size of targets/nontargets changes as a group

Harry Haladjian[1,2] (haladjian@ruccs.rutgers.edu), Zenon Pylyshyn[1]; [1]Rutgers Center for Cognitive Science, New Brunswick, NJ, [2]Department of Psychology, Rutgers University, New Brunswick, NJ

In a previous report (VSS 2002), we found no differences in tracking performance on MOT between “asynchronous” conditions (where objects changed colors smoothly and at the same time so that no two objects were ever the same color) and “synchronous” conditions (where objects changed colors in the same way but in synchrony so that objects were always the same color) – see also Klieger et al. (VSS 2004). However, a different result might be obtained if the object property were more “spatial”, or if it segregated targets and nontargets as a group. In this study, we manipulated object size in a way that produced a perception of looming and receding. Subjects tracked four independently-moving target circles among four identical distractors for 5 or 10 seconds in four conditions where objects changed size (1) synchronously, or (2) asynchronously. In addition, we added two “segregated” conditions where targets expanded or shrank smoothly to a fixed size: (3) 138% of the nontarget size, or (4) 62% of the nontarget size. In conditions (3) and (4) targets and nontargets could easily be distinguished during the midpart of the trial by their different size (but not at the beginning or end when they were the same size). Since conditions (3) and (4) constituted only 16.5% of the trials presented at random, we reasoned that subjects might not notice the correlation of object size with targethood. As with the earlier color study, tracking performance in both synchronous and asynchronous conditions was the same for 5-second trials (84% correct) and 10-second trials (77% correct). However, segregating targets and nontargets by size yielded consistently better tracking (93% correct), which was the same for both 5-second and 10-second trial durations. This suggests that spatially-perceived properties may be used in tracking to help discriminate between targets and nontargets.

H87 1001 Reference frames for covert spatial attention during smooth pursuit tracking of visual targets

Robert Niebergall[1,2] (robert.niebergall@mail.mcgill.ca), Julio C. Martinez-Trujillo[2]; [1]Cognitive Neuroscience Laboratory, German Primate Center, Goettingen, Germany, [2]Cognitive Neurophysiology Laboratory, Department of Physiology, Faculty of Medicine, McGill University

Previous studies have demonstrated that attention favors the processing of visual information at attended locations. However, it remains unclear the reference frame in which spatial attention operates. For example it is possible that attention selects object locations in an eye-centered frame of reference. This implies that when the eyes move (e.g., during smooth pursuit eye movements) targets that remain fixed in retinal coordinates will be better attended than other targets that move relative to the retina. On the other hand, it is also possible that in the same situation, we better attend to targets that remain fixed in space-coordinates, even if those targets are moving relative to the retina. To investigate this issue we tested human subjects' performance during an orientation discrimination task in which they pursued a fixation target and covertly attended to a target Sine-Wave grating that, a) remained fixed in eye-centered coordinates but moved in space-centered coordinates (eye-centered condition), and b) vice versa (space-centered condition). The horizontal, vertical and torsional eye movement components were measured during the task trials. Previous to the trials we obtained a measurement of the Listing's plane for each subject. We found that all subjects were able to accurately pursue the fixation target with eye movements following 3D trajectories that fitted their Listing's planes in both conditions. However, there was a bias toward larger deviations from the Listing's plane when targets remained fixed in space coordinates. Orientation discrimination thresholds in all subjects (n=3) were at least 2 times larger in the space-centered relative to the eye-centered condition. These results suggest that (i) covert attention tracks visual targets more efficiently in an eye-centered relative to a space-centered frame of reference and (ii) there may be a violation of Listing's law during attentional pursuit tracking of targets in space centered coordinates.

H88 1002 Consistency of Eye Movements during Multiple Object Tracking

Arash Fazl[1] (arash@cns.bu.edu), Ennio Mingolla[1]; [1]Department of Cognitive and Neural Systems, Boston University

While tracking multiple objects, observers often move their eyes. This experiment studies the consistency of eye movements (EM) while subjects performed a classic MOT task, both when the targets were featurally different from the distractors and when they were not. Observers tracked red target balls among blue distractor balls during an initial "marked" interval of each trial, after which all target balls turned blue. Observers had to track the target balls during this final "unmarked" interval as well and report the original targets. The number of targets varied randomly between three and five in different trials and they moved among a maximum of seven distractors. In order to compare EM consistency between marked and unmarked intervals, we designed pairs of trials to have the same target and distractor trajectories for some of their duration. In the "salient" trials, this "common" trajectory occurred during the marked interval when all targets were red, whereas in its "non-salient" pair it happened in the unmarked interval when both sets of targets and distractors were blue. Different pairs of trials were randomly interleaved in each block. Eye movements were recorded at 500 Hz with an EyeLink II eye-tracker. Subject could track all targets in most of the trials which had three or four targets. For both trial types, each subject tracked the targets through a series of saccades, smooth pursuits and fixations. Each subject showed a unique EM signature. Within subject comparisons showed that EMs were highly consistent during the common trajectories across pairs of trials. Lasting deviations of EM trajectories on non-salient trials from trajectories on corresponding salient trials were associated with the subject's losing track of one or more targets. This finding can be a useful tool for studying attention mechanisms in MOT tasks.

Acknowledgement: AFOSR, NSF, ONR

Poster Session I

Tuesday, May 15, 2:00 - 6:30 pm, Municipal Auditorium

Grouping and Segmentation II

Author Presents: 2:00 - 3:45 pm

I1 1003 **Gradient cut alignment: A cue to ground in figure-ground and depth perception**

Tandra Ghose[1] (tandra@berkeley.edu), Stephen Palmer[2]; [1]Vision Science Program, University of California, Berkeley, [2]Department of Psychology, University of California, Berkeley

In a previous study of figure-ground effects due to the presence of shading gradients at extremal edges (Palmer & Ghose, VSS 2006), we found that when edges were parallel to the equiluminance contours of the shading gradient (i.e., at extremal edges), perception was very powerfully biased toward seeing the gradient-side as closer and figural. We also found that when the edges were misaligned with the gradients, perception seemed to be biased toward seeing the gradient-side as farther and ground. The goal of the present research was to systematically study this cue to ground arising from gradient cuts: edges that are not parallel to the equiluminance contours of a shading gradient. We varied the nature of the shared edge between bipartite displays, one side of which contained a simple sine-wave-like shading gradient (typically seen as a series of cylinders lying side-by-side) and the other side of which was a homogeneous gray (seen as a solid flat surface). Although the angle of a straight edge relative to the equiluminance contours of the gradient had surprisingly little effect, more complex edge shapes containing turning points (e.g., triangular and sinusoidal edges) produced large and systematic figural/depth effects that depended on the alignment between the turning points and the shading gradient. In particular, the gradient side was perceived as closer when deep concavities in the gradient side of the edge were aligned with luminance minima in the gradient, but the flat side was perceived as closer when they were aligned with luminance maxima. Further experiments with asymmetrical triangular-wave edges demonstrated that alignment with luminance minima is crucial: Y-junctions with the luminance minima bias perception toward the gradient side being seen as figural, and arrow-junctions bias perception toward the gradient side being seen as ground, with T-junctions having an intermediate effect.

URL: http://socrates.berkeley.edu/~plab/projects.htm

I2 1004 **The Mechanism for Contextual Influences on the Configural Cue of Convexity**

Elizabeth Salvagio[1] (bsalvag@email.arizona.edu), Jee Hyun Kim[1], Mary Peterson[1]; [1]University of Arizona

Convex regions are more likely to appear as shapes (figures) than adjacent concave regions. Using displays with alternating black/white convex/concave regions, Peterson and Kim (2002, VSS) reported that (local) convexity exerts only a small influence in two-region displays (58%), but an increasingly larger influence as region number increases (85% in eight-region displays). Here we investigate the mechanism for these context effects. Experiment 1 tested whether repetition of convex regions was sufficient using displays where like regions (convex or concave) were no more similar in color than unlike regions. No context effects were observed. Experiments 2 and 3 investigated whether uniform fill (e.g., color) was necessary in convex, concave, or in both regions. Context effects were obtained with uniform concave regions (and multicolored convex regions) but not with uniform convex regions (and multicolored concave regions). We interpret these results within a competitive model of figure-ground in which (local) convexities inhibit adjacent concave regions, and inhibition is summed across non-adjacent regions filled with the same feature. This model requires inhibition of one region by a figural cue favoring the adjacent region. Experiment 4 tested whether this requirement was satisfied using displays in which multicolored straight-edged regions alternated with identical uniformly colored regions. These displays lacking figural cues revealed no context effects. Thus, context effects are obtained only when one of the alternating regions is positively cued as figure and alternating un-cued regions are filled with the same feature (e.g., color). In Experiment 5, we obtained context effects with displays in which alternating white convex/concave regions were delimited by black borders, indicating that the color of positively cued regions need not differ from that of inhibited regions. These results suggest that long-range interactions occur between inhibited regions that are uniform in color and span intermediate regions regardless of their color.

Acknowledgement: NSF 0425650 to MAP and Graduate College Fellowship and Arizona Scholars Fellowship to ES

I3 1005 **Studying the neural mechanisms of visual context integration in border ownership assignment**

Nan Zhang[1,2] (nanzhang@jhmi.edu), Rudiger von der Heydt[1,2], Fangtu Qiu[2]; [1]Department of Neuroscience, Johns Hopkins School of Medicine, [2]The Zanvyl Krieger Mind and Brain Institute, Johns Hopkins University

Neural signals in area V2 carry information about the assignment of edges to figures (border ownership) indicating mechanisms that integrate image context information far beyond the classical receptive fields (CRF). To elucidate the spatial integration structure of these mechanisms we devised a nonlinear reverse correlation method. As in previous studies of border ownership coding (Zhou et al., J Neurosci 20:6594, 2000), one edge of a rectangular figure was placed in the receptive field under study, and the border ownership signal was defined as the difference between the responses to a given local edge when this edge was part of a figure on one side of the receptive field or the other. We then presented the same displays with additively superimposed dynamic binary noise (e.g., 16 by 15 pixels, figure occupying 5 by 5) and computed the spike-triggered sum (STS) of the noise for either location of figure. We expected that each noise pixel would enhance or reduce the visibility of the figure according on its location and contrast. Because border ownership modulation consists in an enhancement of responses for one figure location, or a reduction for the opposite location, we expected that the difference between the STSs for the two figure locations would reveal the features of the figure-ground display that contribute to border ownership modulation. The CRF would cancel in the difference. We estimated the responses of hypothetical filters from the differential STS for each neuron. In a few cells we found significant filter responses, revealing critical features of the figure, such as corners or edges outside the CRF, as well as combinations of features. As yet, we did not find a positive correlation between the filter responses and the border ownership modulation index of the cells.

Acknowledgement: NIH grant RO1 EY02966

I4 1006 A deficit in horizontal interactions causes an imbalance between feedforward and recurrent visual processing, resulting in texture segregation deficits

Myriam Vandenbroucke[1,2] (m.w.g.vandenbroucke@uva.nl), H.Steven Scholte[1], Herman van Engeland[2], Chantal Kemner[2], Victor Lamme[1]; [1]University of Amsterdam (Department of Psychology), [2]University Medical Center Utrecht (Department of Child and Adolescent Psychiatry)

Although there is considerable evidence for the role of feedforward, horizontal, and recurrent interactions in figure-ground segregation, little is known about how this process would be affected by a selective deficit in one of these interactions. We conjectured that an early deficit in horizontal interactions would disturb the balance between feedforward and recurrent activity. Such an imbalance was expected in Autism Spectrum Disorder (ASD), considering their aberrancies in visual perception. Accordingly, while recording EEG we tested healthy subjects and subjects with ASD on a new texture discrimination task, where surface segregation was varied independently from orientation boundaries. The data confirmed the already established role of recurrent processing in figure-ground segregation, as the feedback related activity decreased with decreasing perceptibility of the surface layout. Second, we found that subjects with ASD had lower performance scores compared to healthy controls on stimuli for which the detection of texture discontinuities was important. However, performance was similar for stimuli in which an extra surface layout was present. The EEG data confirmed this as the ERP associated with the detection of orientation boundaries was absent in the patient group. Interestingly, consecutive feedforward activity to extrastriate cortex was enhanced compared to controls and, finally, feedback activity was normal (although slightly delayed). Apparently, an initial deficit in boundary detection results in a subsequent imbalance between feedforward and recurrent activity. By this imbalance the visual system is able to compensate for deficits in early visual processing, resulting in the proper interpretation of a surface layout.

I5 1007 Contextual modulation of vernier thresholds by chromaticity-based grouping mechanisms

Bilge Sayim[1] (bilge.sayim@epfl.ch), Michael M. Herzog[1], Gerald Westheimer[2]; [1]Brain Mind Institute, Ecole Polytechnique Fédérale de Lausanne (EPFL), [2]Department of Molecular & Cell Biology, University of California Berkeley

In contextual modulation, neighbouring elements often impede performance on a target. For example, vernier offset discrimination deteriorates if lines flank the vernier. Explanations are usually based on local spatial interactions. However, we have recently shown that increasing the number of flanks can improve performance arguing against purely local interactions. We proposed instead that contextual interference diminishes when the flanks are grouped and the vernier stands out from the configuration. Here, we show analogous results for color-based grouping. A red vernier flanked by arrays of 10 red lines yielded much higher vernier thresholds than when flanked by arrays of 10 isoluminant green lines and vice versa. Moreover, when a red vernier was flanked by alternating red and green lines, thresholds were even higher than in the condition with only red flanks. We suggest that in the latter configurations the vernier does not stand out from the flanks compared to when all flanks are green. These results add further evidence to the proposition that global rather than local spatial interactions have to be considered in explaining contextual modulation.

I6 1008 Spatial-temporal grouping and perceived writing sequence of Chinese characters in the human brain: Comparison of readers and non-readers

Su-Ling Yeh[1] (suling@ntu.edu.tw), San-Yuan Lin[1], Wei-Lun Chou[1], Der-Yow Chen[1,2], Jyh-Horng Chen[2], Chien-Chung Chen[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan, [2] Interdisciplinary MR lab, Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

Perceptual grouping by spatial-temporal congruency is important for perceiving continuous actions. We investigated neural substrates for perceived actions by measuring BOLD (blood oxygenation level dependent) activation to Chinese character writing sequences. The block design fMRI experiment had one test block containing characters presented stroke by stroke in generally accepted writing sequence (normal) and a control block containing characters with random stroke sequence. Chinese readers and non-readers were asked to count either the number of strokes (relevant task) or the number of color changes of the fixation (irreverent task). The BOLD activation was collected on a Bruker 3T magnet (EPI, TR=3s, TE=60ms, flip angle=90°). The lateral occipital complex (LOC), the intraoccipital sulcus (IOS), and the intraparietal sulcus (IPS) showed differential activation between normal and random writing sequence. Compared with readers, non-readers showed significantly reduced activation in these brain areas except the left IOS. Both groups showed much greater activation with relevant attention task than with irrelevant task. These results suggest two components in perceived writing sequence of Chinese characters: A general spatial-temporal grouping effect in perceiving motor sequence that requires attention, and a stimulus-specific ordering effect formed through learning experience.

Acknowledgement: [Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE]

I7 1009 A biologically-plausible model for curvature-based texture segregation

Guy Ben-Yosef[1] (guybeny@cs.bgu.ac.il), Ohad Ben-Shahar[1]; [1]Computer Science Department and the Zlotowski Center for Neuroscience, Ben-Gurion University, Israel

The analysis of texture patterns is at the heart of visual processing. Texture perception, texture segregation, and the perception of salient texture borders between perceptually coherent regions are traditionally linked to the notion of feature gradient (e.g., Nothdurft, 1985,1991; Landy&Bergen, 1991; Mussap&Levi ,1999). We recently argued (Ben-Shahar, 2006) that at least for the commonly studied Orientation-Defined Textures (ODTs) this link is fundamentally flawed since general ODTs of varying orientation generically exhibit salient perceptual singularities (i.e., perceptual boundaries between perceptually coherent regions) despite having no outstanding orientation contrasts. Although these singularities are extremely robust and consistent across observers, they defy not only popular texture segregation theories, but virtually all neural models (e.g., Li, 2000) and computational segmentation methods, either local (e.g., Malik&Perona, 1990) or global (e.g., Shi&Malik, 2000). Given this gap, in our previous theoretical account we argued that an appropriate approach to handle the segregation of ODTs should not (indeed, could not) rely on orientation gradients but rather on two orientation curvatures, one tangential and one normal, that come about naturally from considering the differential geometry of the ODT from an intrinsic point of view. Based on these ideas, here we present a novel biologically-plausible computational model that computes the two ODT curvatures from the output of V1 oriented receptive fields and continues to compute a perceptual singularity measure (Ben-

Shahar, 2006) directly from any given ODT image. The results match human performance to great accuracy and provide an important first step towards a general curvature-based approach for the segregation of general textures.

I8 1010 Gestalt and Translucency

Jan Koenderink[1] (j.j.koenderink@phys.uu.nl), Andrea van Doorn[1], Sylvia Pont[1], Whitman Richards[2]; [1]Physics and Astronomy, Universiteit Utrecht, [2]Brain and Cognitive Sciences, M.I.T.

We reconsider the stimulus configuration due to Metelli, in which (in the "translucent" experience) an observer sees two adjacent panels with a smaller, superimposed and translucent overlay. The stimulus configuration consists of four areas A, B, P and Q, such that the pairs AB, PQ, AP and QB meet at common borders, whereas the quadruple of the regions A, B, Q and P occurs in two X-junctions. Common experiences are (1) a "mosaic" in which the four areas appear as opaque and juxtaposed and (2) a mosaic of two adjacent panels A and B, overlaid with a single, translucent area W=P+Q (say), such that P is "due" to A seen through W and Q "due" to B seen through W. Observers experience difficulties with the dichotomy because they frequently "see" Gestalts differing from these two. An analysis reveals that five distinct categories may be expected. Observers experienced no difficulties with these categories. Their responses closely satisfy Metelli's constraints (which are very similar to the simplest physical model on the basis of superimposed turbid layers). Observer confusions can be understood on the basis of volatility of the constraints. The main deviation from the simplest model is that observers show an idiosyncratic preference for certain Gestalts over others, in particular, they prefer objects over holes.

I9 1011 Search Asymmetries with Emergent Features

Mary Portillo[1] (mcport@rice.edu), James Pomerantz[1]; [1]Rice University

Building on our work on emergent features (EFs), we looked for further evidence that EFs behave as basic features in human vision. EFs arise when simpler elements combine in Gestalt groups, and they are diagnosed by configural superiority effects (CSEs), wherein discrimination between two elements becomes better when informationless context is added. Since our task involves the search for an odd quadrant among three identical ones (where targets are presented alone or with uninformative context in singleton and composite conditions respectively) the possibility of search asymmetries (SAs) arises. Indeed, our data from experiments using dot patterns show that proximity, orientation, linearity, symmetry, surroundedness and inside/outside relationship produce SAs. For example, for orientation, finding a diagonally-related pair of dots among vertical or horizontal pairs is faster than the reverse. Similarly, with linearity, finding a nonlinear arrangement of three dots among linear arrangement is faster than its opposite. We note how in some cases the search asymmetry is present in the single dot condition, suggesting that the asymmetry does not emerge from the added context and highlighting the importance of pinpointing the real source of the asymmetry, a factor that should be taken into account when looking at any search asymmetry. Most importantly, in other cases we find SAs in composite conditions when there is none in the equivalent singleton condition. Moreover, in some cases the direction of the search asymmetry is reversed when a new EF is created even though the original signal remains constant. Indeed in one extreme case we discovered a triple reversal in the direction of asymmetry as additional context was added. Last, we present search asymmetry information for more complex EFs produced with lines rather than dots. In all, we take the presence of SAs with EFs as further evidence that EFs behave as basic in vision.

I10 1012 Object perception influences contrast discrimination

Serena K. Thompson[1] (thom1712@umn.edu), Cheryl A. Olman[2]; [1]Department of Neuroscience, University of Minnesota, [2]Departments of Psychology and Radiology, University of Minnesota

Does a segmented object bias an observer's low-level feature perception or do low-level features bias object segmentation? Borders represent contrast between many feature dimensions (luminance, contrast, orientation) and can aid segmentation. However, borders generally subtend less area and are less reliable figure-specific representations. Perhaps, then, coarse segmentation occurs before boundary definition and biases low-level features for a better figure estimate. Figure-ground segmentation is already known to modulate neural responses in primary visual cortex; context is known to modulate human observers' sensitivity to low-level image features.

To further understand how object recognition and low-level feature sensitivity interact, we have measured human observers' performance for the detection of a white noise-filled disk defined by second order contrast against a white noise background. The disk and background were blended by a cosine-squared function, so observers did not have exact location knowledge of the disk edge. Discrimination thresholds for this contrast-defined figure were measured at a series of pedestal contrasts, for both contrast increments (contrast of disk greater than contrast of background) and contrast decrements.

We found, for three observers, that contrast discrimination thresholds increased with pedestal contrast but were not the same for increments and decrements: thresholds were lower when the disk contrast was lower than the background (surround) contrast. These data are interpreted as behavioral evidence for the influence of object recognition on detection of low-level feature contrast. Further experiments will systematically investigate the dependence of this effect on the type of texture and quality of boundary used to define figure and ground. Additionally, functional imaging data will address the question of whether the asymmetry in contrast discrimination thresholds is reflected in the primary visual cortex BOLD response.

Acknowledgement: This work was funded in part by R01 EY015261 and T32 HD00715.

I11 1013 The Effect of Distracters on Enumeration in the Periphery

Ramakrishna Chakravarthi[1] (chakrava@wjh.harvard.edu), Patrick Cavanagh[1]; [1]Vision Sciences Laboratory, Department of Psychology, Harvard University

We examined enumeration in the periphery both in the presence and in the absence of distracters. 1 – 9 black circles (0.5 deg diameter) were presented on each trial, placed at least 1 degree apart within a 5 x 5 deg region centered at 7.5 deg eccentricity. There were three conditions: no-distracters, White X distracters, and Black Square distracters. In the two distracter conditions a total of 4 distracters, each measuring 0.6 degrees, were placed one on each side of the grid at three possible distances (0.35 – 2.9 degrees from the edge of the grid). Subjects reported the number of targets (black circles) and when reaction times were plotted as a function of number of objects, separate ranges for subitization (rapid and precise quantification, average slope=55ms/item for 1 – 3 objects) and counting (slow, serial enumeration, slope=429ms/item for 5 – 8 objects) were discernable in the no-distracter condition. Both of these slopes are significantly steeper than those over the same ranges with foveal presentation, suggesting some modification of the subitizing and counting strategies in the periphery when spacing may be too close to allow all targets to be individuated. Distracters also had a significant effect: black, but not white, distracters significantly increased both error rates and reaction times of responses especially at their closest spacing. Further analysis showed that black distracters specifically interfered with the enumeration of small numbers (slope=162ms/item), suggesting that subjects were counting and not subitizing even at the lower end of the number scale. However, slopes for enumerating large numbers were unchanged. Consequently, our results suggest that the subitization process can discriminate black targets from white distracters but cannot separate targets and black distracters in the periphery, requiring a switch to the slower counting strategy to avoid errors.

I12 1014 Memory for location is influenced by part-based segmentation of space

Mark Holden[1] (mholden@temple.edu), Thomas Shipley[1], Nora Newcombe[1]; [1]Department of Psychology, Temple University

Little is known about how people remember locations in complex environments. Huttenlocher, Hedges and Duncan (1991) suggested a model that includes metric information and categorization using spontaneously imposed spatial boundaries. Evidence for this comes from systematic error patterns in participants' recall of the location of a dot within simple forms (e.g., circles, rectangles, triangles). Recently, Wedell, Fitting and Allen (in press) examined the number of such boundaries within several different shapes, finding that the shape of the figure in which the dot is displayed affects the spacing, but not the number of prototypes.

However, the use of simple geometric stimuli may not capture spatial memory as it functions in a more naturalistic setting. Here, we asked participants to recall the locations of dots enclosed in complex shapes. Geometric models of part segmentation (e.g., Singh & Hoffman, 2001) make clear predictions about where complex figures will be subdivided into parts. These parts could serve as natural categories for the memory of locations.

Our results suggest parts play an important role in memory for location. Memory for dot location in a complex figure was subject to systematic distortions that are best explained in terms of spatial segmentation. Errors tended to reflect biases toward centers of component parts and towards prominent features (e.g., curvature extrema). This pattern of errors may reflect the use of different strategies, dependent upon the specific location within the figure. These strategies make use of local, rather than global categories.

References:

Huttenlocher, Hedges, & Duncan. (1991). Categories and particulars- Prototype effects in estimating spatial location. Psychological Review, 98, 352-376.

Wedell, Fitting, & Allen. (in press). Shape effects on memory for location. Psychonomic Bulletin & Review.

Singh. & Hoffman. (2001). Part-based representations of visual shape and implications for visual cognition. In Shipley & Kellman's From fragments to objects. 401-459.

I13 1015 When features go around the corner in human vision

Thomas U. Otto[1] (tom.otto@epfl.ch), Haluk Ogmen[2,3], Michael H. Herzog[1]; [1]Laboratory of Psychophysics, Brain Mind Institute, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, [2]Center for Neuro-Engineering & Cognitive Science, University of Houston, [3]Department of Electrical & Computer Engineering, University of Houston

Information processing in the human brain is highly parallel. One prediction of this parallel processing is that features of different objects may be combined erroneously. Using a backward masking paradigm, we showed recently that features presented at different retinotopic locations can be combined. (Otto, Ogmen, & Herzog, 2006, Journal of Vision, 6(10), 1079-1086). Here, we show that such feature “mis-bindings” occur not only across retinotopic maps but also across orientation maps. We presented a central Vernier that was offset either to the left or right. On either side of this Vernier, a sequence of flanking lines devoid of any Vernier offset followed. Flanking lines were successively shifted further away in space and successively rotated by a slight orientation difference. A motion percept of two orbital streams of lines was elicited whereas the central Vernier itself was largely rendered invisible. However, the Vernier offset was perceived in the stream of flanking lines. If one of the flanking lines was offset itself, this offset was integrated with the offset of the central Vernier even when the orientation difference between the central Vernier and the flanking line was more than 30°. Hence, features presented at substantially different locations and orientations can be bound together. We suggest that these feature “mis-bindings” are not errors of the visual system but part of a computational strategy.

Acknowledgement: Thomas Otto was supported by Swiss National Science Foundation (SNF)

I14 1016 Are Objects Required for Object-Files?

Tao Gao[1] (tao.gao@yale.edu), Brian Scholl[1]; [1]Department of Psychology, Yale University

A central task of vision is to segment the retinal image into discrete objects, and to keep track of them as the same persisting individuals over time and motion. Such processing is often discussed in terms of object files -- midlevel visual representations that 'stick' to moving objects on the basis of spatiotemporal properties, and store (and update) information about those properties. Object files have traditionally been studied via 'object-specific preview benefits' (OSPBs): discriminations of an object's features are speeded when an earlier preview of those features occurs on the same object, as opposed to on a different object, beyond general display-wide priming. This effect is clearly 'object-based' (vs. space-based), but what counts as an 'object' in this framework? Here we studied this question via much more extreme manipulations than previous work, by removing all static segmentation cues. In Experiment 1, both the objects and the background were composed of random visual noise -- so that the objects were defined only via their motion. Experiment 2 went even further, removing all segmentation cues: the entire random-noise background simply rotated as a whole. Robust OSPBs were nevertheless found in both cases. We conclude that the construction and maintenance of object files does not require static surface cues to 'objecthood', nor any segmentation cues at all. In addition, since objects were always invisible until the motion began -- after the offset of the previewed features -- we conclude that object files can be established 'after the fact', postdictively. These results clearly conflict with the assumption that object-files require previously segmented objects, but they do maintain the two key aspects of the object-file framework -- individuation and tracking. Overall, these experiments help characterize what "object files" really are, and how they do and do not relate to our commonsense notions of objects.

URL: http://www.yale.edu/perception/

I15 1017 The Origins of Causal Perception: Evidence from Postdictive Processing in Infancy

George Newman[1] (george.newman@yale.edu), Hoon Choi[2], Karen Wynn[1], Brian Scholl[1]; [1]Department of Psychology, Yale University, [2]Department of Psychology, Boston University

The currency of our visual experience consists not only of visual features such as color and motion, but also seemingly higher-level features such as causality -- as when we see two billiard balls collide, with one causing the other to move. One of the most important and controversial questions about causal perception involves its origin: do we learn to see causality, or does this ability derive in part from innately specified aspects of our cognitive architecture? Such questions are difficult to answer, but can be indirectly addressed via experiments with infants. Here we explore causal perception in 7-month-old infants, using a different approach from previous work. Recent work in adult visual cognition has demonstrated a postdictive aspect to causal perception: in certain situations, we can perceive a collision between two objects in an ambiguous display even after the moment of potential 'impact' has already passed. This illustrates one way in which our conscious perception of the world is not an instantaneous moment-by-moment construction, but rather is formed by integrating information over short temporal windows. Here we demonstrate analogous postdictive processing in infants' causal perception. This result demonstrates that even infants' visual systems engage in subtle spatiotemporal grouping, and process information in temporally extended chunks. Moreover, this work provides a new way of demonstrating causal perception in infants that differs from previous strategies, and is immune to some previous types of critiques.

URL: http://www.yale.edu/perception/

I16 1018 **A specific autistic trait that modulates illusion susceptibility**

Paul Dassonville[1,2] (prd@uoregon.edu), Elizabeth Walter[1,2], Tiana Bochsler[1,3]; [1]Psychology, University of Oregon, [2]Institute of Neuroscience, University of Oregon, [3]Clark Honors College, University of Oregon

It has been suggested that a core feature of the autism spectrum disorders (ASD) is a profound inability to integrate the contextual elements of a perceptual scene ("weak central coherence," Frith 1989). While this theory suggests that a contextual processing deficit causes many of the impairments associated with ASD, it could also explain the enhanced performance on some visuospatial tasks, such as the Hidden Figures Task (HFT; Happe 1999). The theory also predicts that individuals with ASD should be less susceptible to visual illusions, as they should not naturally integrate the misleading contextual elements that cause the illusions. Unfortunately, experimental evidence of a decreased susceptibility to illusions in ASD is spotty at best (see Happe 1996; Ropar & Mitchell 2000, 2001). However, these previous studies may have suffered from confounds associated with the diverse spectrum of traits exhibited by individuals with ASD, and with differences in illusion susceptibility associated with chronological-age (children with ASD were matched with controls of a similar mental-age). Here, we examined the relationship between illusion susceptibility and specific autistic traits, as exhibited (in varying degrees) within a population of healthy college students. Using a factor analysis to find underlying patterns in the data from 301 participants, we found that illusion susceptibility was negatively correlated to the autistic trait of systemizing as measured by the Systemizing Quotient (SQ, Baron-Cohen et al. 2003) while performance in HFT and intuitive physics (Baron-Cohen et al. 2001) were positively correlated with SQ. In contrast, performance in these tasks was not related to scores on the Empathizing Quotient or the more general Autism Quotient (EQ, AQ; Baron-Cohen et al. 2004, 2001). Thus, although ASD is associated with enhanced performance on visuospatial tasks, the degree of enhancement is most directly modulated by the extent to which an individual exhibits the systemizing trait.

Acknowledgement: NIH 5-T32-GM07257

Object Perception

Author Presents: 4:00 - 5:45 pm

I17 1019 **Filling-in of a line segment presented on one side of the blind spot**

Yukyu Araragi[1] (uqa@psycho.hes.kyushu-u.ac.jp), Hiroyuki Ito[1], Shoji Sunaga[1]; [1]Faculty of Design, Kyushu University

Previous studies showed that stimuli on the both sides of the blind spot are needed for perceptual completion at the blind spot to occur (Kawabata, 1982; Kobayashi et al., 1999). In this study, we examined whether perceptual filling-in occurs or not in the blind spot when a line segment presented on one side of the blind spot. A test line segment was a horizontal line segment which was presented so that an end of the test line segment coincided with the edge of the blind spot in blind spot condition. Two vertical line segments were also presented above and below the test line segment so that they were horizontally aligned with the end of the test line segment at near side to the blind spot. For comparison, we performed control condition in which the end of the test line segment was detached from the edge of the blind spot. Observer's task was to judge whether the end of the test line segment at the near side to the blind spot was perceived on the right or left side to the two vertical line segments. The results showed that the response of which the end was perceived at the near side to the blind spot in the blind spot condition was significantly more than that in the control condition and the chance level. The results suggest that filling-in of a line segment presented on one side of blind spot occurs in the blind spot.

Acknowledgement: The present study was supported in part by a Grant-in-Aid for the 21st Century COE Program.

I18 1020 **Detection of global shape in radial frequency patterns involves interacting contour shape channels operating independently of local form processes**

Jason Bell[1] (bellj02@student.uwa.edu.au), David Badcock[1], Hugh Wilson[2], Fran Wilkinson[2]; [1]School of Psychology, University of Western Australia, [2]Centre for Vision Research, York University

Radial frequency (RF) patterns have been used to examine the processes involved in shape perception. Current literature suggests that there are distinct global and local shape detection processes for low and high radial frequency patterns, but this has not been tested in a combined contour pattern, such as would be needed to represent the contours of most natural objects. To test this, we combined RF components onto a single path to make a compound RF structure. Psychophysical thresholds for detecting a single RF component were measured and compared to thresholds for detecting the same component in a compound pattern. Experiment 1 combined frequencies from the local and global range. The results show that local and global RF shape information can be detected independently despite appearing on the same contour; suggesting separate processes that can function in parallel. For the range of RF patterns that are processed globally, multiple curvature mechanisms are proposed to account for human performance. To test for interactions, Experiment 2 combined RF components within the global range. Masking was present, and was tuned for RF, suggesting the existence of several narrow band shape channels. Adaptation was then used to selectively desensitise channels. Adapting to a single RF pattern reduced sensitivity to RF patterns of similar frequency but improved sensitivity to a dissimilar RF component on the compound contour. Effects were shown to be independent of the radius of the adaptor, and also occurred with adaptors composed of contrast modulated noise, suggesting that post-adaptation results are not contaminated by fatiguing of local V1 orientation-tuned cells. The results are consistent with at least two contour shape channels, which operate in a competitive network. The findings are discussed in relation to current models of shape perception.

I19 1021 **Orientation invariance in shape representation**

Caroline Blais[1] (caroline.blais@umontreal.ca), Martin Arguin[1,2], Ian Marleau[1]; [1]Centre de Recherche en Neuropsychologie et Cognition, Departement de psychologie, Universite de Montreal, [2]Centre de Recherche, Institut Universitaire de Geriatrie de Montreal

The viewpoint invariance of shape recognition is accounted either by proposing three-dimensional (3D) shape descriptions or multiple two-dimensional (2D) representations (obtained from various viewpoints). Almost all of the relevant studies assessing the code for shape representation have based their conclusions on the measurement of rotation effects on absolute reaction times, which can be influenced by low level mechanisms that precede those specifically subserving shape representation. The present experiments used a visual search task to assess directly the code for shape representation by examining whether plane and depth rotations modulate the conjunction (CONJ; decreased search rate when the shape properties of the target are a conjunction of the distrator properties) and the linear non-separability (LNS; decreased search rate when the shape properties of the target are a linear combination of distrator properties) effects, which reflect key features of shape representations (Arguin & Saumier, 2000; Saumier & Arguin, 2003). Experiments 1 and 2 assessed the CONJ and LNS effects when distractor exemplars had either all the same or different orientations, with rotations applied either on the image-plane (Exp. 1) or in depth (Exp. 2). The logic underlying these experiments is that if shape representations are orientation-dependent then the visual properties of the target should no longer be a conjunction or a linear combination of the visual properties of the distractors in the "different-orientation" condition and the CONJ and LNS effects should therefore be eliminated. In contrast, if shape representations are rotation-invariant then the CONJ and LNS effects should be maintained even in the "different-orientation" condition. In both experiments, the results show that the CONJ and LNS effects are unaffected when the distractors are in different orientations. These findings argue for orientation-invariant shape representation codes.

I20 1022 Category-dependent variations in visual processing time

Sébastien Crouzet[1] (sebastien.crouzet@cerco.ups-tlse.fr), Simon J. Thorpe[1], Holle Kirchner[1]; [1]CerCo, CNRS-Université Toulouse 3, 31062, Toulouse, France

In a choice saccade paradigm where two natural scenes are simultaneously flashed left and right of fixation, subjects can initiate saccades to the side containing an animal in as little as 120 ms (Kirchner & Thorpe, Vis Res, 2006). Here, we investigated whether this processing time depends on the nature of the target category. Previous go/no-go studies had suggested that rapid processing of natural scenes was comparable for categories such as animals, faces and means of transport (VanRullen & Thorpe, Perception, 2001; Rousselet et al., JOV, 2004). But in the present experiments, we found clear evidence that certain image categories were processed more rapidly than others. In different blocks of trials, subjects had to respond to target categories such as animals, faces and means of transport using distractors that were made of various landscapes. The results showed a category-dependent variation of processing time. Mean RTs, varied from 140 ms for human faces (with the first saccades occurring only 110 ms after stimulus onset) to 190 ms for means of transport. In a second series of experiments, we investigated the effect of the type of distractor on performance, testing categories against each other. A major observation was that the image categories that were fastest when used as targets were also the most disturbing ones when they were used as distractors. These category-specific differences in processing time may also be reflected in the fact that certain key stimuli such as faces are also more resistant to backward masking and rapid sequential visual presentation (Bacon-Macé et al., in preparation). We propose that the ability to perform the choice saccade task and the resistance to masking could both reflect the speed with which information can be extracted during cortical processing.

I21 1023 The impact of action similarity on visual object identification.

Genevieve Desmarais[1] (gdesmara@ahsmail.uwaterloo.ca), Mike Dixon[2], Eric Roy[1,2]; [1]Department of Kinesiology, University of Waterloo, [2]Department of Psychology, University of Waterloo

Previous research has shown that visual similarity influences visual object identification: participants tend to confuse objects that are visually similar rather than objects that are visually dissimilar. It has also been suggested that nonvisual information, for example information about how objects are used, can impact visual object identification. The visual identification of novel objects can be facilitated in some neurological patients by associating novel objects to the names of dissimilar objects. With healthy participants, making novel objects distinct by associating them to non-overlapping features can serve to make them more discriminable when asked to perform same / different judgements. In both cases, the associations are verbally based: novel objects are associated with verbal labels (object names or attributes). We evaluated the impact of visual similarity and action similarity on visual object identification using a learning paradigm where novel associations were formed between objects and actions. We taught participants to associate novel objects with novel actions, and taught them to identify these novel objects with non-word labels. Specific objects were paired with specific actions. Visually similar objects paired with similar actions were confused more often in memory than when these same objects were paired with dissimilar actions. Hence the actions associated with objects served to increase or decrease their separation in memory space, and influenced the ease with which these objects could be identified. These experiments ultimately demonstrated that when identifying stationary objects, the memory of how these object were used dramatically influenced the ability to identify these objects.

I22 1024 Some tests of the standard model

Kenneth Hayworth[1] (khaywort@usc.edu), Xiaomin Yue[1], Irving Biederman[1]; [1]University of Southern California

HMAX (Serre et al. 2005), a model of processing in the primate visual cortex, has been referred to (by its authors) as the "standard model." HMAX extends a classical Gabor-filter model of V1 by interleaving layers performing spatial pooling (to achieve invariance) with layers computing feature conjunctions, some learned, to achieve more complex features.

From object line drawings we produced local feature deleted (LFD) complementary pairs (A, B) by deleting every other vertex from one image and the alternating vertices from the other. We scrambled the contour fragments of A (by translation only) generating A_SCR, then conducted match-to-sample trials (Is A more similar to B or A_SCR?). Subjects invariably chose B. HMAX chose A_SCR in 95% of trials. With learned features, HMAX performed close to chance. In a separate test, we created match-to-sample trials where the target depicted Object1, the first test image also depicted Object1 but with complementary vertices, the second test image depicted Object2 but matched in local vertex content to the target. HMAX (with and without learned features) matched Object2 to Object1--exactly opposite to what humans did.

HMAX fails on these tests because it perceives an object only as a list of features. Parts-based structural descriptions (SD) can explain these results because LFD complements contain information sufficient for the same parts to be extracted. Recent single unit studies in IT are supportive of SDs. Yamane et al. (2006) reported IT neurons that were tuned to individual parts and relations between parts. We describe ways to revise feature hierarchy models (like HMAX) to achieve a model of human performance that more closely accommodates both our own psychophysical experiments as well as the neural data.

I23 1025 Exploring visual object representations with similarity-matrix analysis

Nikolaus Kriegeskorte[1] (niko@nih.gov), Marieke Mur[1], Doug Ruff[1], Roozbeh Kiani[2], Jerzy Bodurka[1], Peter Bandettini[1]; [1]Section on Functional Imaging Methods, Laboratory of Brain and Cognition, National Institute of Mental Health, Bethesda, Maryland, [2]Department of Neurobiology and Behavior, University of Washington, Seattle, Washington

We propose a novel approach to studying visual object representations on the basis of multi-channel brain-activity data as provided by high-resolution functional magnetic resonance imaging (hi-res fMRI). The core idea is to describe a region's representation of a set of object images in terms of the pairwise similarities of the multivariate response patterns elicited by the stimuli. Analogously, the predictions of theoretical models of the representation (including simple category models as well as computational models processing the actual stimuli) can be expressed in terms of the pairwise similarities between the response patterns associated with the stimuli. The similarity matrix, as an abstract description of the representational space, can then be used to quantitatively relate the data from each brain region to each of the models.

The similarity matrix is a square matrix containing a similarity estimate for each pair of single-image response patterns within a given region. For each pair of stimuli, the spatial response patterns are compared by linear correlation. We then assess how well each model's similarity matrix fits each functional region's similarity matrix. In addition, we continuously map the model fits by moving a multivariate searchlight (in the form of a spherical cluster of voxels) throughout the imaged volume.

Results indicate that the human inferotemporal representation of visually presented objects is well described as a categorical distributed code: a simple model of basic-level object categories (as has been widely assumed but never tested) predicts the similarity structure more accurately than other models. The human inferotemporal similarity matrix also appears to match the similarity matrix obtained by analogous analysis of monkey-IT single-cell responses to the same images.

I24 1026 **A Cross-Cultural Test of the Independence of the Representation of Generalized-Cone Dimensions**

Mark D. Lescroart[1] (lescroar@usc.edu), Xiaomin Yue[1], Jules Davidoff[2], Irving Biederman[1]; [1]University of Southern California, [2]Goldsmiths, Universtiy of London

A number of parts-based theories of 3D object representation (e.g., Marr & Nishihara, 1977; Biederman, 1987) hold that simple object parts can be modeled as generalized cones (GCs). GCs are the volume created by sweeping a cross-section along an axis as, for example, when a circle is moved along a straight axis to produce a cylinder. Different volumes can be produced through variations along different dimensions, such as axis curvature, the size variation of the cross-section during its sweep, and aspect ratio. GC dimensions may be coded independently, as shown by Stanckiewicz (2002), who reported that discrimination of noisy variations in one GC dimension could be performed independently of the noise level on another GC dimension. Kayaert et al. (2005) showed that 95% of the variance of the firing of macaque IT cells to 2D shapes could be accounted for by independent representation of the GC dimensions. (Sweeping a line along an axis will produce a 2D GC shape, such as a rectangle.) Because both the psychophysical subjects and the monkeys live in environments replete with geometrically regular shapes, one could argue that the sensitivity to GC dimensions reflects familiarity rather than being a function of robust statistics of images that would characterize any natural environment. The Himba, a semi-nomadic people in a remote area of Namibia, have little exposure to developed-world artifacts. They performed a texture discrimination task in which they had to judge whether the boundary between two texture regions composed of macaroni-like shapes differing in aspect ratio (narrow-wide) and axis curvature (low-high) was vertical or horizontal. For both Westerners and the Himba, when the boundary was defined by variation in a single shape dimension, performance was markedly superior to when the boundary was defined by variation in two dimensions.

I25 1027 **Laser disability glare with and without a windscreen**

Leon McLin[1] (leon.mclin@brooks.af.mil), Laura Barnes[1], James Dykes[2], Peter Smith[2], Brenda Novar[2], David Kee[2], Paul Garcia[2]; [1]Air Force Research Laboratory, Optical Radiation Branch, Brooks City-Base TX, [2]Northrop Grumman Corporation, San Antonio, TX

Purpose: To examine the difference in green laser disability glare with and without an aircraft windscreen. Methods: Gabor patches were presented coincident with, and up to 55½ eccentric from, a laser glare source. Subjects viewed the Gabor stimuli with their left eye while the right eye was covered and responded whether the Gabor was tilted left or right. The patch subtended 1, 2, 10, and 20½ and contained 2¾ grating cycles at 33% contrast. Two groups of subjects performed the task: one group viewed the laser through an aircraft windscreen, the other group viewed without the windscreen. The laser irradiance levels were from 0.6 microwatts•cm^{-2} to 600 microwatts•cm^{-2}, in 0.5 log steps. A night ambient luminance condition (3 cd•m^{-2}), a dawn/dusk ambient condition (30 cd•m^{-2}) and a daytime condition (3000 cd•m^{-2}) were evaluated. The probability of an error as a function of eccentricity was computed for each condition (laser irradiance x windscreen x target size x ambient level, and the area under this curve calculated for each. Results: Errors increased with laser irradiance; $F(2.280, 34.203) = 374.475$; $p< .001$, decreased as target size increased; $F(1.651, 24.761) = 246.708$; $p< .001$. More errors were made with a windscreen than without a windscreen; $F(1,15) = 14.229$; $p = .002$., and errors increased as ambient luminance decreased; $F(2, 23)= 91.025$; $p< .001$. Conclusions: Laser induced disability glare effects are exacerbated by light scatter through an optical media such as an aircraft windscreen, especially for small targets at night. The results can be fitted to the CIE disability glare function, adjusted for the presence of an extraocular scattering element.

I26 1028 **Estimation of Contrast Origin in Natural Images**

Ganesh Padmanabhan[1] (ganesh.padmanabhan@ndsu.edu), Mark Brady[1]; [1]Psychology, North Dakota State University

Purpose:

Classification by cause of local contrast elements is a critical part of object recognition and other image interpretation processes. For example, occlusion boundaries, albedo discontinuities, specularity edges, shadow edges, etc. in the scene, are all possible causes. It is not known whether this classification takes place prior to object recognition (bottom up process) or if it takes place after object recognition (top down process). In order to better understand the role of contrast cause estimation, we studied estimation performance given local information only.

Methods:

Natural images were collected by calibrated camera and converted to luminance images. By changing the background, the experimenter determined the true object contour. By manipulation of illumination, the shadow and specularity edges shadow edges were distinguished from the albedo edges.

Subjects then viewed local regions of the object images thru an aperture and were asked to estimate the cause of contrast in a four alternative forced choice procedure (occlusion, albedo, specularity, shadow). Five aperture sizes, from 21.6 to 124 moa, were used.

Subject responses were collected and compared to ground truth.

Results:

A contingency table analysis showed that subjects were above chance in correctly estimating the true cause of contrast in an image from local information. Performance was at 47.5% correct for small apertures and 48.75% correct for large apertures. Chi-Square for small apertures and for large apertures were both significant at $p<.001$. The strength of the observer's performance was determined by Cramer's V, which was .395 for the small apertures and .362 for the large apertures. Both indicate a strong association between predicted cause and ground truth.

Conclusions:

The results show that observers perform above chance with very little global information. Also surprisingly, aperture size and global information conferred little advantage over the large range tested.

Acknowledgement: This research supported by NIH Grant Number P20-RR-020-151

I27 1029 **Removing Non-Accidental Properties Increases the Duration of Object Awareness**

Justin D.N. Ruppel[1] (justin.ruppel@utoronto.ca), Stephen M. Emrich[1], Susanne Ferber[1]; [1]Department of Psychology, University of Toronto

While countless experiments have investigated the properties and conditions that affect initial object recognition, little is known about how the awareness of objects is maintained after successful recognition. Substantial evidence demonstrates that vertices, defined as points of cotermination, are crucial properties for object recognition. Removing the vertices or "non-accidental properties" of objects impairs recognition speed and accuracy more than when the vertices are left intact. Here, we tested whether removing vertices from fragmented objects also impaired the maintenance of object awareness using a shape-from-motion (SFM) paradigm. Fragmented line-drawings of objects were rotated relative to a background of randomly-oriented lines. After the motion is stopped, the percept of the object persists briefly. Participants made a response to indicate when they were able to identify the object, as well as when their subjective awareness for the object had disappeared. Object vertices were either removed or left intact. We confirmed earlier studies demonstrating that objects without vertices take longer to recognize. Interestingly, these same objects are nonetheless maintained in awareness for longer. The results suggest the mechanisms underlying object recognition are different from those subserving the maintenance of object awareness.

I28 1030 Perceptual judgments, psychophysics, and biological data

Alan Stubbs[1] (alan.stubbs@umit.maine.edu), Constance Stubbs[2], Lisa Best[3], Laurence Smith[1]; [1] Deprtment of Psychology, University of Maine, [2] Deprtment of Biological Sciences, University of Maine, [3] Deprtment of Psychology, University of New Brunswick

Biologists sometimes make perceptual judgments when collecting data. For example, a scale of lichen quality or an estimate of amount leaf consumption by beetles might be part of data collection. But how accurate are these estimates? Should one base data collection on perceptual observations? And, should we worry about bias in the observations? Can forest quality be estimated only on a relatively imprecise1-5 scale or a 1-7 scale? Or might more accurate estimates be possible? Several psychophysical experiments had people make more direct and specific estimates and these judgments were compared with actual environmental cases. For one experiment, judgment of amount of leaves consumed by beetles was compared with the actual amount consumed. In another, percentage of insects judged as covering an area was compared with the actual percentage. A psychophysical analysis indicated that estimates were quite accurate and generally were within five percent of the actual value. We observed some instances of bias and some of the factors affecting it. The experiments demonstrate that visual estimates of biological data, even those that might seem complex, can be quite accurate. And there are psychophysical procedures that allow us to assess both the level of sensitivity and bias.

I29 1031 Dissociation of Egocentric and Object-Centric Processing in Mental Rotation

Wei-Dong Tao[1] (sunhong@mcmaster.ca), Jing-Jiang Yan[1], Peng Wang[1], Liu Zhou[1], Hong-Jin Sun[2]; [1]School of Psychology, Southwest University, China, [2]Department of Psychology, McMaster University, Canada

Mental rotation can take either egocentric or object-centric forms. We explored the dissociation of these two processing mechanisms using a special stimulus (hand), which may invoke a mental transformation of either the viewer's own body (hand) or the visual display. In Experiment 1, the stimuli consisted of back view of human hands created by a 3D graphics software. Each picture of the hand was presented at an orientation rotated in lateral or medial direction from the upright orientation. Each participant completed (1) a left or right hand judgment task (LR task) when either a left or right hand picture was presented and (2) a same or different judgment task (SD task) when pictures of two hands were presented. The results showed that in-rotation (rotated medially) hand was recognized more quickly and accurately than out-rotation hand in LR task (in-rotation effect), but not so in SD task. This suggests that the processing of mental rotation in LR task is limited by the biomechanical constraints of the corresponding physical rotation. In Experiment 2, participants responded through a microphone while seated in front of a computer screen with their hands positioned on their laps and the back of their hands faced up. The same patterns of result were observed as in Experiment 1 for both back and palm views of hand stimuli. However, the back view of the hands was recognized more quickly and accurately than the palm view in LR task, but not so for SD task. These results suggest participants use different spatial transformation mechanisms in LR (egocentric) and SD (object-centric) task. It appears that both the material of the body parts and paradigms of mental rotation determine the reference frame participants adopted and the in-rotation effect might serve as indicator for the dissociation of egocentric and object-centric mental rotation.

Acknowledgement: Supported by Key Subject Grant from Southwest University

I30 1032 The Effects of Visual-Perceptual Variables on Object Naming in Control Subjects

Audrey H. Gutherie[1] (ahgutherie@yahoo.com), Anna Bacon Moore[1], Ronald Schuchard[1]; [1]Atlanta VA Rehabilitation R&D Center

Objective: The purpose of this control study was to assess how visual information interacts with the cognitive processes involved in naming. The impact of subtle alterations in the visual-perceptual integrity of target stimuli on naming was investigated. Methods: Stimuli consisted of 150 black and white line drawings of everyday objects (75 living & 75 non-living). Manipulations of contrast and spatial frequency were made independently during one of two experimental sessions. Session A investigated the effects of 5 levels of contrast (i.e., 1.25%, 2.5%, 5%, 10%, and 20%) on naming. Session B investigated the effects of 6 spatial frequency bandpass filters (i.e., 0.25-0.5; 0.5-01; 1-2; 2-4; 4-8; 8-16 c/deg) on naming. Two neurologically normal adults participated in Session A, two neurologically normal adults participated in Session B, and one neurologically normal adult participated in both (age range = 35-60 years). Results: Significant differences were found between level 1 and levels 3-6 of spatial frequency for latency to name, and differences were found between the lowest two levels and all subsequent levels for accuracy to name. For contrast, there were significant differences between 1.25% contrast and the higher levels (10% & 20%, latency data; 5% & 20%, accuracy data). Discussion: The long-term trajectory of this study is to develop an object naming test for the detection of incipient Alzheimer's disease. In order to achieve this goal, it is important to understand what elements of visual processing are most important in naming in general. This study investigated the influence of spatial frequency and contrast on naming in normal subjects. These pilot data suggest that there is no statistically significant improvement in accuracy and latency to name obtained above and beyond 1-2 c/deg of spatial frequency. The results for the contrast sessions were more ambiguous, and additional data is needed in order to make any conclusions.

I31 1033 Familiarity vs. novelty principles for preference

Eiko Shimojo[1,2] (eiko@caltech.edu), Junghuyn Park[1], Lauren Lebon[1], Stephen Schleim[3], Shinsuke Shimojo[1,2]; [1]Biology/CNS, California Institute of Technology, [2]JST.ERATO Shimojo Implicit Brain Function Project, [3]Psychiatry, Medical Psychology, University of Bonn

Purpose: Understanding preference decision making is a challenging problem because the underlying process is partly implicit and dependent on context, including past experience. There is evidence for both familiarity and novelty as a critical factor for preference decision making in adults and infants. To resolve this seeming contradiction, we examined cumulative effects of exposure in different categories of object.

Methods: Faces, geometric figures, and natural scenes were tested separately in 3 blocks with the order counterbalanced across participants. Each block has 8 sets of trials, in each of which 26 pairs of within-category images were presented sequentially, and for each pair the participant judged relative preference in a 7-point scale. In each set of trials, one image was repeatedly presented at randomized location (L or R), paired with a new image each time. Thus except for the first trial, the pair/choice was always old vs. new.

Results: When probability of preference for the old stimulus was plotted against trial number, faces showed a steady increase, thus a general tendency towards familiarity preference. There is no tendency of novelty preference throughout the face set. On the other hand, natural scenes showed a quick decrease with saturation, a tendency of novelty preference in general. Geometric figures stayed neutral over trials, thus no strong bias either way. The overall pattern of results points to a possibility that the familiarity and the novelty principles are segregated across object categories. Different social/ecological significances may partly account for it.

I32 1034 Uncovering the structure of 3-D shape representations in human vision through analyses of eye movement patterns in object recognition

Charles Leek[1] (e.c.leek@bangor.ac.uk); [1]Centre for Cognitive Neuroscience, University of Wales, Bangor, UK

A fundamental question for vision research concerns how the visual system represents the shapes of three-dimensional (3-D) objects for recognition. To examine this issue we measured eye movement patterns during single object identification. While eye movements have been widely studied in a variety of other domains such as scene analysis, reading, visual search and face perception, there is surprisingly little evidence about eye movement patterns in relation to object recognition. We asked three questions. First, do eye movement patterns show preferences for specific types of image features? Second, are gaze preferences consistent between stimulus encoding and recognition? Third, are they invariant across changes in 3-D viewpoint and illumination? Eye movements were recorded while Ss attempted to first encode and then recognize the shapes of novel 3-D objects each composed of distinct volumetric components. An area of interest (AOI) analysis revealed remarkable consistency in the eye movement patterns between the learning and testing phases, and across different viewpoints of the same objects and lighting conditions. These gaze patterns cannot be predicted from low-level image salience. Rather, the results suggest that fixation patterns during object recognition are driven by higher-level 3-D object representations.

Face Perception: Emotion I

Author Presents: 4:00 - 5:45 pm

I33 1035 Familiarity and Emotion Adaptation

Susan Barrett[1] (seb6@lehigh.edu), Alice O'Toole[2], Leigh Richards[1]; [1]Lehigh University, [2]University of Texas at Dallas

Familiarity with a face strengthens identity adaptation aftereffects and increases the degree to which adaptation effects transfer across changes in view (Jiang et al., 2007). In the present study, we examine whether familiarity with an emotionally expressive face has a similar effect on emotion adaptation. Participants were familiarized with dynamic emotionally expressive faces. After familiarization, emotion adaptation effects were assessed for familiar and unfamiliar faces. In our study, familiarization was associated with a restriction in the range of values that produce a strong adaptation effect. More specifically, adaptation effects were weaker at intermediate morph levels for familiar faces than they were for unfamiliar faces. These findings suggests that adaptation effects can be used to study how perceptual mechanisms are fine tuned to recognize subtle emotional expressions.

I34 1036 A Negative Compatibility Effect in Priming of Emotional Faces

Jennifer D. Bennett[1] (bennett.jenn@gmail.com), Alejandro Lleras[2], Chris Oriet[3], James T. Enns[1]; [1]University of British Columbia, [2]University of Illinois, [3]University of Regina

Visual priming is the influence of a previously presented image on the response to a current image. In most cases, this influence is positive, speeding target identification. Yet under some conditions, the influence is reversed, as in the Negative Compatibility Effect (NCE). The NCE was first demonstrated in a simple arrow discrimination task. A prime arrow was presented briefly, followed by a mask pattern designed to reduce prime visibility to near-chance levels, and then a clearly-visible target arrow was presented. Surprisingly, participants responded most rapidly when the target was opposite in direction to the preceding prime.

The present study extends the exploration of the NCE to the classification of emotion in human faces. When inverted faces with neutral expressions were presented as flankers beside emotional prime and target faces, only strong positive priming occurred. However, when the neutral faces resembled the target faces in geometry (upright orientation), time (flashing briefly), and space (appearing in the same location), positive priming gradually weakened and turned into negative priming.

These result demonstrate that the NCE is not limited to simple stimuli, pre-existing response mappings, or to reduced prime visibility. Moreover, they have important implications for theories of the NCE, including unconscious motor inhibition theories — an NCE does not depend on reduced prime visibility — (Eimer & Schlaghecken, 1998; Klapp & Hinkley, 2002, Praamstra & Seiss, 2005), object updating — the priming effects extend beyond the representation of single objects to entire conceptual categories — (Lleras & Enns, 2004; Verleger et al., 2004), and source confusion and discounting — source confusion is influenced by the features of the visible mask that occurs between prime and target (Huber, Shiffrin, Lyle & Ruys, 2001; Huber, Shiffrin, Lyle & Quach, 2002).

I35 1037 Two-element classification images for the discrimination of emotional expression in upright and inverted face

Patrick J. Bennett[1,2] (bennett@mcmaster.ca), Masayoshi Nagai[3], Motoyasu Honma[4], Melissa D. Rutherford[1], Carl M. Gaspar[1], Diana Carbone[1], Masako Nara[3], Hijiri Ishii[5], Takatsune Kumada[3], Allison B. Sekuler[1,2]; [1]Department of Psychology, Neuroscience & Behaviour, McMaster University, [2]Centre for Vision Research, York University, [3]National Institute of Advanced Industrial Science and Technology (AIST), [4]College of Contemporary Psychology, Rikkyo University, [5]Kololo Gakusya (Social Welfare Public Corporation)

Classification images (CI) can reveal an observer's strategy for discriminating faces (e.g., Sekuler, Gaspar, Gold, & Bennett, 2004, Cur Biol). The present study used a variation of the CI method to examine the strategy used to discriminate the emotional expression of schematic faces. The faces consisted of two eyebrows and a mouth -- each represented by a curved or straight line -- and two eyes represented as small disks. Expression was manipulated by varying the curvature of the eyebrows and mouth. For example, downward curvature of the eyebrows combined with upward curvature of the mouth produced a happy face. The observer's task was to classify a face as ‘Happy’ or ‘Non-Happy’. Feature curvature was varied across trials with a staircase procedure to estimate a discrimination threshold. Curvature noise was added to the mouth and eyebrows on each trial: noise added to the mouth and eyebrows was independent, but the noise values for the two eyebrows on each trial were equal. We collected responses on 400 trials for upright and inverted faces from 12 Japanese healthy observers. Logistic regression showed that the judgments of all observers were influenced significantly by mouth curvature in both conditions. One observer in the upright condition and five in the inverted condition were not influenced by eyebrow curvature. Additionally, the interaction between eyebrow and mouth curvature was not significant in all but two observers in the upright face condition. Hence, judgments from most observers were well fit by an additive linear model that placed greater emphasis on mouth curvature than eyebrow curvature, especially for inverted faces. Currently we are testing Japanese autistic observers, as well as typical and autistic Canadian observers, to measure the effects of autism on emotional judgments and to determine if the results are similar for observers drawn from different cultures.

Acknowledgement: Supported by the CIHR-JSPS Japan-Canada Joint Health Research Program, the Canada Research Chair programme, and Grant-in-Aid for Young Scientists (B)

I36 1038 Visual Expectation Paradigm and Keypress Identification Compared: Mapping Emotion Category Boundaries

Jenna L. Cheal[1] (chealjl@mcmaster.ca), M.D. Rutherford[1]; [1]McMaster University

Some physical continua (e.g. color, speech sounds, and central to the current study, emotional facial expressions) are perceptually grouped into discrete categories. We tested the category boundary for four continua of 11 morphed photographs representing physically equidistant images with “happy” and “sad” as endpoints. Here, we compare results from a 2AFC keypress identification to categories derived from participant’s anticipatory eye movement data. Experiment 1 relied on an identification task in which participants saw continuum endpoint images (Unambiguous images) and selected “happy” or “sad” via keypress. Then they were asked to make the same decision for the five middle images (Ambiguous images) from the same continuum. Participants clearly categorized emotion images as happy or sad except for one image which elicited chance performance, suggesting a category boundary at this location. In Experiment 2, naïve participants saw a subset of these same stimuli in a visual expectation paradigm. During a training phase, the emotion (happy or sad) of an Unambiguous image displayed in the center of the screen predicted the location of a visual reward (e.g. a happy image was followed by a cartoon to the left, a sad image by a cartoon to the right). This visual reward appeared 750 ms after the central face image, allowing anticipatory eye movements to be recorded with an eye-tracker. After training, participants were presented with the five Ambiguous images and anticipatory eye movements were recorded. Experiments 1 and 2 revealed similar results: The middle images of the continuum had the most variable responses. The presence of a category boundary was further suggested by the greater number of non-responses (participants failing to show anticipatory eye movements) for images near the expected category boundary. The visual expectation paradigm is a viable methodology for the study of category boundaries.

I37 1039 Do facial identity and facial expression processing dissociate in prosopagnosia?

Lucia Garrido[1] (m.garrido@ucl.ac.uk), Bradley Duchaine[1]; [1]Institute of Cognitive Neuroscience, University College of London

The investigation of individuals with prosopagnosia has often suggested that the visuoperceptual mechanisms required for facial identity processing are dissociable from the mechanisms important for facial expression processing. However, Calder and Young (2005) have recently challenged this view. They propose that previous neuropsychological cases of dissociations between the two abilities might in fact result from trend dissociations. They point out that because facial emotion tasks tend to be easier than identity tasks the dissociation may result from differential difficulty. To better address this issue, we extensively tested individuals with developmental prosopagnosia on tasks of facial emotion processing. Most of these prosopagnosics do not complain of problems recognizing emotions, and they perform normally in some traditional tests of emotion recognition. We attempted to build tasks that put similar demands on facial identity and facial emotion perception by applying similar designs to test both abilities and using the same number of options of responses. We found that, when this is the case, most prosopagnosics also show some difficulties in the facial emotion tasks. Nevertheless, some cases seem to show disproportionate impairments with facial identity. These results are relevant to the discussion whether a single perceptual system or two separate systems are needed for processing identity and expression from the face.

Acknowledgement: Studentship from Foundation for Science and Technology (Portugal) for LG ESRC grant to BD (RES/061/23/0040)

I38 1040 Attentional modulation of face expression perception

Julia Gomez Cuerva[1] (j.gomez@bangor.ac.uk), Jane Raymomd[2]; [1]University of Wales, Bangor, [2]University of Wales, Bangor

Previous studies in our lab have shown that the attentional state (attending versus ignoring) that is applied when initially exposed to a novel face can determine later how that face will be evaluated on social emotional scales. Specifically, faces that are ignored in difficult attention tasks are later seen as less trustworthy than attended faces. A possible explanation for attentional modulation of affective appraisal of faces is that prior active ignoring subtly alters subsequent sensitivity to face expression. To test this possibility, we made careful psychometric measurements of face expression perception using face morphs (e.g., angry-neutral; happy-neutral) of the same individuals expressing different expressions. Participants judged faces with a range of morph values as neutral versus expressive. The resultant psychometric curves (% "expressive" response plotted as a function of % face expression intensity) were used to select approximately equivalently intense expressions for each face and expression dimension in the stimulus set. Faces with these values were then used in the main experiment. Here, observers engaged in a simple but demanding visual search task (to control their attention state) using neutral faces only. Immediately after each search trial, they made by a face expression judgement (using the morph values derived from our psychometric measurements) on a face that was either a prior target or distractor. The post-search psychometric functions were then used to reveal whether prior attention modulated the slope or shifted the expression sensitivity functions laterally. The former indicates sensitivity change whereas the latter reflects a biasing mechanism. Results for both happy and angry expression will be discussed in terms of attentional modulation of perception in other stimulus domains.

I39 1041 The role of ambiguity in gaze and expression interactions

Reiko Graham[1] (rg30@txstate.edu), Teal Shalek[1], Kevin LaBar[2]; [1]Department of Psychology, Texas State University, [2]Center for Cognitive Neuroscience, Duke University

Information about changeable aspects of faces, such as gaze and emotional expression, provides us with powerful social signals that allow us to make inferences about others. In spite of this, an understanding of how gaze and expression interact is elusive. One theory (Adams & Kleck, 2003, 2005) posits that that gaze and expression are processed together such that direct gaze facilitates processing of approach-oriented emotions (e.g., anger), whereas averted gaze facilitates processing of avoidance-related emotions (e.g., fear). Another theory (Senju & Hasagawa, 2005) argues for a special role for direct gaze in expression perception. The purpose of this study was to clarify the conditions under which gaze and facial expression interact. We used a two-alternative forced choice task to examine the perception of morphed facial expressions with either direct or averted gaze. Three morph progressions were administered to healthy undergraduates: neutral to anger, neutral to fear, and fear to anger. The probability of endorsing the latter emotion in each progression was calculated for each morph increment and gaze direction, and sensitivity and reaction times across the different increments and gaze directions were determined. Results indicated that gaze direction did not affect sensitivity to facial expressions, but did modulate reaction times. Specifically, reaction times to angry faces were faster when gaze was direct. Reaction times to fearful faces were faster when gaze was averted, but only when expressions were ambiguous. This suggests that gaze direction can act as context to make expression processing more efficient, particularly under conditions of uncertainty. These results support an approach/avoidance account of gaze and expression interactions, but qualify the conditions under which these interactions occur.

I40 1042 Scanning fixations during processing of facial expression versus identity: an exploration of top-down and bottom-up effects.

George Malcolm[1] (G.L.Malcolm@sms.ed.ac.uk), Linda Lanyon[2], Jason Barton[3]; [1]Department of Psychology, University of Edinburgh, [2]Department of Medicine, University of British Columbia, [3]Division of Neurology and Department of Ophthalmology and Visual Sciences, University of British Columbia

Perceptual studies suggest that processing facial identity emphasizes information in the upper face, whereas processing expressions of anger and happiness emphasizes the lower face. Our goal was to determine if scanning fixations showed a similar upper/lower-face difference when shifting from identity to expression, consistent with a proposed role for fixations in information processing.

We tested eight subjects on two experiments. In each experiment subjects viewed a target face and then a pair of morphed faces, and had to report which of the pair was most similar to the target. In experiment 1, the two faces differed slightly in both expression and identity simultaneously, but in one set of trials the subjects were asked to judge which morph was most similar in identity, whereas in another set the subjects were asked to judge which morph was most similar in expression. Because the same stimuli were used in both sets, differences between identity and expression processing would represent top-down effects. In experiment 2, the two faces were morphed either in expression but not identity, or in identity but not expression, and the subject was not informed which dimension differed on a given trial: hence this experiment probed for bottom-up effects. We measured the number of fixations and total duration of fixations spent on the upper versus the lower half of the morphed faces. ANOVA showed a significant interaction between experiment and dimension (expression versus identity). Identity processing showed more upper-face scanning and expression processing showed more lower-face scanning during experiment 1 (top-down effects), whereas no difference was found between identity and expression processing in experiment 2 (bottom-up effects). We conclude that fixations are related to the regional distribution of information in face perception, but that these reflect top-down guidance of information acquisition rather than bottom-up effects of the stimulus.

I41 1043 Face Configuration Biases the Perception of Facial Expressions

Aleix Martinez[1] (aleix@ece.osu.edu), Don Neth[1]; [1]Ohio State University

Perception of facial expressions has been primarily related to changes in the activation of the facial muscles. However, everyday experience suggests that neutral faces of different individuals are perceived as if they had different expressions. It is our hypothesis that the static configuration of facial components biases the perception of the face. Specifically, in this present work, we hypothesize that increasing the distance between the relative position of the nose, mouth, and eyes in neutral faces will result in the perception of sadness. Similarly, a decrease in those distances will result in the perception of increased anger. To test this hypothesis, twelve face images (768 x 576 pixels) with neutral expressions were selected. Each face was subjected to six morphing operations in which the distances among the eyes, nose, and mouth were varied. The eyebrows were moved in conjunction with the eyes, with the distance between the eyes and brows remaining constant at its initial value. The morph configurations included an increase (decrease) of 5, 10, 15, and 20 pixels. These stimuli were used in an experiment with one session for the angry class of images and another for the sad class. Pairs of images were sequentially presented for a period of 600 msec each, with a masked inter-stimulus interval of 500 msec. Subjects were asked to respond by keystroke to indicate if the second image was more, same or less sad (or angry) than the first image. Each image was presented randomly at one of the four morph levels or as the original image. Results demonstrated an increase of sadness (anger) perception as the distance between the eyes and mouth increased (decreased). A face-space based on the principal components of the shape of each face is shown to be sufficient for representing the variability in anger / sadness perception.

Acknowledgement: Supported in part by a grant from NIH.

I42 1044 A dynamic facial expression database

Sylvain Roy[1] (sylvain.r.roy@umontreal.ca), Cynthia Roy[1], Isabelle Fortin[1], Catherine Ethier-Majcher[1], Pascal Belin[1], Frederic Gosselin[1]; [1]Departement de Psychologie, Universite de Montreal

Facial expressions provide crucial information for adaptive behaviors, since they help us make inferences about what others are thinking and feeling. To date, most studies that have investigated the perception of facial expressions have used static displays (Ekman & Friesen, 1975). Such stimuli underestimate the importance of motion, or the dynamic changes that occur in a face, in emotion recognition (Ambadar, Schooler, & Cohn, 2005).The few studies of dynamic facial expressions have used stimuli, which present methodological limitations that we sought to remedy. In particular, most video database currently used, have not been empirically validated. For our freely available database, we recruited a total of 34 actors to express various emotions. A total of 1,088 grayscale video clips (34 actors * 4 exemplars * 8 expressions) were created. Clips include all basic emotions (happiness, fear, surprise, disgust, sadness, anger) as well as pain and neutral expressions. These videos were spatially aligned frame by frame, on the average coordinates of the eyes and nose (i.e., the clips only contain facial movements), and the luminance was calibrated to allow linear manipulation. All clips contain 15 frames (30 Hz) beginning on the last neutral frame. We empirically validated these stimuli through participants' rating the intensity of the emotions in all stimuli on continuous scales. The video database was adjusted to reflect a confusability matrix with satisfactory d's. We will discuss the main characteristics of the selected clips.

I43 1045 Different views of facial expressions: an image sequence dataset.

Christopher Benton[1] (chris.benton@bristol.ac.uk), Andrew Clark[1], Robbie Cooper[1], Ian Penton-Voak[1], Stavri Nikolov[2]; [1]Department of Experimental Psychology, University of Bristol, UK, [2]Department of Electrical & Electronic Engineering, University of Bristol, UK

Here we describe a face expression dataset containing image sequences showing different views of facial expressions as they develop from neutral to full onset. We recruited actors (11 female, 8 male) from our Drama Department and elicited 5 facial expressions (anger, disgust, fear, happiness and sadness) in a controlled lighting environment. We used a multi-camera array to gather high definition (1920x1080 pixels) uncompressed RGB image sequences (2 seconds at 25 Hz) simultaneously from 5 viewpoints (-45, -22.5, 0, 22.5 and 45 degrees), capturing the onset and development of the facial expressions. Actors faced the 0 degree camera. The angle of rotation was parallel to the ground plane and the cameras were equidistant from the actors' faces. In order to aid colour-adjustment of the images for (for example) daylight, we also gathered pictures of the actors using a calibrated digital camera and measured the colour characteristics of our scene using a spectral photometer (sampled from 380 to 760 nm in 5 nm steps). We show how our dataset can be combined with morphing techniques to produce finely graded changes in emotional expressions suitable for use in psychophysical experiments. Such sequences closely follow the actual development of the expressions and avoid morph-induced artifacts that may occur when one morphs between a neutral face and a full-blown expression. When combined with standard non-parametric staircase techniques this offers a powerful tool to assess sensitivity to facial expressions. In addition, we present data using facial emotion ratings and identification to provide a direct comparison of the facial expressions of our 19 actors with those of 10 actors from the Ekman and Friesen (1976) image set. To our knowledge our dataset provides a unique resource that can potentially be used by a wide variety of researchers interested in the perception of facial expression.

Acknowledgement: This research was supported by the British Academy

I44 1046 Color and facial expressions

Maiko Yasuda[1] (maiko@unr.nevada.edu), Shernaaz Webster[1], Michael Webster[1]; [1]University of Nevada, Reno

Colors are often strongly associated with different emotional states and facial expressions, and primate trichromacy may be specifically adapted for judging the health and state of conspecifics from the color of their complexion (e.g. Mollon, 1989; Changizi et al., 2006). We examined the influence of color on perceived expression, by examining how a change in color interacted with facial shape cues when subjects classified the expression on face images. Stimuli were frontal-view images of average male or female faces created with Singular Inversions FaceGen Modeller. The faces had a neutral expression or strong expressions of anger, happiness, or fear. Color in the faces was varied by rotating the hue angle and contrast of all pixels relative to the original color or to a grayscale image along cone-opponent or unique-hue axes. In the first experiment, arrays of faces were generated by morphing between each pair of the three expressions. The morph level was varied in a staircase to find the category boundary between expressions. These boundaries were unaffected by either natural or extreme variations in color. In a second task, subjects viewed a neutral-expression face in different colors and chose among 6 basic expressions. This revealed a large effect of color, with redder (+L/-M cone) faces rated more angry and greener (+M/-L cone) faces more afraid. In a final task, we tested for a direct link between color and expression coding by testing for contingent aftereffects when subjects were adapted to alternating red-angry and green-fearful faces. No color aftereffect was visible, consistent with previous reports for color and facial distortions (Yamashita et al., 2005). Together our results suggest that color and shape provide independently coded information about facial expression and that color cues become salient only in the absence of shape cues.

Attention: Theoretical and Computational Models

Author Presents: 2:00 - 3:45 pm

I45 1047 Interesting objects in natural scenes are more salient

Lior Elazary[1] (lelazary@yahoo.com), Itti Laurent[1]; [1]Department of Computer Science and Neuroscience Graduate Program, University of Southern California

How do we decide which objects in a visual scene are more interesting? Intuition suggests a complex process of recognizing different candidate scene elements in turn, evaluating their identity and other attributes against behavioral preferences and goals, and finally deciding which among the candidates are more relevant and interesting. Here we investigate the contributions of a much simpler process, saliency-based visual attention. We used the publicly available LabelMe database of 24,863 digital photographs in which 74,454 presumably interesting objects have been manually outlined. We evaluated how often these objects were among the few most salient locations by a computational model of bottom-up attention. We find that in 43% of all images the model's first fixation falls within a labeled region, twice above chance (21%). Furthermore, within three fixations, the saliency map is able to pick a labeled region over 85% of the time, with performance leveling off after six fixations. The bottom-up attention model has no notion of object nor of semantic relevance. Hence, our results indicate that selecting interesting objects in a scene is largely constrained by low-level visual properties of scene elements, rather than solely determined by recognition and higher cognitive processes. The saliency map is a strong predictor of what humans find interesting in complex natural scenes.

URL: ilab.usc.edu

I46 1048 Attentional modulation of tuning width, preferred features and gains during visual search

Vidhya Navalpakkam[1] (navalpak@usc.edu), Laurent Itti[1]; [1]Dept. of Computer Science, University of Southern California

Although attention is known to modulate neural activity, there has been much debate on whether it modulates tuning width, or preferred features, or gains. While some studies show evidence for changes in tuning width and preferred features without change in gains, other studies show evidence for gain modulation only. Here, we adopt a computational approach and ask what is the best way in which attention can modulate neural activity so as to maximize visual search performance. Our simulation results predict that all forms of modulation occur, but their utility varies with task difficulty due to target-distractor discriminability. While modulation of tuning width contributes little in easy tasks where the target and distractor are very different, its contribution increases in difficult tasks where the target and distractor are similar. The opposite trend is shown for gain modulation, whose contribution decreases with increasing task difficulty. This suggests that the conflicting experimental observations in the field may be due to differences in tasks and in their difficulty. This calls for new experiments that systematically investigate neural modulation as a function of task difficulty.

I47 1049 Integrating low-level and high-level visual influences on eye movement behavior

Robert Peters[1] (rjpeters@usc.edu), Laurent Itti[2]; [1]Computer Science, University of Southern California, [2]Computer Science, Neuroscience, Psychology, University of Southern California

We propose a comprehensive computational framework unifying previous qualitative studies of high-level cognitive influences on eye movements with quantitative studies demonstrating the influence of low-level factors such as saliency. In this framework, a top-level "governor" uses high-level task information to determine how best to combine low-level saliency and gist-based task-relevance maps into a single eye-movement priority map.

We recorded the eye movements of six trained subjects playing 18 different sessions of first-person perspective video games (car racing, flight combat, and "first-person shooter") and simultaneously recorded the game's video frames, giving about 18 hours of recording for ~15,000,000 eye movement samples (240Hz) and ~1.1TB of video data (640x480 pixels at 30Hz). We then computed measures of how well the individual saliency and task-relevance maps predicted observers' eye positions in each frame, and probed for the role of the governor in relationships between high-level task information -- such as altimeter and damage meter settings, or the presence/absence of a target -- and the predictive strength of the maps.

One such relationship occurred in the flight combat game. In this game, observers are actively task-driven while tracking enemy planes, ignoring bottom-up saliency in favor of task-relevant items like the radar screen; then, after firing a missile, observers become passively stimulus-driven while awaiting visual confirmation of the missile hit. We confirmed this quantitatively by analyzing the correspondence between saliency and eye position across a window of ±10s relative to the time of 328 such missile hits. Around –200ms (before the hit), the saliency correspondence begins to rise, reaching a peak at +100ms (after the hit) of 10-fold above the previous baseline, then is suppressed below baseline at +800ms, and rebounds back to baseline at +2000ms. Thus, one mechanism by which high-level cognitive information can influence eye movements is through dynamically weighting competing saliency and task-relevance maps.

Acknowledgement: Intelligence Community (IC) postdoctoral fellowship program
URL: http://ilab.usc.edu/rjpeters/

I48 1050 Attention based on Information Maximization

Neil Bruce[1,2] (neil@cse.yorku.ca), John Tsotsos[1,2]; [1]Centre for Vision Research, York University, [2]Department of Computer Science and Engineering, York University

Formal arguments exist establishing that the complexity of visual search prohibits extensive analysis of all visual content in parallel. It follows that the task of selecting important content out of the enormous pool of incoming sensory input may be regarded as a critical component of animal vision; theoretically as well as practically this remains an open, unsolved problem.

The history of this problem has seen many definitions for what comprises important visual content. This work posits a model termed Attention by Information Maximization (AIM) derived from first principles and firmly rooted in Information Theory. The proposal is a generalization of prior work (Bruce and Tsotsos, NIPS 2005) with the focus in this effort on how the model addresses classic psychophysics results.

The AIM model is derived from a single principle, specifically, that attention seeks to select visual content that is most informative in a formal sense. Although previous information theoretic models exist, we demonstrate that AIM forms a more natural definition and offer examples where existing efforts based on similar principles fail, additionally arguing that the model subsumes previous efforts based on analytic or heuristic definitions. The relation of the model to primate neural circuitry is also demonstrated.

AIM is compared to a variety of classic visual search paradigms revealing its efficacy in explaining an unprecedented range of effects such as pop-out, search efficiency, distractor heterogeneity, target and distractor familiarity, and visual search asymmetries among others. The model is described with sufficient specificity to operate on real images and is revealed to have a greater capacity to predict human gaze patterns than existing efforts. The generality of the definition allows consideration of saliency of arbitrary ensembles of neurons and examples derived from neurons coding for spatiotemporal content and complex stimuli are presented in addition to saliency based on simple V1 type cells.

I49 1051 Visual Search with Selective Tuning

Evgueni Simine[1] (eugene@cse.yorku.ca), Antonio J. Rodriguez-Sanchez[1], John K. Tsotsos[1]; [1]Dept. of Computer Science & Engineering, and Centre for Vision Research, York University, Toronto, Canada

Visual attention involves much more than simply the selection of next fixation for the eyes or for a camera system. Selective Tuning (ST) (Tsotsos et al. 1995;2005) presents a framework for modeling this broader view of attention and in this work we show how it performs in covert visual search tasks by comparing its performance to the same input visual displays that human subjects have seen and qualitatively comparing the model's performance to human performance. Two implementations of ST have been developed. The Motion Model (MM) recognizes and attends to motion patterns and the Object Recognition Model (ORM) recognizes and attends to simple objects formed by the conjunction of various features. Two experiments were carried out in the motion domain. A simple odd-man-out search for CCW rotating octagon among identical CW rotating octagons produced linear increase in search time with the increase of set size. The second experiment was similar to one described in Thornton and Gilden(2001) paper and produced qualitatively similar results. The validity of the ORM was first tested by successfully duplicating the results of Nagy and Sanchez(1990). Our second experiment aimed at an evaluation of the model's performance for the feature-conjunction-inefficient continuum search slopes (Wolfe, 1998). For conjunction search we followed Bichot and Schall(1999) (find a red circle among green circles and red crosses). For feature search ORM looked for a circle among crosses and for inefficient search we simulated Egeth and Dagenbach(1991). Inefficient search produced a slope of 0.49, followed by conjunction search (slope of 0.36) and feature search was practically flat (slope of 0.00), these results show the same kind continuum of search slopes as described by Wolfe(1998). We conclude that ST provides a valid explanatory mechanism for human covert visual search performance, an explanation going far beyond the conventional saliency map based explanations.

I50 1052 Parietal Lesion Leading to Hemineglect and Reduced Extrastriate Activity in a Computational Model of Visual Attention

Linda Lanyon[1] (llanyon@eyecarecentre.org), Susan Denham[2]; [1]Human Vision & Eye Movement Laboratory, University of British Columbia, [2]Centre for Theoretical & Computational Neuroscience, University of Plymouth

A neurophysiological computational model of visual attention [1] shows how replication of spatial and object-based attentional effects at the cellular level can lead to systems level performance that mimics search scan path behavior found in humans and monkeys [2]. Here we show how lesion of this model's parietal cortex leads to symptoms of visual neglect similar to that found in search scan paths produced by parietal patients with hemineglect [3]. Scan paths produced by the lesioned model are attracted to the ipsilateral hemifield of the search display and ignore stimuli present in the contralesional hemifield. Similar to patients [3], the lesioned model tends to re-fixate locations in the scan path more often. Lesion of the orbitofrontal portion of the model also increases re-fixation rates. During parietal lesion simulations, activity is also modulated within the ipsilesional extrastriate area (V4) of the model's ventral visual stream, despite this area being intact. This offers explanation of neuroimaging results showing increased activity in extrastriate cortex when stimuli are consciously perceived by parietal patients compared to when these stimuli do not enter conscious awareness [4].

[1] Lanyon, L. J. & Denham, S.L. (2004) Neural Networks: Special Issue: Vision & Brain, 17(5-6), 873-897

[2] Motter, B. & Belky, E.J. (1998) Vision Research, 38(12), 1805-1815

[3] Husain, M, Mannan, S, Hodgson, T, Wojciulik, E, Driver, J. & Kennard, C. (2001) Brain, 124, 941-952

[4] Driver, J., Vuilleumier, P., Eimer, M. & Rees, G. (2001) Neuroimage, 14, S68-S75

I51 1053 A decision-theoretic saliency, its biological plausibility and implications for pre-attentive vision

Dashan Gao[1] (dgao@ucsd.edu), Nuno Vasconcelos[1]; [1]Statistical Visual Computing Laboratory, University of California San Diego

A decision-theoretic formulation of visual saliency, first proposed for top-down processing (object recognition) in (Gao & Vasconcelos, 2005) is extended to the problem of bottom-up saliency. Under this formulation, optimality is defined in the minimum probability of error sense, under a constraint of computational parsimony. The saliency of the visual features at a given location of the visual field is defined as the power of those features to discriminate between the stimulus at the location and a null hypotheses. For bottom-up saliency, this is the set of visual features that surround the location under consideration. Discrimination is defined in an information-theoretic sense and the optimal saliency detector derived for a class of stimuli that complies with known statistical properties of natural images.

It is shown that the optimal detector consists of what is usually referred to as the standard architecture of V1 (Carandini, Demb, Mante, Tolhurst, Dan, Olshausen, et al., 2005): a cascade of linear filtering, divisive normalization, rectification and spatial pooling. The optimal detector is also shown to replicate the fundamental properties of the psychophysics of saliency (Treisman & Gelade, 1980): stimulus pop-out, saliency asymmetries for stimulus presence vs. absence, disregard of feature conjunctions, and Weber's law. Finally, it is shown that the optimal saliency architecture can be applied to the solution of generic inference problems. In particular, for the class stimuli studied, it performs the three fundamental operations of statistical inference: assessment of probabilities, implementation of Bayes decision rule, and feature selection.

Acknowledgement: This research was supported by NSF Career award IIS-0448609, NSF award IIS-0534985, and a gift from Google Inc.

I52 1054 Attention and contrast: A model linking single-unit and psychophysical data

Franco Pestilli[1] (fp302@nyu.edu), Samuel Ling[1], Marisa Carrasco[1,2]; [1]Department of Psychology, New York University, [2]Center for Neural Sciences, New York University

Several psychophysical studies with humans have reported that attention affects the contrast response function via contrast gain, response gain or both. Correspondingly, several neurophysiological studies have shown that attention modifies the contrast response functions of neurons in early visual areas, such as V4 and MT, by either contrast- or response-gain mechanisms. Whereas contrast gain corresponds to a change in sensitivity of the contrast response function, response gain corresponds to a multiplicative increase in response.

Although the pattern of results are consistent between psychophysical and neurophysiological studies, comparisons need to be made with caution, and an explicit link between psychophysical data and single-unit recordings should be established. To narrow this gap, we propose a simple biologically plausible model based on an extension of Jazayeri & Movshon's model (2006), which predicts optimal representation of sensory information given neural population response. To assess the effect of attention on contrast response, the model we propose makes specific quantitative predictions regarding gain changes in neural response as a function of performance in 2AFC orientation discrimination tasks. By changing the parameters of the assumed population – orientation tuning, threshold and saturation of the contrast response function– the model can predict attentional modulation at several visual areas (e.g., V1, V4).

I53 1055 A Model of Voluntary and Involuntary Attention

William Prinzmetal[1] (wprinz@berkeley.edu); [1]University of California, Berkeley

Many investigators have assumed that there are at least two kinds of attention: voluntary and involuntary attention. Both forms of attention affect reaction time (RT), but it is not clear whether they do so with the same mechanism. Recent evidence suggests that voluntary attention affects the perceptual representation but that involuntary attention does not. For example, Prinzmetal et al. (2005) reported that while voluntary and involuntary attention both affected RT in spatial-cueing experiments, only voluntary attention affected accuracy when displays were data limited and there was no speed pressure. Voluntary attention enhances a stimulus specific ventral-stream area (FFA), while involuntary attention does not (Esterman, et al., 2005). Using high frequency gamma band activity, Laudau et al. (2006) found different patterns of activity for voluntary and involuntary attention. These and other results have lead to the conclusion that involuntary attention does not affect perception.

If involuntary attention does not affect the perceptual representation, what are the mechanisms by which it affects RT? In this talk, I present a model of attention that illustrates how involuntary attention affects RT without influencing perceptual processing. The theory, based on the "Leaky Accumulator" model (Usher, & McClelland, 2001), accounts for involuntary attention by postulating that involuntary attention primes responses to stimuli presented at the cued location, irrespective if their identity. Voluntary attention, on the other hand, affects the rate of accumulation of perceptual information. This theory was tested in several experiments in which subjects were put under speed pressure to respond before a deadline. Results were consistent with predictions of the model, which postulates different mechanisms for voluntary and involuntary attention. Furthermore, the model accounts for a variety of findings in the spatial-cueing paradigm for both voluntary and involuntary attention.

I54 1056 Deriving and Modeling the Functional Architecture of Visual Selective Attention

George Sperling[1,2] (sperling@uci.edu), Ian Scofield[1], Arvin Hsu[1]; [1]Department of Cognitive Science, University of California, Irvine, [2]Department of Neurobiology and Behavior, University of California, Irvine

To derive a computational theory of the distribution of visual attention, use a linear systems approach. First, we measure an observer's ability to distribute his or her attention sinusoidally in space as per Gobell, Tseng, & Sperling (Vision Research, 2004, 19, 1273-1296). These sinusoidal data then enable us to make accurate, parameter-free predictions of the same observer's ability to distribute spatial attention in arbitrarily complex requested patterns, i.e., to attend to various locations arbitrarily arranged in space. Basic search task. Observers view a 150 msec exposure of an array of 144 disks arranged in a jittered 12x12 array. Observers must find a target (a larger disk in one of 72 attended locations) among the remaining smaller disks (distractors). To force an observer to confine attention to the 72 attended locations, 10 false targets (large disks) are distributed in the 72 unattended locations. In Experiment 1, the 72 attended locations constitute a grating of alternating columns (or rows). Spatial frequency 1 is 6 attended columns adjacent to 6 unattended columns, AAAAAA,UUUUUU. SF2 is AAA,UUU,AAA,UUU; SF3 is AA,UU,AA,UU,AA,UU; SF4 is A,U,A,U,A,U,A,U,A,U,A,U. In Experiment 2, the 72 attended locations are defined by 8 arbitrarily placed 3x3 blocks among the 144 locations. In Experiment 3, the 72 attended locations are defined by 18 arbitrarily placed 2x2 blocks. From the data of Experiment 1, we derived a spatial acuity function and an attentional modulation transfer function that enabled accurate predictions of performance in each the 144 locations of Experiments 2, and approximate predictions in Experiment 3 where the extreme complexity of the required distribution of attention itself became a new limiting factor. The attentional model enables predictions of performance in all the the less extreme configurations of spatial attention that have been previously studied.

Acknowledgement: Supported by Air Force Office of Scientific Research, Life Sciences

I55 1057 Sparing at a Cost: The Attentional Blink Serves to Enhance Episodic Distinctiveness

Brad Wyble[1] (bw5@kent.ac.uk), Howard Bowman[1], Mary Potter[2]; [1]Centre for Cognitive Neuroscience and Cognitive Systems, University of Kent, Canterbury UK, [2]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA

The Attentional Blink (Raymond , Shapiro, & Arnell 1992) is a well known example of the limited capacity of visual encoding. Recently, the phenomenon of sparing has been demonstrated to occur for four or more targets in a row (Nieuwenstein & Potter 2006; Olivers, Van Der Stigchel & Hulleman 2005; Kawahara, Kumada & DiLollo in Press), effectively eliminating the blink for targets presented at lags 2 and 3. This finding places traditional limited capacity accounts in a difficult position.

Our modeling work, suggesting the use of types and tokens as a working memory substrate, broadens the notion of capacity to include not just the identity, but also the episodic distinctiveness of targets. Our simulations suggest that sparing of target identity occurs because the system is incapable of disengaging attention from an unbroken sequence of targets. When this occurs, multiple items are encoded into a single perceptual episode, resulting in a loss of the episodic distinctiveness of individual items. This loss of episodic information predicts a number of impairments that are verified in behavioral experiments that will be described. These effects include (a) loss of temporal order of targets, (b) increased binding errors for elements of complex targets and (c) repetition blindness for identical items within a sequence of spared items.

Acknowledgement: EPSRC grant GR/S15075/01, NIMH MH47432

I56 1058 Abstract withdrawn

I57 1059 Evaluating the weighted salience account of eye movements

Benjamin Vincent[1] (ben.vincent@bris.ac.uk), Tom Troscianko[1], Iain Gilchrist[1]; [1]Department of Experimental Psychology, University of Bristol

The weighted salience model is a prominent account of image-driven visual attention (Itti & Koch, 2000). This model operates by: sampling the visual environment, calculating feature maps, combining them in a weighted sum, and using this to refixate the eye. Despite the model's simplicity, Bayesian approaches have become popular as they provide a single framework for examining the role of bottom-up and top-down factors, such as spatial context (Torralba, 2003). We show that weighted salience models can be seen as implementing Bayesian target/non-target discrimination which enables faster learning of feature weightings at the expense of assuming target and distracters are linearly separable in feature space. In conjunction searches with linearly separable targets and distracters, differences between predicted and actual visual search performance can explained by an inbuilt independence assumption between features. This may be overcome with learning of the joint statistics of these features.

We examined all of these stages of the weighted salience model, starting by accounting for the non-uniform retinal sampling. We found that spatial aliasing causes feature coding unreliability, raising unanswered questions about the distribution of receptive field properties in each feature map. Using natural images, we found good discrimination between targets and non-targets in the weighted sum 'salience' map using signal detection theory methods. However when we analyse the fixation criterion toward 'peak salience,' we find the strategy poor when distracter heterogeneity is high, a situation which might be expected in real world complex natural scenes.

In summary, the natural statistics of image features may need to be considered in order to explain variation in visual search performance. The 'weighted salience' model can be considered within the Bayesian approach which allows bottom-up and top-down factors to be addressed in a single framework.

Acknowledgement: Funded by EPSRC grant no GR/S47953/01(P)
URL: http://ben.psy.bris.ac.uk/

I58 1060 Towards a descriptive theory of value of information in categorization tasks: implications for theories of eye movement and information search

Jonathan D Nelson[1] (jnelson@salk.edu), Craig McKenzie[2], Garrison Cottrell[3], Terrence Sejnowski[1]; [1]Computational Neurobiology Lab, Salk Institute, [2]Rady School of Management and Psychology Department, University of California, San Diego, [3]Computer Science and Engineering Department, University of California, San Diego

Tuesday Posters

Statisticians have proposed a number of theories for choosing between possible experiments in order to identify which experiment is expected to be the most useful. Behavioral and eye movement research has addressed whether one or more of these theories describe human information acquisition in eye movement and behavioral information search tasks. Based on theoretical analysis and an experiment, Nelson (2005) suggested (1) that two theories of the value of information, Bayesian diagnosticity and log diagnosticity, are not credible descriptive psychological theories of the value of information, but (2) that data to date did not differentiate which of several other theories — information gain-KL distance, probability gain, and impact — best approximates human search.

We now report an experiment to test the different theories. Subjects learned the statistics of an environment involving simulated plankton. The plankton could be one of two species, which depended probabilistically on two binary features. Subjects first went through a learning phase, in which they classified randomly drawn plankton specimens as species A or B, with feedback. Once a subject consistently performed optimally, the experiment moved into the information-acquisition phase, in which the features of interest were obscured on each trial, and the subject selected a single feature to view.

Several between-subjects conditions contrasted the various theories of information search and, in every condition, the feature with higher probability gain was preferred by a majority of subjects. It appears that probability gain explains human information search much better than information gain-KL distance, impact, Bayesian diagnosticity or log diagnosticity.

Acknowledgement: funding provided by NIH 5T32MH020002-04

Spatial Vision: Natural Scenes and Texture

Author Presents: 2:00 - 3:45 pm

I59 1061 Efficiency in the discrimination of 1/f textures.

Craig Abbey[1,2] (abbey@psych.ucsb.edu), Miguel Eckstein[1]; [1]Dept. of Psychology, University of California, Santa Barbara, [2]Dept. of Biomedical Engineering, University of California, Davis

Human observer performance in visual texture discrimination tasks has become an important tool for understanding how the visual system encodes natural images (See, for example, Hansen and Hess, JOV, 2006). Much of the work in this area has built on a seminal set of experiments by Knill and colleagues (Knill, Field, and Kersten, JOSA-A, 1990) that used stationary and isotropic Gaussian textures with constant RMS contrast and power-law noise-power spectra (P(f) ò 1/fb). Exponents in the range of 2 to 4 are considered to be fractals. They find increased sensitivity for power-law exponents in the range of 2.8 to 3.6, and conclude that this may represent tuning of the visual system to these textures. While sensitivity is an important measure of visual function, it can also be revealing to consider efficiency, which is sensitivity normalized by the sensitivity of the ideal observer. To investigate the efficiency of texture discrimination for power-law processes, we have derived the Bayesian ideal observer, the optimal discriminator for a forced-choice discrimination task under reasonable prior probabilities and decision costs. The ideal observer decision variable is equivalent to a weighted integration of the stimulus power-spectrum, and performance of the ideal observer can be evaluated through Monte-Carlo simulations. The ideal observer sensitivity to Gaussian power-law textures increases substantially going from an exponent of 1 to 4. As a result, the efficiency of texture discrimination is approximately an order of magnitude higher at exponents near 1 compared to the exponents reported by Knill et al. Thus, from an efficiency perspective, the visual system is tuned to much lower exponents, well out of the fractal range.

Acknowledgement: NIH EY015925

I60 1062 Discrimination of amplitude spectrum slope of natural scenes during childhood

Dave Ellemberg[1,2] (dave.ellemberg@umontreal.ca), Bruce Hansen[3], Aaron Johnson[4]; [1]Department of Kinesiology, Université de Montréal, Montreal, Canada, [2]Centre de Recherche en Neuropsychologie et Cognition (CERNEC), [3]McGill Vision Research Unit, McGill University, Montreal, Canada, [4]Department of Psychology, Concordia University, Montreal, Canada

Accumulating evidence suggests that the adult visual system is optimally tuned for processing the spatial properties of natural scenes ($1/f^{\alpha}$ amplitude spectra). It is also documented that different aspects of spatial vision (e.g., acuity and spatial contrast sensitivity) develop at different rates and some do not become mature until late childhood. We compared natural scene perception in children aged 6, 8, and 10 years (n = 16 per age) and in adults (mean age = 23). A same-different task combined with a staircase procedure measured thresholds for discriminating change in the slope of the amplitude spectra of natural scene stimuli with reference α's of 0.7, 1.0, or 1.3. First, consistent with previous studies, adults were least sensitive for the shallowest · (i.e., 0.7) and most sensitive for the steepest · (i.e., 1.3). Second, a 4 (age group) X 3 (reference α's) repeated measures ANOVA revealed a significant interaction ($p < 0.01$). Post-hoc analyses of the interaction indicated no difference in threshold among any of the age groups for the α of 0.7. However, the 6- and 8-year-olds had significantly higher discrimination thresholds compared to the 10-year-olds and adults for α's of 1.0 and 1.3. Finally, the 10-year-olds' thresholds did not differ significantly from those of adults for any of the α's tested. These data suggest that sensitivity for detecting change in the spatial characteristics of natural scenes during childhood may not be optimally tuned to the statistics of natural images until about 10 years of age.

Acknowledgement: Supported by an NSERC grant to D.E.

I61 1063 Super-summation with natural scenes – size more than matters

Pinglei Bao[1] (pbao@usc.edu), Bosco S Tjan[1,2]; [1]Neuroscience Graduate Program, University of Southern California, [2]Department of Psychology, University of Southern California

Visual perception in a natural environment requires integration of information across space. Previous spatial summation experiments (contrast threshold vs. signal area) with gratings showed that optimal integration occurred only over a limited spatial extent (Kersten, 1984). We measured threshold contrast as a function of signal area in a scene-identification task. The scenes were either masked with correlated Gaussian noise that had an amplitude spectrum similar to those of the scenes, or were presented without noise. An observer's task was to determine if two simultaneously presented pictures (3.5½(w) x 9.9½ (h)) were taken from the same scenery (the pictures themselves were always different). Signal area was manipulated by cropping the pictures horizontally from full height to 15% of the full height. In the noise condition (noise RMS contrast = 10%), threshold contrast decreased with signal area with a log-log slope of -1/2 (0.54±0.07) over the entire range of signal area without reaching any plateau. This result suggests that the visual system can optimally integrate task-relevant information over an unlimited spatial extent! In the noise-free condition, threshold contrast vs. signal area had a log-log slope steeper than -1/2 (-0.94±0.18). This result can be explained by postulating that both local and long-range feature detectors mediate scene perception, with the long-range feature detectors being less noise-tolerant and less responsive to partial features. Reducing the signal area leads to more partial features and inactivates disproportionably many long-range feature detectors. The result is a sharp rise in contrast threshold for small signal area and thus a steep summation slope.

Acknowledgement: Supported by: NIH EY016391

I62 1064 **Learning Invariant and Variant Components of Time-Varying Natural Images**

Bruno Olshausen[1] (baolshausen@berkeley.edu), Charles Cadieu[1]; [1]Helen Wills Neuroscience Insitute and School of Optometry, UC Berkeley

A remarkable property of biological visual systems is their ability to infer and represent invariances in the visual environment. This information is important for determining 'what' we are seeing- i.e. recognizing objects and interpreting scenes. However, such a representation only addresses half of the story: the variant part, such as the motion of an object, captures the 'where' or 'how' information which is equally important for interpreting and interacting with the environment. Therefore, a complete visual representation should capture both the invariant and variant parts of images. Here we present a model that learns to separate the variant from the invariant part of time varying natural images. First, we reformulate the sparse coding model [Olshausen and Field, 1996] so that images are explained in terms of a multiplicative interaction between two sets of causal variables. One set of variables is constrained to change slowly over time (the invariant representation), and another set of variables is allowed to change quickly over time and is encoded as a phase angle (the variant representation). After training on natural image sequences, the learned basis functions are similar to those produced by the original sparse coding model – i.e., a set of Gabor-like functions that are spatially localized, oriented and bandpass. In this case, though, the multiplicative decomposition produces both invariant components with slowly changing responses, representing aspects of visual shape, and variant components in the form of phase angles precessing over time, representing their transformations. The model predicts the existence of two classes of cells in primary visual cortex that form the beginnings of a 'what' and 'where' representation of images. Moreover, the decomposition provided by this model paves the way toward the construction of hierarchical models for capturing more global aspects of the 'what' and 'where' structure in natural images.

Acknowledgement: NGA grant MCA 015894-UCB, NSF grant IIS-06-25223

I63 1065 **Imposing both local and global image statistics leads to perceptually improved superresolution**

Yuanzhen Li[1] (yzli@mit.edu), Edward Adelson[1]; [1]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology

When an image is degraded by noise or blur, an image enhancement technique can be used to push it toward its original appearance. This might mean either: (a) getting the individual pixels to resemble those of the original, or (b) getting the overall "texture" (e.g., noisiness or sharpness) to resemble that of the original. Most techniques are designed to get the pixels right, and use an objective error criterion such as mean squared error or a variant. In superresolution, the goal is to hallucinate missing high frequencies, especially those belonging to sharp edges. If the hallucinated edge position is slightly wrong, the error will be large. Therefore the best strategy may be to leave the edges soft, but then the goal of restoring sharpness has been lost. We argue that textural similarity is a valid additional criterion, both perceptually and statistically. If we know that our image came from a set of images with certain textural statistics, then we can impose them as a prior. An image with sharp hallucinated edges gets points for looking sharp, which can balance the points lost due to misalignments or other errors. We have developed a superresolution technique that learns, based on a training set, to impose local estimates of subband coefficients as well as global estimates of subband histograms. We had subjects compare our enhanced images with those produced by competing techniques, including commercial superresolution software. Our images were judged significantly better looking than the competition.

I64 1066 **Histogram skewness is useful and easily computed in neural hardware**

Lavanya Sharan[1] (l_sharan@mit.edu), Edward Adelson[1], Isamu Motoyoshi[2], Shin'ya Nishida[2]; [1]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, [2]NTT Communication Science Laboratories, Japan

There has been much interest in natural image statistics, notably the power spectrum of images and the kurtotic nature of histograms produced by subband filters. That is to say, the second moment (variance) and the fourth moment (kurtosis) of subband histograms have been widely studied, but the third moment (skewness) has been largely ignored. We have previously demonstrated that skewness is diagnostic of reflectance properties of surfaces such as albedo and gloss. In addition, skewness is correlated with perceptual judgments of albedo and gloss, suggesting that skewness or a related mechanism (e.g. blackshot, Chubb et al 2004) is utilized in surface perception. How might the human visual system compute skewness? We suggest a framework based on Heeger's contrast normalization model (Heeger 1993) with the following stages– i) linear filtering with on and off center-surround filters ii) half-wave rectification and an accelerating non-linearity iii) divisive normalization with pooling over both on-center and off-center streams iv) subtraction of the normalized on-center and off-center streams followed by spatial pooling. The resulting signal provides a measure of local skewness, similar to Pearson's skewness. By maintaining separate on and off-center streams, the model can keep track of contrast sign, an essential step in skewness calculations. There have been reports of cells in V1 and V2 that are selective for sign, and respond to either bright or dark dots and lines but not both. The accelerating non-linearity in ii) is required because it emphasizes the tails of the histogram. We find that squaring or cubing non-linearities work; in fact the precise choice of the exponent is not crucial. Thus, skewness or a similar measure of the asymmetry of a distribution can be computed with neural mechanisms and hardware.

Acknowledgement: NTT, NSF

I65 1067 **Center-surround effects in human discrimination of amplitude spectrum slope.**

Aaron Johnson[1] (aaron.johnson@concordia.ca), Bruce Hansen[2], Dave Ellemberg[3]; [1]Dept. Psychology, Concordia University, Montréal, Canada., [2]McGill Vision Research, Dept. Opthalmology, McGill University, Montréal, Canada., [3]Dept. Kinesiology, Université de Montréal, Montréal, Canada.

The human visual system is capable of effectively discriminating between different slope exponents in the amplitude spectra of natural scene images. Many stimuli used in previous studies were designed to stimulate only the foveal or parafoveal regions of the retina. However, in real-world viewing conditions, images are rarely presented in isolation, and are almost always embedded in a similar visual context. It is therefore important to understand how the visual system can discriminate between different natural scene slope spectra when they are embedded in surrounds possessing different amplitude spectra slopes. Subjects performed a same-different task combined with a staircase procedure to measure the thresholds for discriminating changes in the amplitude spectra slope of a central target image (α=0.7,1.0,1.3) that was embedded in a larger surround image. The surround varied in amplitude spectra fall-off (same as target, higher [+ 0.6 α], or lower [- 0.6 α]). The results were compared to a condition in which the central target was presented alone, without the surrounding patch. The results showed that discrimination thresholds were lower when the surround amplitude spectral slope was similar to that of the embedded target patch. Converesely, an increase in discrimination thresholds was found for conditions in which the amplitude spectral slope of the surround was higher or lower to that of the embedded target. This pattern was similar for the three target · values. Finally, for the conditions in which the centre and surround had the same spectral slope, discrimination thresholds were lowest when the target patch amplitude slope had an exponent of 1.0, and highest when the exponent was 0.7. Together, these results suggest that the foveal and peripheral mechanisms receive simultaneous and comparable activation in order for the visual system to optimally discriminate between different natural scene spectra.

I66 1068 **Minkowski summation of cues in complex visual discriminations using natural scene stimuli**

Michelle To[1] (mpst2@cam.ac.uk), P. George Lovell[2], Tom Troscianko[2], David Tolhurst[1]; [1]Department of Physiology, Development and Neuroscience, University of Cambridge, [2]Department of Experimental Psychology, University of Bristol

Quick's vector magnitude model (1974, Kybernetik 16, 65-67) suggests that the detectability of a compound visual stimulus can be estimated by nonlinearly summing the detectability of the component elements. We investigated whether this could be extended to suprathreshold tasks using complex natural images. In three discrimination experiments, observers made subjective ratings of the difference between many naturalistic image pairs. Each experiment comprised combination groups that were composed of three image pairs: in two pairs the images differed along different single dimensions; the third pair was a composite, differing along both dimensions (e.g. change of object colour in Pair 1; change of image blur in Pair 2; and changes of both colour and blur in Pair 3). We investigated whether the ratings for composite pairs could be predicted by combining the ratings from their respective component pairs. In Experiment 1, 11 observers were presented with a wide variety of image pairs (900) that included 136 combination sets. The ratings for component pairs accurately predicted the ratings for the 136 combination pairs using Minkowski summation with an exponent of 2.78. Similar results were obtained in Experiment 2 when repeating the procedure using colour-distorted and inverted image pairs on 11 new observers (best Minkowski exponent of 2.79). In Experiment 3, 15 observers were retested on 432 new combination sets, generated from 6 parent images by summing coupled cues in various proportions (best Minkowski exponent of 2.95). When all 704 combination sets were compiled, Minkowski summation with an exponent of 2.84 had the strongest predictive power, a value similar to that previously reported in compound grating detection experiments. The correlation coefficient between predicted and measured combination-pair ratings was 0.96. This suggests that vision theories for detecting simple stimuli can be extended to more complex types of visual processing.

Acknowledgement: Supported by EPSRC/Dstl (GR/S56399/01 & GR/S56405/01).

I67 1069 **Labeling contours in natural scenes**

James Christensen[1] (christensen.68@osu.edu), James Todd[1]; [1]Department of Psychology, The Ohio State University

Contours in natural images can arise from a variety of causes such as reflectance changes, shadows, occlusions, sharp edges or specularities. However, there are no existing computational models for determining 3D shape from image data that can successfully analyze all of these possible contour types. In order to avoid the application of these models to inappropriate image structures, it would be especially useful to identify contours at an early level of processing. The present research was designed to measure the ability of human observers to label the contours within small isolated patches of photographs or computer generated images, in an effort to determine the minimal amount of contextual information that is required for accurate performance. On each trial, a small region of a larger image was presented within a circular aperture, and observers were required to estimate the identity of a designated contour and provide a confidence rating. They were also asked to identify the depicted object if possible. The aperture sizes were gradually increased throughout the experiment, such that the contours in the smallest apertures were completely ambiguous, while those in the largest apertures could be identified with perfect accuracy. Stimuli were randomly mixed such that all contours in the smallest apertures were judged prior to increasing the aperture sizes. The results reveal that humans are capable of identifying contour types with relatively little contextual information, and this usually occurs when they are still unable to identify any specific objects in a scene. In most cases, correct contour identification occurs when the aperture is sufficiently large to reveal a single vertex, such as a Y, X or arrow.

I68 1070 **Salience of mirror symmetry in natural patterns.**

Elias Cohen[1] (ecohen@sunyopt.edu), Qasim Zaidi[1]; [1]SUNY College of Optometry

Many studies suggest that axes of mirror symmetry are salient visual structures perceived effortlessly. While this may be true for classes of noise or dot stimuli used in previous studies of symmetry perception, it is unknown whether this is true when the underlying pattern also contains structure. This study quantifies the salience of symmetry across a variety of patterns and identifies the determining factors. Observers were presented with 101 classes of symmetric pattern, generated by reflecting and adding Brodatz textures. The minimum presentation duration required to reliably identify the axis of symmetry as vertical or horizontal was measured by randomly interleaved 2AFC staircases. Thresholds for texture types varied between 40 and 400 ms, showing that salience of symmetry depends on the underlying pattern. Using image analysis, we identified two factors that underlie this dependence. First, if the structure at the symmetry axis is similar to the structure in the rest of the image, longer durations are required to identify the axis. Second, a comparison of the pooled responses of V-shaped filters oriented at, versus orthogonal to and surrounding, the axis of symmetry correlated with salience of the axis. Taken together these two factors explain more than 50% of the variance in duration thresholds. Since V-shaped filters pick up mirror orientations across the axis, their success demonstrates that mirror orientations are the major component of pattern symmetry. Combinations of V-shaped filters of different angles would also be suited to extracting 3-D shape from texture orientation flows, suggesting a common neural substrate for two different visual functions.

I69 1071 **Evidence for linear summation of information across orientation channels in texture perception.**

Nicolaas Prins[1] (nprins@olemiss.edu); [1]Department of Psychology, University of Mississippi

Rotating an orientationally narrow-band texture is akin to increasing contrast in one 'off-orientation' channel while decreasing contrast in the opposing off-orientation channel. Varying the amplitude of rotation primarily affects the contrast amplitudes in the off-orientation channels, while the locations on the orientation continuum of the off-orientations remain relatively stable. As such, an orientation-modulated (OM) texture, in which alternating regions are rotated in opposite directions, contains four distinct contrast deviations relative to its unmodulated counterpart. Each of these four deviations could serve as a cue to detect the modulation. In the experiments reported here, textures were created in which the four cues are combined in a variety of ways. The cues were added to an unmodulated 'base texture'. The addition of cues was performed in the Fourier domain, resulting in a lack of perceived transparency between the base texture and the added cues. Rather, an increase of contrast in one off-orientation channel, for example, leads to a perceived increase of overall contrast and a slight shift in the perceived global orientation in the texture region. Depending on the particular combination of cues, either the texture's overall orientation, overall contrast, or both are modulated. Results indicated that cues within the same orientation channel always sum linearly. It was also found, somewhat surprisingly, that cues sum linearly across orientation channels as well, but only when cues are combined such that the resulting texture is modulated in overall contrast. All other combinations lead to probability summation of cues. Finally, a difference between the naive, inexperienced observers and the author was observed, in that the author displayed probability summation of cues under all conditions. Control experiments explored the source of this observed difference.

I70 1072 **Cross-frequency Interactions Contribute to the Central Performance Drop**

Rick Gurnsey[1] (Rick.Gurnsey@concordia.ca), Cindy Potechin[1]; [1]Department of Psychology, Concordia University

Sensitivity to texture contrasts often improves as the disparate region is moved from fixation into the periphery. Because performance is non-optimal at fixation this phenomenon is referred to as the Central Performance Drop (CPD). The CPD has been explained as a mismatch between the scale of the texture and the scale of the available texture segmentation mechanisms; at fixation the available mechanisms are too small to support segmentation whereas at some point in the periphery the match is optimal. However, one would expect the range of available scales in the periphery to be a subset of the range available at fixation. One resolution to this apparent conundrum suggests that the responses of uninformative high-frequency mechanisms at fixation dilute the information available in more informative low-frequency mechanisms. This has been termed Cross-Frequency Interference (CFI). Gurnsey et al. (1996, JEP:HPP) reasoned that when high frequencies are removed through low-pass filtering the result should be a release from inhibition and improved performance at the fovea; this result was not obtained. Following the same logic Morikawa (2000, Vision Research) found that low-pass filtering improved foveal performance. However, the filtered stimuli were contrast enhanced thus rendering the results ambiguous. Carrasco et al. (in press, Perception & Psychophysics) found release from inhibition (attenuation of the CPD) following adaptation to a high frequency grating. However, the adapting stimulus had the same orientation as the background texture (but not the disparate texture) suggesting that adaptation functioned to enhance the relative salience of the disparate texture. We reran each of these three experiments with appropriate modifications. In contrast to Gurnsey et al. (1996) we found clear evidence for CFI when textures were low-pass filtered. We found no evidence that adaptation enhanced the salience of the disparate texture. We conclude that there is a role for CFI in the CPD

I71 1073 **Distinct neural correlates of texture segmentation and grouping by collinearity in humans**

Clara Casco[1] (clara.casco@unipd.it), Gianluca Campana[1]; [1]Department of General Psychology, University of Padova

We investigated whether facilitation by collinearity in segmentation and grouping of texture elements arises through the same or different neural mechanisms. The texture stimuli consisted of 9x9 matrices of Gabor-elements all oriented at 45° except for three central Gabors oriented at either 90° or 180° to form horizontal or vertical 3-Gabor groups. Within a block, the Gabors in the groups were either collinear and iso-oriented with group orientation, or else non-collinear and ortho-oriented. Both psychophysical and event-related potentials (ERP) responses were obtained under identical stimulus conditions and two different tasks, each performed with attention either fully engaged or partially withdrawn by a digit categorization in eccentric RSVP. The local task involved segmentation based on local orientation contrast, and consisted in discriminating the orientation (horizontal or vertical) of the central Gabor in the 3-Gabor group. The global task, involving both segmentation and grouping, consisted in discriminating the orientation of the 3-Gabor group.

Psychophysical data showed lower accuracy and larger effect of attention in the local task, but similar collinear facilitation in the two tasks. Texture-specific potentials reflected a collinear facilitation in the local task, indexed by a larger negativity peaking at N75 and N200 for electrodes in the occipital region (Oz, O1 and O2). In the global task, collinear facilitation was indexed by a larger positivity peaking at P60, and a reduced negativity peaking at N75 and at N150 for Oz, O1 and O2 electrodes. Consistently with our previous work (Casco et al., 2005), disengagement of attention affected the ERPs amplitude more for collinear stimuli, specifically for the N75 component (in both tasks) and for the P60 (in the global task).

The novel findings are a different neural correlate of facilitation by collinearity in segmentation and grouping, and a different neural correlate of attentional modulation for segmentation and grouping.

I72 1074 **Evidence from fMRI for structural non-selectivity in texture segregation**

Lars Strother[1] (strother@cmu.edu), Sarah Shomstein[1], Marlene Behrmann[1,2]; [1]Department of Psychology, Carnegie Mellon University, [2]Department of Psychology, University of Toronto

Texture segregation is a fundamental process in visual perception. The present study employed rapid event-related functional magnetic resonance imaging (fMRI) to investigate neural mechanisms involved in the perception of texture-defined regions. Observers viewed arrays of Gabor elements arranged on a polar grid and were instructed to indicate the location of a target region that differed in global structure from the remainder of the array. Local orientation determined three types of structure in this region: (a) concentric curvilinear structure, (b) randomly arranged elements or (c) an intermediate level of perturbed curvilinear structure. These same properties also characterized regions surrounding the target. Target salience was determined behaviorally both prior to and during fMRI acquisition and was confirmed to be a function of the structure of the target region relative to its surroundings.

We used retinotopic mapping to compare BOLD responses in early visual areas (V1, V2, V3/VP, V4/V8) to those obtained in higher visual areas. We found strong evidence for correlations between BOLD signal and target salience in V4/V8 but not in earlier visual areas. The strongest correlations were observed for attention-related areas in parietal cortex (e.g. SPL and TPJ). Our findings suggest differential sensitivity to the structure of a target relative to its surroundings. Whereas some visual areas (e.g. V4/V8 and LO) exhibited responses consistent with the acquired behavioral data, this consistency was observed to a lesser degree in earlier retinotopic visual areas. Interestingly, the observed fMRI responses do not seem to correspond to the specific structure of a target region but to the salience of this region in a particular context. Our findings have implications for the neural systems involved in mapping visual salience irrespective of the basic visual properties that give rise to the perceived global structure.

I73 1075 **Interactive effects of size, contrast, intensity and configuration of background objects in evoking disruptive camouflage in cuttlefish**

Chuan-Chin Chiao[1] (ccchiao@life.nthu.edu.tw), Charles Chubb[2], Roger Hanlon[3]; [1]Department of Life Science, National Tsing Hua University, Hsinchu, Taiwan, [2]Department of Cognitive Sciences & Institute for Mathematical Behavioral Sciences, University of California at Irvine, [3]Marine Biological Laboratory, Woods Hole, Massachusetts

Disruptive body coloration is a primary camouflage tactic of cuttlefish. Because rapid changeable coloration of cephalopods is guided visually, we can present different visual backgrounds (e.g., computer-generated, 2-dimensional prints) and video record the animal's response by describing and grading its body pattern. We showed previously that certain aspects of size, contrast, and number of light squares on a checkerboard background elicit disruptive coloration in cuttlefish. Here we test some of the complex interactions among key background features such as size, contrast, overall intensity, and context (or configuration). A key finding is that contrast (measured as Weber contrast) has a strong influence on evoking disruptive coloration, even over large variations in size of the light objects on a dark surround (shown previously to be the central basic stimulus). Moreover, for fixed light object Weber contrast, disruptive responding decreases with increasing background mean luminance. This study highlights the complex interactions of multiple features of visual backgrounds that directly influence the choice of camouflage pattern that a cuttlefish will choose as it encounters different visual microhabitats in the natural environment.

Acknowledgement: Support: National Science Council of Taiwan, NSC-95-2621-B-007-001-MY3

I74 1076 **A New Method for Generating Discriminable Texture Pairs With Identical Autocorrelation Functions**

Steven Kies[1] (skies@uci.edu), Charles Chubb[1]; [1]Cognitive Sciences, University of California, Irvine

Julesz (1975) famously conjectured that any two textures with identical autocorrelation functions would be indiscriminable. Although various counterexamples have been discovered, new methods for constructing textures with identical space-average autocorrelation functions remain important because they often lead to useful insights about preattentive visual processing.

We describe a new method that uses three simple facts in concert to generate texture pairs with equal space-average autocorrelation functions. First, if an image is shifted, its autocorrelation function remains unchanged. Second, if an image is rotated 180 degrees, its autocorrelation function remains unchanged. Third, for any two random stimuli, at least one of which has expectation 0 (i.e., expectation equal to the uniform background field), the expectation of the autocorrelation function of their sum is equal to the sum of the expectations of their separate autocorrelation functions.

How do we use these facts to make textures? Start, for example, with two small figures, A and B (e.g., an 'L' shape and a rectangle), configured in some way on a gray background. Fix the contrast of figure A (e.g., make A white), but let B be white or black with equal probability: call this type of micropattern M1. Then translate and/or rotate by 180 deg. either or both of A and/or B to form a new micropattern type, M2. Tile the left side of the stimulus field with independent realizations of M1 and the right side with realizations of M2.

This method often yields powerfully distinct texture pairs. Discriminability is harder to achieve if one requires that M1 and M2 "share the same footprint" (i.e., |M1| = |M2|). We will demonstrate several discriminable textures satisfying this constraint.

Motion: Apparent Motion and Illusions

Author Presents: 4:00 - 5:45 pm

I75 1077 **Illusory motion due to causal time filtering**

Cornelia Fermuller[1] (fer@cfar.umd.edu), Hui Ji[2]; [1]Computer Vision Laboratory, UMIACS, University of Maryland, [2]Department of Mathematics, National University of Singapore

Static patterns by Kitaoka (2006), the most well known of which is the "Rotating Snake", elicit forceful illusory motion. The patterns are composed of repeating patches of asymmetric intensity profile, in most cases organized circularly. Motion perception depends on the size of the patches and is found to occur in the periphery for larger patches and closer to the center of the eye for small patches. We propose as main cause for these illusions erroneous estimation of image motion due to eye movements. The reason is that image motion is estimated from the spatial and temporal energy of the image signal with filters which are symmetric in space, but asymmetric (causal) in time. In other words, only the past, but not the future, is used to estimate the temporal energy. It is shown that such filters mis-estimate the motion of locally asymmetric intensity signals for a range of spatial frequencies. This mis-estimation predicts the perceived motion in the different patterns of Kitaoka as well as the peripheral drift illusion, and accounts for the effect at varying patch size. This study builds upon our prior work on the distortion of image features and movement (Fermüller and Malm 2004). Kiatoka (2006): http://www.ritsumei.ac.jp/~akitaoka/index-e.html.

C. Fermüller and H. Malm (2004)." Uncertainty in visual processes predicts geometrical optical illusions ", Vision Research, 4, 727-749.

I76 1078 **Aperture Induced Motion: Illusory motion percepts arising from conflicting terminator and component motion signals**

Gideon P. Caplovitz[1] (gcap@dartmouth.edu), Peter U. Tse[1]; [1]Dartmouth College

When a drifting grating is observed through a stationary circular aperture, the aperture itself will appear to either displace (De Valois & De Valois, 1991) or move (Zhang, Yeh & De Valois 1993; Tse & Hsieh 2006) creating an illusory global motion percept. Here we describe a novel stimulus in which a drifting grating moving behind a stationary rectangular aperture induces an illusory motion percept: Aperture Induced Motion (AIM) that is dependent upon the relationship between terminator and component motion. The stimulus is a variant of that used to demonstrate the Barberpole Illusion (Wallach 1935). When a drifting grating is viewed through a stationary and diagonally-oriented rectangular aperture, either the aperture or the occluders can be observed to move. In a series of motion-nulling and constant-stimuli psychophysics experiments we describe the relationship between the illusory percept and the orientations of the aperture and drifting grating and explore the roles of occlusion, component-motion, trackable features, and contour relationships. Results: The angle between the orientation of the grating, which determines the component motion, and the orientation of the aperture, which determines the terminator motion, is critical in determining the magnitude of the AIM.

Acknowledgement: This project was funded by NIH Grant R03 MH0609660-01 grant to PUT and by a predoctoral NSF fellowship 2005031192 to GPC.

I77 1079 **A new Barbers Pole configuration to study the integration of local motion information**

Johannes Zanker[1] (j.zanker@rhul.ac.uk), Stefano Targher[1], Szonya Durant[1]; [1]Department of Psychology, Royal Holloway University of London

The Barbers Pole illusion is an instructive demonstration of the mechanisms in the visual system that integrate local motion information. Long-range interactions between ambiguous and unambiguous motion components have been investigated in a cross shaped arrangement of two elongated apertures (Castet et al., Spatial Vision 12, 1999). Here we present experiments using a lattice configuration of several horizontally and vertically extended apertures ('slits') behind which a diagonal grating is moving at constant speed. As expected from the Barbers Pole illusion, observers perceive horizontal motion in the horizontal slits and vertical motion in the vertical slits. At the intersections between the perpendicular slits the ambiguous information is resolved as a bistable motion percept – observers report an alternation between horizontal and vertical motion, which interestingly appears to happen in synchrony for all intersections. We used small occluders to extend either the horizontal or vertical aperture outlines across one of the intersections, and asked participants to report the dominating motion direction at this intersection, or at neighbouring intersections which had no occluders. These experiments show that bistable percepts disappear not only in the intersection that has been disambiguated but also in neighbouring ones, for a wide range of stimulus parameters. This bias towards the disambiguated motion direction drops off with increasing distance from the occluded intersection, allowing us to assess the relative strength of long-range interactions between local motion signals that play a crucial role in the Barbers Pole illusion.

I78 1080 **Sub-threshold summation of Glass patterns and real motion**

Maria Michela Del Viva[1,2] (michela@in.pi.cnr.it), Monica Gori[3,4]; [1]Dipartimento di Psicologia, Universit‡ di Firenze, [2]Istituto di Neuroscienze, CNR Pisa, [3]IIT, [4]DIST, University of Genova

Glass patterns (Glass, 1969) are arrays of dot pairs (dipoles) randomly positioned, sharing a common global orientation. A sequence of such patterns, where dipoles are randomly repositioned at each screen refresh, conveys a strong sense of global motion, without containing motion information (Ross et al., 2000). Glass patterns influence perceived direction and speed of global motion when added to real motion stimuli (Ross, 2004), and activate the same brain regions (Krekelberg et al., 2003).

However, motion induced by Glass patterns is peculiar: it is perceived alternatively in two opposite directions, without producing any sense of transparency. This observation suggests that the conflict between directions is generated before analysis by global motion areas. Low-level directional mechanisms, such as Reichardt detectors, are the most likely candidates for this analysis.

To address this issue we superimposed Glass patterns sequences on moving dots with sub-threshold contrast, and measured motion-direction discrimination as a function of Glass patterns contrast. All subjects perceived motion in the direction of sub-threshold moving dots with at least 70% correct performance, with several of them reaching 90%. This summation effect drops down to chance level when the Glass pattern contrast is increased beyond 10%, likely due to the Glass patterns' ambiguous signals prevailing over the weaker signal from real motion.

A control stimulus obtained by replacing Glass pattern dipoles with single dots showed no summation effect.

The results suggest that Glass patterns and real motion are analyzed by the same low-level directional mechanism.

I79 1081 Graphic invariants for representing motion throughout the history of art

Simone Gori[1] (simone.gori@unipd.it), Riccardo Pedersini[1], Enrico Giora[1]; [1]Department of General Psychology, University of Padua

Identifying graphic invariants holding throughout the all history of art is an important aim not only for a comparative study of art history, but also from the perspective of visual science, interested in the mechanisms underlying visual perception. In the present study, we describe how painters use the same graphic solutions to represent motion in garments across countries and centuries. A pilot experiment, using 160 paintings representative of all main western European art movements from the XIII to the XX century, shows that different artists represented motion in garments by means of lines having the same pattern of orientation, curvature and convergence. The strongest perception of dynamism was obtained using a major number of curved, convergent and diagonal lines. On the contrary straight, parallel and orthogonal lines leaded to a clear impression of stativity. Expt 1 demonstrates, with a smaller sample of paintings (16, i.e. two per century) that orientation, curvature and convergence of lines can be used as good predictors of perceived motion. Expt 2 shows how the same garments, isolated from the context of the paintings, still give different dynamism impressions according to the same rules. Finally, Expt 3 confirmed the same results when the stimuli were a set of squares of fixed size, containing only high contrast lines reproducing the geometrical patterns present in the stimuli showed in Expts 1 and 2. Our data suggest the existence of a perceptual mechanism underlying motion perception that specifically recognizes orientation, curvature and parallelism of lines as cues of motion in a static pattern. These results seem to suggest that three-dimensional indices in a two-dimensional static image can trigger an impression of motion.

I80 1082 Explaining the Footsteps, Bellydancer, Wenceslas, and Kickback Illusions

Piers Howe[1] (phowe@hms.harvard.edu), Peter Thompson[2], Stuart Anstis[3], Hersh Sagreiya[1], Margaret Livingstone[1]; [1]Dept. Neurobiology, Harvard Medical School, [2]Dept. Psychology, University of York, [3]Dept. Psychology, University of California San Diego

The Footsteps Illusion demonstrates that an object's background can have a profound effect on the object's perceived speed. This illusion consists of a yellow bar and a blue bar that move over a black and white striped background. Though the bars move at a constant rate, they appear to repeatedly accelerate and decelerate in antiphase with each other. Previously, this illusion has been explained in terms of the variations in contrast at the leading and trailing edges of the bars that occur as the bars traverse the striped background. Here we show that this explanation is inadequate and instead propose that for each bar the bar's leading edge, trailing edge, lateral edges, and the surrounding background edges all contribute to the bar's perceived speed, and the degree to which each edge contributes to the motion percept is determined by that edge's contrast. We show that this theory can explain all the data on the Footsteps Illusion and also can explain the Bellydancer and Wenceslas Illusions. We conclude by presenting a new illusion, the Kickback Illusion, which, though geometrically similar to the Footsteps Illusion, is mediated by a different mechanism, namely reverse phi motion. Examples of all the stimuli used in the experiments will be shown.

Acknowledgement: This work was supported by a Helen Hay Whitney Foundation grant to P.H., a grant from the UCSD Academic Senate to S.A., and NIH grant EY 13135 and ARO grant 46961 to M.L.

URL: http://mysite.verizon.net/vzeejf0b/index.html

I81 1083 Effects of eccentricity and retinal illuminance on the rotating snakes illusion.

Rumi Hisakata[1] (hisakata@fechner.c.u-tokyo.ac.jp), Ikuya Murakami[1]; [1]Department of Life Sciences, University of Tokyo.

Kitaoka recently reported a novel dramatic illusion, the Rotating Snakes (Kitaoka & Ashida, 2003), in which a stationary pattern appears to rotate constantly. The pattern is comprised of luminance defined micropatterns, each having four adjacent regions of different luminances, black, dark gray, white, and light gray. The direction of the illusory motion is perceived in this order. However, it remains a fundamental question as to why and how such an illusion occurs. Here we introduce a cancellation method to quantify this motion illusion, thereby determining the strength of illusion as the physical rotation velocity in the opposite direction that just cancels the illusion. In the first experiment, we attempted to quantify the anecdote that this illusion is better perceived in the periphery. The stimulus was a ring composed of the stepwise luminance patterns mentioned above and was presented in the left visual field constantly. The right eye was used. The subject's task was to indicate in which direction, clockwise or counterclockwise, the stimulus ring appeared to rotate. With increasing eccentricity, the cancellation velocity increased, and was saturated at about 12 degrees. In the next experiment, we examined the effect of retinal illuminance. The stimulus was always presented at 12 degrees eccentricity. The illuminance was varied by putting neutral density filters in front of the subject's eye. Interestingly, the cancellation velocity decreased as the retinal illuminance was decreased. From these results, we argue that (1) the rotating snakes illusion maximally occurs at a certain spatial scale in relation to early retinotopic organization, and that (2) it is mediated by an early mechanism that is sensitive to illuminance level. More specifically, we discuss that this illusion is a result of some early process having different temporal response properties depending on photopic levels, presumably in the form of different temporal impulse response functions.

Acknowledgement: Supported by Grant-in-Aid,MESC 18203036.

I82 1084 Rotating Ouchi illusion

Akiyoshi Kitaoka[1] (akitaoka@lt.ritsumei.ac.jp), Ikuya Murakami[2]; [1]Department of Psychology, Ritsumeikan University, [2]Department of Life Sciences, University of Tokyo

We devised a new method to observe the Ouchi illusion more easily than the original image made up of elongated checker patterns. The new image consists of "spiral" checker patterns, in which black and white parallelograms are drawn along Bernoulli's spirals. Of the four "sides" defining each parallelogram, the top and bottom are drawn along Bernoulli's spirals of a particular orientation while the other two are Bernoulli's spirals of a different orientation. When observers approach or move away from the image while fixating at the center, the image appears to rotate clockwise or counterclockwise depending on the orientations of the spirals assigned to the shorter sides and the longer sides. We examined apparent rotation by systematically changing the orientations of spirals. As a result, for most of the images examined, observers reported apparent rotation in the direction that agrees with the prediction from the aperture problem. That is, for the physically expanding/contracting retinal image, the perceived motion of each edge was biased toward the perpendicular direction to the local edge orientation, thus creating rotary global motion. However, the opposite direction was also reported in some cases. We argue that these results are reconciled in terms of Fourier components in the image.

URL: http://www.ritsumei.ac.jp/~akitaoka/index-e.html

I83 1085 A Filehne illusion at equiluminance

Ikuya Murakami[1] (ikuya@fechner.c.u-tokyo.ac.jp); [1]Department of Life Sciences, University of Tokyo

Equiluminance is known to compromise several aspects of temporal vision including perceived speed. However, most studies have been conducted with fixating eyes, making it difficult to infer what happens in more naturalistic viewing conditions with moving eyes. During smooth pursuit eye movements, the visual image retinally moves in the opposite direction. To compensate for such retinal image slip, the visual system is arguably comparing two velocity signals, one from visual inputs and the other from extraretinal information such as the efference copy of oculomotor commands. If both signals were obtained with the gain of unity, externally stationary objects would be perfectly stable in the visual world as well. However, a stationary object usually appears to move in the opposite direction to pursuit (the Filehne illusion), indicating that the gain of extraretinal information may be less than one. The question of this study is, what kind of motion is perceived if the stationary object is equiluminant? The prediction is that, if the input gain of retinal velocity is lower at equiluminance, the Filehne illusion will be reduced or even reversed to the same direction as pursuit. Our observations revealed that it is actually the case, though within a limited range of pursuit speed. This reversed Filehne illusion was more pronounced in peripheral viewing, in which an equiluminant stationary object sometimes appeared to be glued to the moving gaze. These results suggest that speed reduction at equiluminance takes place in an early processing level of retinocentric coding, in accord with current neurophysiological knowledge about the parvocellular-blob information stream, but that the successive stage of velocity comparison with extraretinal information can result in overestimation of the external velocity of the equiluminant object, so color-defined things can look faster. This is also consistent with classical claims about unstable, "jazzy" impressions of equiluminant stimuli.

Acknowledgement: Supported by Nissan Science Foundation

I84 1086 Measuring the freezing rotation illusion

Max R. Dürsteler[1] (max.duersteler@usz.ch); [1]Dept. of Neurology, University Hospital Zurich, CH-8091 Zurich, Switzerland

I presented the “freezing rotation illusion” at the 2006 “Best Visual Illusion of the Year Contest”. When a foreground object (center) is continuously rotating while its surround is rotating sinusoidally back and forth, the rotation of the center is perceived as periodically slowing down. The slowdown occurs when the center rotates in the same direction as the surround. It is seen best, when the center’s rotational speed is below the surround speed. If the speed of the center is close to speed of the swaying surround, a different percept reminiscent of motion capture may arise: the center sticks to the surround throughout the half-period, when center and surround are rotating in the same direction. The motion capture effect is stronger with small translucent objects and eccentric fixation. The roles of surround and center cannot be exchanged: an oscillating center does not alter the perceived speed of a continuously turning surround.

I measured the effects of surround rotation and center rotations on the rotational speed perception of center and surround. Test stimuli where composed of a central disk and an equal-sized annular surround painted with random dot patterns. Probe stimuli were similar to the test stimuli: the random dot pattern of the surrounding annulus was replaced with a uniformly gray; in control experiments, the central disk was gray. To minimize motion after-effects seen in pilot experiments, I adapted a stair-case method to my experimental paradigm allowing for short stimulus presentation times. Subjects had to compare the rotational speeds of corresponding stimulus elements. In all four healthy subjects, the changes of rotational speed induced by the surround (range of averages: 2.0 °/s to 15.5 °/s) were significantly higher ($p < 0.005$) than the changes induced by the center (range of averages: 0.0 °/s to 1.3°/s). The results confirm the above observations.

URL: http://journalofvision.org/6/6/547

I85 1087 Competition for perception: Internal models vs retinal transients in perceiving positions of moving objects

Gerrit W Maus[1] (G.W.Maus@sussex.ac.uk), Romi Nijhawan[1]; [1]Psychology Department, University of Sussex

Mislocalisation phenomena (e.g. the Fr^hlich, flash-lag, and representational momentum illusions) have sparked a debate into what mechanisms underlie the perceived position of moving objects. Proposed models include temporal integration and spatial extrapolation of positions. Findings showing that abruptly disappearing moving objects do not ‘overshoot’ have been used to argue against spatial extrapolation. We recently proposed that abrupt offsets lead to competing neural representations: one bearing an extrapolated position due to a cortical internal model, the other based on transient retinal signals (Desimone, 1998; Keysers & Perrett 2002; Maus & Nijhawan, 2006). Here we investigate a new effect predicted by this ‘competition model’.

Two bars, one directly above the other, moved horizontally across the screen. One bar disappeared abruptly (offset-bar), while the other bar moved on. Observers (n=6) judged the position of the continuously moving bar in relation to the position in which the offset-bar vanished (offset-position). Methods of adjustment and constant stimuli (2AFC) were used. As predicted, observers perceived the continuously moving bar as being ahead of the offset-position. In a control experiment we confirmed that the offset-position is perceived accurately (with a small undershoot). When the offset-bar reappeared after various short time intervals, intermediate positions were perceived.

A simple computational model of temporal averaging did not reproduce these results. Our findings are consistent with the notion that a moving object’s perceived position is based on competing neural representations. We argue that the perceived position of continuously moving objects is based on cortical internal models, which spatially extrapolate positions to compensate for temporal delays in the visual pathway. However, abrupt offsets elicit strong retinal transients, carrying accurate position information, that usually win the competition for perception.

I86 1088 Pre-saccadic Changes in Visual Motion Discrimination

Alby Richard[1] (alby.richard@mcgill.ca), Jan Churan[1], Daniel Guitton[1], Christopher Pack[1]; [1]Neurology and Neurosurgery, Montreal Neurological Institute, McGill University

Changes in visual perception are known to accompany both the preparation and execution of saccadic eye movements. Specifically, saccades are associated with a decrease in visual sensitivity, as well as errors in visual spatial localization (Burr et al, 2002). Here we describe an enhancement of motion sensitivity that occurs in a period before the onset of saccades.

We tested subjects’ ability to discriminate visual motion direction at different times before and during the execution of saccades. The stimulus was a two-frame motion pulse, constructed by shifting the phase of a Gabor patch on consecutive frames. The size and contrast of the Gabor stimulus varied randomly from trial to trial.

When the stimulus was presented a long time (70 - 150ms) before saccade onset, performance depended strongly on stimulus size and contrast. Discrimination was best for small stimuli at high contrast and for large stimuli at low contrast, presumably as a result of inhibitory spatial influences (Tadin et al, 2003).

When the stimulus was presented in a small time window (30 - 70ms) before saccade onset, the performance changed in a contrast dependent manner. In the majority of subjects tested, motion discrimination improved markedly for the high contrast gratings, but was impaired for low contrast stimuli.

These changes were not linked in any obvious way to the attentional shifts that are known to accompany saccades. Theories of attention based on contrast gain did not account for instances in which increased target saliency would be expected to decrease performance. Rather, the observed increase in performance may be linked to an eye movement signal or attentional mechanism that narrows the tuning curves of direction-selective neurons.

Acknowledgement: Supported by CIHR and NSF Cognitive Neuroscience Grant

I87 1089 Neural Correlates of a Saltation Illusion

Harald Stogbauer[1,2] (h.stoegbauer@gmail.com), Virginie van Wassenhove[1,2], Shinsuke Shimojo[1,2]; [1]Division of Biology, California Institute of Technology, Pasadena, California, [2]"Shimojo Implicit Brain Function" Project, JST.ERATO, Japan

Stationary flashes shown before the presentation of an apparent motion stimulus are mislocalized in the direction of apparent motion (visual rabbit illusion, Geldard 1976). This perceptual displacement depends on the position of the last flash suggesting that a "backward reconstruction" is taking place in perception. Here, participants were tested on a visual rabbit paradigm while being recorded under electroencephalography (EEG). The stimuli consisted of three flashes: the first and third flash were 4 degrees apart (either to the left or right) and 25 degrees away from fixation. The second flash was shown either at the same location as the first flash (RAB) or at a location between the first and third flashes (SAL). Psychophysical results show that participants are unable to discriminate between RAB and SAL conditions. The EEG study investigated the time course of cortical processing by contrasting the SAL and RAB conditions. First, event-related potentials (ERPs) in occipital electrodes showed a significant amplitude difference between stimulus types shortly (~100 milliseconds) after the presentation of the second flash. At about 180 ms after presentation of the third flash, a significant amplitude difference was found in parietal electrodes. This ERP profile clustered RAB and SAL according to the perceptual outcome for the direction of motion (left or right). Starting at about 240 ms after presentation of the last flash, a significant difference between the RAB and SAL conditions was found independent of the direction of apparent motion. This difference was observed mainly in the frontal electrodes. The ERP results suggest three distinct stages in the processing of the visual rabbit illusion, a low-level feature stage in which the different locations for the second flash can be seen, a discrimination of motion direction stage and an "anti-illusion" stage which shows a categorization of RAB and SAL, despite no perceptual difference.

Acknowledgement: JST/ERATO Shimojo Implicit Brain Research Project

I88 1090 How robust is apparent motion across stimulus change?

Cathleen M Moore[1] (cmm15@psu.edu), Teresa Stephens[1]; [1]Department of Psychology, Pennsylvania State University

When the image of a moving object undergoes an abrupt change, such as suddenly becoming 10% of its original size for one frame of motion, it can result in a phenomenon that we have called change-related persistence. The image of the changed stimulus visibly persists causing the perception of two simultaneously present objects, the changed object and the post-change original-sized object (Moore & Enns, 2004). We offered an explanation in terms of an object-mediated representational updating process. The changes were too extreme for the perceptual system to tolerate as having occurred within a single object. So a new object representation was established. As a distinct object it was not overwritten by later information associated with the original object and therefore persisted. Consistent with this account, providing a scene-based reason for why the image of the object changed, like depicting it as moving behind an occluding surface with a small window through which 10% of the original stimulus is revealed as it passes, reduced change-related persistence (Moore, Mordkoff, & Enns, in press). A challenge to the object-mediated updating account, however, is that the perception of apparent motion between two stimuli tends to be robust across large differences in stimulus attributes like shape and color, suggesting that these differences are not sufficient to elicit the establishment of a new object representation (e.g., Kolers & Pomerantz, 1971). Why the difference across the two situations? We replicated the robustness of two-frame apparent motion over figural changes that maintain approximate size. Apparent motion across large changes in size, however, was not as robust. In addition, the fact that only two frames of motion are used in most apparent motion studies, whereas many frames of motion preceded the change in the change-related persistence studies may also play an important role in the apparent conflict.

I89 1091 Apparent Motion for Agents and Non-linear Trajectories

Venkat Lakshminaryanan[1] (webb.phillips@yale.edu), Webb Phillips[1], Justin Junge[1], Laurie Santos[1]; [1]Yale University

Apparent motion is a well studied phenomena observed with rapid sequential presentation of two or more static images containing similar features and different proximal spatial location of those features. Although classic studies of apparent motion involve perception of motion along the shortest possible path between the objects perceived as moving, cases of biological motion can invoke curved paths consistent with likely biological trajectories. We examined numerous cases of apparent motion for recognizable agents with prototypical motion trajectories differing from the traditional shortest path, along with three-dimensional constraints invoking non-linear paths. These experiments demonstrate that semantic information and physical affordances of three dimensional layouts can directly impact perceived apparent motion. Our findings extend the range of stimuli considered, and provide numerous striking examples of non-linear trajectories produced postdictively in an interaction of high-level knowledge with salient phenomenology. We also introduce a novel application of a dot-probe task to assay perceived trajectories during apparent motion.

Wednesday Talk Sessions

Wednesday, May 16, 2007

Face Perception: Emotion II (1092-1097)
Eye Movements: Cognitive II (1098-1103)
2D Motion II (1104-1110)
Temporal Processing (1111-1116)

Face Perception: Emotion II

Wednesday, May 16, 8:30 - 10:00 am, Hyatt Ballroom South
Moderator: Jason Barton

8:30 1092 **A new perspective on portraiture**

Pietro Perona[1] (perona@caltech.edu); [1]California Institute of Technology

Realistic portraits, whether paintings or photographs, are traditionally obtained using perspective projection. Pictures of the face taken from different distances along the same viewing direction (e.g. frontal) may be scaled to occupy the same size on the image plane. However, such portraits differ systematically: e.g. when the center of projection (the camera) is closer to the face the nose is proportionally larger in the picture. These differences are small (for typical camera distances of 50-500cm): do they have an effect on how the face is perceived?

Ten naive subjects of both sexes, viewed equally scaled frontal pictures of 15 neutral-expression adult male faces, each photographed from distances of 56, 124 and 400cm. The photographs were corrected for lens distortion to obtain ideal perspective projections. The subjects were asked to rate each portrait according to 13 attributes (evil-good, repulsive-attractive, hostile-friendly, pushy-respectful, sad-happy, dishonest-honest, introvert-extrovert, violent-peaceful, dumb-smart, distant-approachable, evasive-candid, week-strong, unpleasant-pleasant). While the subjects were unaware of the manipulation, their ratings are systematically correlated with the distance: faces imaged from the closer distance appear significantly more benevolent (good, peaceful, pleasant, approachable), those taken from a larger distance appear more impressive (smarter, stronger). Intermediate-distance portraits appeared more attractive. The remaining attributes are not significantly different across distance.

Our findings suggest that painters and photographers may manipulate the emotional content of a portrait by choosing an appropriate viewing distance: e.g. a formal and official portrait may benefit from a distant viewpoint, while an effect of intimacy and opennes may be obtained with a close viewpoint. Multiple inconsistent viewpoints found in classical full-length portraits may be explained by the need to combine close-up views of some body parts, within an overall undistorted figure.

Acknowledgement: D. Freedberg, S. Shimojo, R. Adolphs, P. Hanrahan

8:45 1093 **Facial expressional adaptation aftereffects contingent on racial categories**

Robert Shannon[1,2] (RobertwShannon@gmail.com), Sheng He[1,2]; [1]Graduate Program in Neuroscience, University of Minnesota, [2]Department of Psychology, University of Minnesota

Face identity and facial expression are believed to be represented by separate neural mechanisms in the human brain. Both face identity and facial expression are adaptable and perceptual aftereffects can be observed in each. Further, expression aftereffects can be generated with faces of different individuals, consistent with an expression representation independent of identity representation. However, given the well known "other-race" effect in face perception, it remains possible that faces from different races are encoded by distinct neural mechanisms or different neuronal subpopulations. Consequently, the question arises on whether there is a single expression analysis system across faces from different race categories.

We investigated this issue by testing whether or not a race-contingent expressional aftereffect could be observed, despite evidence that expression aftereffects are insensitive to identity within the same race. Participants adapted to alternating faces of two different races (Caucasian (C) and African American (AA)). During adaptation, faces from the two races were consistently rendered in two opposing expressions (e.g., C-happy and AA-sad or the other way around). Following this combined adaptation, briefly presented faces with neutral expression were perceived as slightly sad or happy, depending on the racial category of the test face and the race-expression pairings during adaptation. The results show that facial expression adaptation could be made contingent on the racial identity of the faces. These results suggest that facial expression analysis is not completely independent of the face identities. At the neuronal level, the observation of a race-contingent expression aftereffect implies the existence of neurons with joint tuning sensitivity to expression and racial category of the face.

Acknowledgement: This research was supported by the James S. McDonnell foundation, the US National Institutes of Health Grant R01 EY015261-01.

9:00 1094 **High-level after-effects in the recognition of dynamic facial expressions**

Cristóbal Curio[1] (cristobal.curio@tuebingen.mpg.de), Martin Giese[2], Martin Breidt[1], Mario Kleiner[1], Heinrich Bülthoff[1]; [1]Max Planck Institute for Biological Cybernetics, Tübingen, Germany, [2]ARL, Dept. of Cogn. Neurology, Hertie Inst. for Clinical Brain Science, Tübingen, Germany

Strong high-level after-effects have been reported for the recognition of static faces (Webster et al. 1999; Leopold et al. 2001). Presentation of static 'anti-faces' biases the perception of neutral test faces temporarily towards perception of specific identities or facial expressions. Recent experiments have demonstrated high-level after-effects also for point-light walkers, resulting in shifts of perceived gender. Our study presents first results on after-effects for dynamic facial expressions. In particular, we investigated how such after-effects depend on facial identity and dynamic vs. static adapting stimuli.

STIMULI: Stimuli were generated using a 3D morphable model for facial expressions based on laser scans. The 3D model is driven by facial motion capture data recorded with a VICON system. We recorded data of two facial expressions (Disgust and Happy) from an amateur actor. In order to create 'dynamic anti-expressions' the motion data was projected onto a basis of 17 facial action units. These units were parameterized by motion data obtained from specially trained actors, who are capable of executing individual action units according to FACS (Ekman 1978). Anti-expressions were obtained by inverting the vectors in this linear projection space.

METHOD: After determining a baseline-performance for expression recognition, participants were adapted with dynamic anti-expressions or static adapting stimuli (extreme keyframes of same duration), followed by an expression recognition test. Test stimuli were Disgust and Happy with strongly reduced expression strength (corresponding to vectors of reduced length in linear projection space). Adaptation and test stimuli were derived from faces with same or different identities.

RESULTS: Adaptation with dynamic anti-expressions resulted in selective after-effects: increased recognition for matching test stimuli ($p < 0.05$, $N=13$). Adaptation effects were significantly reduced for static adapting stimuli, and for different identities of adapting and test face. This suggests identity-specific neural representations of dynamic facial expressions.

Acknowledgement: Supported by EU Projects BACS and COBOL, Perceptual Graphics DFG, HFSP, Volkswagenstiftung.

9:15 1095 Looking for emotion in facial expressions: fixation patterns are emotion-specific

Jeffrey Nelson[1] (j-nelson1@northwestern.edu), Steven Franconeri[1], Joan Chiao[1]; [1]Department of Psychology, Northwestern University

We have a remarkable ability to determine the emotional states of others simply by looking at their face. But which regions of the face contain this rich information, and do we implicitly know where to look to find it? In this study, we show that fixation patterns on faces differ depending on the kind of emotion an observer is told to detect in the face.

We recorded the eye movements of subjects as they performed an emotion judgment task on emotionally neutral or emotionally expressive (angry, happy, sad, frightened, disgusted, ashamed) faces. Analysis of the duration and facial regions of eye fixations showed that fixations on the eye regions were prevalent when recognizing fear, shame, and disgust, but less so when recognizing anger or joy. The proportion of fixations on the upper nose of sad faces was significantly higher than on the same region of faces expressing other emotions, suggesting that the upper nose is a source of information for recognizing sadness. Interestingly, the proportion of fixations on the upper nose region was greater whenever subjects were specifically looking for sadness, even when a neutral face was presented. This prevalence of upper nose fixations was absent when subjects viewed the same neutral stimuli while looking for other emotions. Similar effects were observed for other emotions: a prominence of fixations on the right eye of faces expressing disgust, fear, and shame, was also seen when neutral faces were presented during those blocks.

People appear to have pre-determined visual strategies for extracting the emotional content of a face. Despite the overwhelming richness of information conveyed by a face, we have implicit knowledge of where to look to rapidly gain access to the information needed to recognize emotion.

9:30 1096 The N170 Marks the *End* of the Process -- Dynamics of Occipito-Temporal Integration of Facial Features Across Spatial Frequency Bands to Categorize Facial Expressions of Emotion

Philippe G. Schyns[1] (p.schyns@psy.gla.ac.uk), Lucy Petro[1], Marie Smith[1]; [1]Centre for Cognitive Neuroimaging (CCNi), Department of Psychology, University of Glasgow

For the first time, we reveal the time course of integration of Spatial Frequency (SF) facial features from the brain activity of observers who categorized Eckman's six basic expressions of emotions (i.e. happy, surprised, fearful, angry, disgusted, sad). In the experiment, three observers saw 21,000 sparse versions of expressive faces. Their task was to categorize them while we recorded their EEG. Original stimuli were 70 FACS-coded images of 5 males and 5 females, each displaying one of the 6 basic expressions plus neutral. We used Bubbles to synthesize each sparse face by randomly sampling facial information from 5 one-octave non-overlapping SF bands (Gosselin & Schyns, 2001). Online calibration of sampling density ensured 75% accuracy per expression. Using classification image techniques, we reveal the combination of SF features that each observer's brain requires to produce correct categorization behavior (e.g. the mouth for happy, two eyes for fear). With the same techniques applied to the EEG (measured on face sensitive occipito-temporal electrodes P7 and P8), we reveal the SF features that the brain processes over the time course of the N170. Then, we relate the SF features required for behavior with those integrated over the N170 time course. We show, in 42 independent instances (3 observers x 7 expressions x 2 electrodes), that the slopes of the N170 (reflecting phase onset and amplitude) fit with the slopes of a function that integrates SF featural information over time. In all instances, the maximum of the N170 coincides (with a precision of 4 ms) with the plateau of the information integration function. Thus, the N170 marks the end point of a process that integrates SF features in the 50 ms preceding the N170 peak. The characteristics of the N170 curves (latency, amplitude and width) depend on the nature of the SF features integrated.

9:45 1097 Asymmetric relationship in representations of facial identity and expression for novel faces within the human visual system

Christopher J Fox[1,2] (cjfox@interchange.ubc.ca), Jason J S Barton[2]; [1]Graduate Program in Neuroscience, [2]Division of Neurology and Department of Ophthalmology and Visual Sciences, The University of British Columbia

Cognitive models of face processing suggest the existence of parallel streams that are specialized for identity versus expression perception; furthermore, neuroimaging data suggests that there may be distinct anatomic correlates for each of these processes. However, there is evidence that the neural representations of expression and identity are not completely independent. We have shown that aftereffects in the perception of expression are modulated by the identity of the adapting face, suggesting both identity-dependent and identity-independent representations of facial expression. In the present experiment, we asked whether aftereffects in the perception of identity showed a similar modulation by facial expression, which would suggest the existence of expression-dependent and expression-independent representations of facial identity.

We measured the magnitude of aftereffects from three different adapting stimuli on the perception of identity in ambiguous morphed faces. 'Same-picture/expression-congruent' adapting stimuli were the images used to create the morphs. 'Different-picture/expression-congruent' adapting stimuli were different pictures of the same individuals displaying the same expression as was present in the morphs. 'Different-picture/expression-incongruent' adapting stimuli were pictures of the same individuals displaying different expressions than those present in the morphs. Images were cropped to eliminate the possibility of adaptation to non-face features of the image (i.e.-hair color). Images were novel faces selected from the Karolinska Database of Emotional Faces.

We found that the aftereffects on identity perception did not differ significantly between the three different types of adapting stimuli. This suggests that the neural representations activated by novel identities are largely independent of expression, in contrast to the significant identity-dependent component seen in representations of expression that we previously reported. However, unlike learned categorical expressions, novel identities would not activate learned categorical representations of identity. Thus it seems important to determine whether this asymmetric relationship between identity and expression holds true for categorical representations of familiar identities.

Acknowledgement: This work was supported by NIH grant 1R01 MH069898 and CIHR grant MOP 77615. CJF was supported by a Michael Smith Foundation for Health Research Junior Graduate Studentship and a Canadian Institutes of Health Research Canada Graduate Scholarship Doctoral Award. JJSB was supported by a Canada Research Chair and a Michael Smith Foundation for Health Research Senior Scholarship.

Eye Movements: Cognitive II

Wednesday, May 16, 8:30 - 10:00 am, Hyatt Ballroom North
Moderator: Mary Hayhoe

8:30 1098 Infants' eye movements during free-viewing as a window into the development of attention

Michael C. Frank[1] (mcfrank@mit.edu), Ed Vul[1], Scott P. Johnson[2]; [1]Massachusetts Institute of Technology, [2]New York University

How do infants see the world? Are they drawn to the same faces and objects that engage adults and older infants, or is attention captured instead by low-level features such as edges, color, and motion? We addressed these questions by recording eye movements of 3-, 6-, 9-, and 12-month-olds infants and adults as they watched a 4-minute video consisting of alternating clips from A Charlie Brown Christmas and moving random-dot kinematograms.

To investigate the focus of attention, we estimated the density of fixations on each frame for each group (using a Bayesian mixture model to cluster fixations) and calculated the entropy of this distribution, measuring the degree to which individuals in each group looked at the same places. While there were no major developmental changes in this measure on the kinematograms, there was a steady increase in consistency of attention across development for the Charlie Brown movies. Put another way, given a complex, social stimulus, adults virtually all look to the same locations, while infants are much more varied in their point of gaze, suggesting a more protracted time-course of development for visual attention than has previously been observed in infant experiments.

We then examined the targets of infants' and adults' eye movements during the Charlie Brown movies using meaningful regions-of-interest (faces, hands) and image-based saliency-maps. In the ROI analysis, we found developmental increases extending past the first year in time spent looking at faces, while in the saliency-map analysis, we found that younger infants' saccades were better predicted by bottom-up image salience than were the saccades of adults. Taken together, these data suggest that diffuse attention driven by bottom-up salience slowly gives way to more focused attention guided by top-down preferences for faces and other meaningful objects over the course of the first year and beyond.

Acknowledgement: This research supported by a Jacob K. Javits Graduate Fellowship to the first author, NIH R01-HD48733, NIH R01-HD40432, and McDonnell Foundation Grant 412478-G/5-29333.

8:45 1099 Eye Movements During Multiple Object Tracking

Hilda M. Fehd[1] (hilda.m.fehd@vanderbilt.edu), Adriane E. Seiffert[1]; [1]Vanderbilt Vision Research Center and Department of Psychology, Vanderbilt University

Previous work has established that people are capable of successfully tracking multiple moving items simultaneously. While eye movements are not necessary during this tracking, people often move their eyes as the targets move. The goal of this experiment was to investigate where observers tend to look while keeping track of multiple objects. Observers viewed a display containing 8 red dots that moved randomly within a square box on a black background. Either 1 or 3 of the dots were cued as targets, leaving the rest of the dots to serve as distractors. Eye movements were recorded using an ASL 120 Hz video-based eye-tracking system. Results indicate that during 1-target trials observers' eyes were closest to the target dot significantly more of the time (96.6%) than any of the distractor dots (0.3%). This difference was also evident during 3-target trials. However, on 3-target trials, the eyes were closest to the center of the triangle formed by the three target dots for significantly more of the time (65.7%) than they were closest to any of the target dots (8.5%). This result indicates that observers tend to look toward the center of multiple targets, a finding that may reflect a strategy of attempting to minimize the eccentricity of all the targets simultaneously. Another alternative is that observers are perceptually grouping the targets to form a virtual object (Yantis, 1992, Cognitive Psychology, 24:295-340) and that they fixate at the center of this virtual object, as they do with real objects (Vishwanath & Kowler, 2003, Vision Research, 43:1637-1653). In addition, this result implies that people use a mental representation of an object's location during tracking without that object receiving direct foveation.

Acknowledgement: This work was supported by the Vanderbilt Vision Research Center and NIH EY014984.

9:00 1100 Control of gaze while walking in a real environment

Jelena Jovancevic-Misic[1] (jjovancevic@cvs.rochester.edu), Brian Sullivan[2], Kelly Chajka[2], Mary Hayhoe[2]; [1]Center for Visual Science, University of Rochester, [2]Center for Perceptual Systems, University of Texas at Austin

In dynamic environments, gaze patterns are often driven by competing task goals (Hayhoe and Ballard, TICS, 2005). However, it is not clear how observers determine gaze priorities, especially in uncertain environments. We studied whether experience with events in the environment influences distribution of gaze in a real environment. Subjects walked along a circular path with pedestrians who sometimes veered onto a collision course with the subject for a period of 1 sec (approximately). Subjects were given experience with 2 types of pedestrians: one who always veered on a collision course on every circuit around the path (Rogue pedestrian) and one who never veered (Safe pedestrian). In a subsequent trial the roles of Safe and Rogue pedestrian were interchanged. Experience with the Rogue pedestrian elevated fixation probabilities of the Safe pedestrian to 70% (instead of 50% without experience). Conversely, experience with the Safe pedestrian lead to 80 % fixation probability of the Rogue pedestrian (instead of 89% without experience).When subjects had an added task of following a lead pedestrian, overall fixation rates on pedestrians were reduced by about 17%, but the effect of experience (with Rogues and Safe pedestrians) was maintained. These results confirm previous observations in a virtual environment (Jovancevic et al, JOV, in publication), although overall rates of fixating veering pedestrians were higher in the real environment. Thus subjects are sensitive to the probabilistic structure of environmental events and use this information to adjust gaze priorities in situations when there are multiple task goals, consistent with predictions of computational models of attentional allocation while walking (Rothkopf and Ballard, VSS, 2005). This anticipatory allocation of gaze reduces the need for reactive gaze control to unexpected events.

Acknowledgement: This research was supported by National Institutes of Health Grants EY-05729 and RR-09283

9:15 1101 Saliency-driven selection is transient and impenetrable to consciousness.

Wieske van Zoest[1] (w.van.zoest@psy.vu.nl), Mieke Donk[1]; [1]vrije Universiteit Amsterdam

In the present study we investigated observers' ability to make use of saliency-information in a search display. In Experiment 1 participants were instructed to make an eye movement to either the most or the least salient singleton in a search display. The results showed that short-latency eye movements were driven by stimulus-saliency irrespective of the instruction given to the participants. In contrast, long-latency saccades were driven by instruction only and showed no effect of stimulus-salience. The goal of Experiment 2 and 3 was to investigate whether observers were aware of the salience and identity of the items selected. In Experiment 2 and 3, the search display was masked contingent to the eye movement, such that observers viewed a mask when their eyes landed on the saccadic goal. Following each trial, participants were asked to report whether they had correctly selected the most salient item (Experiment 2); or correctly selected the right identity, namely the line element tilted to the right (Experiment 3). Results showed that, regardless of saccadic latency, sensitivity as measured by d' was dramatically low when participants were asked to report on the saliency of the saccadic goal. In contrast, participants were near perfect to report on the identity of the saccadic goal. We conclude that visual selection based on saliency information occurs only when selection latencies are low, and that saliency-driven selection is impenetrable to consciousness.

9:30 1102 Gaze Control and Perceptual Decisions are Modulated by Learned Expected Reward

Jason Droll[1] (droll@psych.ucsb.edu), Binh Pham[1], Craig Abbey[1], Miguel Eckstein[1]; [1]Dept. of Psychology, UC Santa Barbara

Neurophysiology experiments have demonstrated that many cortical areas traditionally characterized as encoding visual signals, or covert visual attention, are also sensitive to the reward structure of a task, and may represent the relative value of competing actions. However, it is not known if human observers learning the reward structure also adapt their gaze and perceptual decisions accordingly. Here, we investigate whether the reward structure of a search task may be learned to optimize performance, and compare human behavior to a Bayesian ideal learner that maximizes reward. Thirteen subjects performed 300 trials in which they searched for a bright target among dimmer distractors with contrast noise (mean RMS 2.38 and 1.75, stdev. 0.25), displayed for 2s. Each of the six stimuli was surrounded by a colored circle. Observers either localized the target or decided it was absent. Correct localizations and rejections resulted in the delivery of a reward (in cents). The reward magnitude was stochastic and dependent upon which circle the target had been present. Subjects were told that some correct localizations would deliver a greater reward, although these values, or their distribution, were not specified. By the final third of trials, first saccades and perceptual decisions for both humans and the ideal observer were biased towards circles corresponding to an average higher reward (human: 35% vs. 29%; 37% vs. 32%), even on trials when no target was in fact present. However, human learning of expected value was suboptimal, both in the number of trials required for learning to manifest, as well as the overall yield of reward. Our results suggest that human gaze control and perceptual decisions are sensitive to reward structure of a search task, and this modulation may be exploited as a learning signal to resolve competing action plans.

Acknowledgement: Supported by NIHEY grant 015925

9:45 1103 Predictive transfer of visual adaptation before saccadic eye movements

David Melcher[1,2] (prof_melcher@yahoo.com); [1]Center for Mind/Brain Studies, University of Trento, Italy, [2]Department of Psychology, Oxford Brookes University, Oxford UK

Saccades pose several problems for visual perception, including how to keep track of objects and how to combine information about object features across glances. In addition, the visual system must take account of the delay after each saccade before new retinal input reaches awareness. We studied the mechanisms underlying visual stability by examining the transfer of tilt adaptation across saccades. Participants viewed a tilted adaptor and then were cued to make a saccade to a new location. The timing of the test stimulus was varied so that it was presented either before or after the saccade, with the test presented either near to fixation or the saccadic target. There was a gradual shift in the tilt after-effect (TAE) from the current fixation to the future gaze position before the saccade. In a second experiment, we placed adapters at the current fixation and at other potential target locations. This allowed a comparison of the relative weighting of information from the fovea and from the periphery in the perceived TAE. Overall, the results suggest that the visual system uses a combination of pre- and post-saccadic re-mapping of visual features to maintain visual stability across saccades.

2D Motion II

Wednesday, May 16, 10:30 am - 12:15 pm,
Hyatt Ballroom South
Moderator: Jocelyn Faubert

10:30 1104 A new gradient approach to the computation of 2D pattern motion

Alan Johnston[1] (a.johnston@ucl.ac.uk); [1]Department of Psychology, CoMPLEX, ICN, University College London

A number of models of motion perception have included an expectation that image motion is likely to be slow – a slowness prior. Weiss et al. (2002, Nature Neuroscience, 5, 598-604) have shown that incorporating a slowness prior into their spatio-temporal gradient model can allow the prediction of a wide range of motion phenomena. However, for 2D patterns, such as plaids, the measured speed and direction from their technique varies with position, requiring smoothing over space. Smoothing leads to the blurring of motion boundaries. Other gradient motion models have a similar problem (Johnston et al. 1999, Proc. R. Soc Lond. B, 266, 509-518). However, by avoiding matrix inversion we can avoid the need for the slowness prior while calculating speed accurately. This leaves the effects of contrast on speed perception to be accounted for on the basis of problems of implementation (e.g. limits on temporal filter sensitivities; Johnston et al. 1999, Vision Research, 39, 3849-3854) rather than prior expectations. This Jet-based gradient method also allows an entirely new approach to 2D pattern motion computation, which nevertheless relies on exactly the same neural measurements as our earlier model. Using non-orthogonal projections of derivatives of Jets it is possible to accurately calculate the image motion of 2D patterns such as plaids uniformly at all points on the plaid. Motion illusions can then be attributed to problems of implementation. This method, like that use by Weiss et al., will not work for 1D pattern without regularisation. However, one can employ a measure of the dimensionality of the spatial pattern (again using the same Jet vectors) to switch between models if required. Interesting, this analysis of motion computation over space can also explain the variety of direction tuning found in V5/MT component and pattern cells.

10:45 1105 Characterizing Changes in Perceived Speed and Speed Discriminability Arising from Motion Adaptation

Alan A Stocker[1,2] (alan.stocker@nyu.edu), Eero P Simoncelli[1,2]; [1]Howard Hughes Medical Institute, [2]Center for Neural Science, New York University

There is ample evidence that humans have the ability to estimate local retinal motion. These estimates are typically not veridical, but are biased by non-motion stimulus characteristics (e.g. contrast, spatial pattern) and the system's contextual state (e.g. attention, adaptation). A complete characterization of human speed perception should thus incorporate all of these effects. Here, we focus on adaptation, and characterize its influence on both the bias (i.e. shift in perceived speed) and variance (i.e. discrimination threshold) of subsequent estimates. We measured the perceived speed of a spatially broadband noise stimulus with veridical speed chosen from the range 0.5-16 deg/s in either horizontal direction, for several different adaptor speeds. Subjective responses were gathered using a 2AFC discrimination paradigm, with a simultaneous presentation of a reference and test stimulus within 3deg apertures on either side of fixation. The reference location was adapted, initially for 40s, and for an additional 5s between each trial.

We find that adaptation affects the subsequent estimation of stimulus speed over the entire range of speeds tested and across direction boundaries. The bias, relative to the unadapted percept, is repulsive yet asymmetric, with a perceived speed at the adaptor that is typically reduced. Discrimination thresholds, measured as the slope of the psychometric function gathered under each reference/test condition, typically increase around the adaptor speed. However, using signal detection theory, we can infer the change in variability and bias of the estimate of the reference speed due to adaptation and predict the discriminability that would result if both the test and reference locations were adapted. We predict a clear increase in discriminability around the adaptor, consistent with some previous literature.

We discuss the relationship of these findings to our previously proposed Bayesian model of speed perception, as well as the implications for the brain's internal representation of retinal speed.

11:00 1106 First- and second-order motion processing are separate at low temporal frequencies but common at high temporal frequencies

Remy Allard[1] (remy.allard@umontreal.ca), Jocelyn Faubert[1]; [1]Visual Psychophysics and Perception Laboratory, Université de Montreal

There is an ongoing debate on whether first- and second-order stimuli are processed by common or separate mechanisms. Some authors suggest that they are initially processed by separate mechanisms and that a rectification within the second-order pathway enables post-rectification mechanisms to process both types of stimuli. Others suggest that nonlinearities within a common motion mechanism enable the detection of both types of stimuli.

In the present study, observers were asked to discriminate the direction of drifting luminance- (LM, first-order) and contrast-modulated (CM, second-order) signals embedded in LM or CM dynamic noise. The signals were drifting at either a low (2 Hz) or high (8 Hz) temporal frequency.

At low temporal frequencies, the results showed no cross-modal interaction: LM noise affected LM discrimination thresholds but had no or little impact on CM discrimination, and CM noise affected CM discrimination thresholds but had no or little impact on LM discrimination. This double dissociation implies that, at low temporal frequencies, LM and CM stimuli are processed, at least at some point, by separated mechanisms.

At high temporal frequencies, the results showed a complete cross-modal interaction: LM noise affected both the LM and CM discrimination thresholds in similar proportions, and CM noise also affected both the LM and CM discrimination thresholds in similar proportions. This complete cross-modal interaction suggests that, at high temporal frequencies, LM and CM stimuli are processed by common mechanisms.

Acknowledgement: This research was supported by NSERC graduate fellowship to RA and NSERC operating grant to JF

11:15 1107 Adaptation to transparent plaids: two repulsive directions or one?

James Hedges[1] (jhh248@nyu.edu), Eero Simoncelli[1,2]; [1]Center for Neural Science, New York University, [2]Howard Hughes Medical Institute, New York University

Adapting to moving patterns changes the perceived direction of motion (DoM) of subsequently viewed stimuli. Specifically, the perceived direction of test stimuli is biased away from that of the adapting stimulus. This basic phenomenon can be explained by gain reduction in direction-selective units that are responsive to the adaptor (Levinson and Sekuler 1976). But what happens if the adaptor is perceived as a transparent combination of two patterns with distinct motions? The simplest hypothesis is that each of the perceived directions arises from the activity of a distinct subpopulation of direction-selective neurons. If each of these subpopulations adapts, we would predict the direction of subsequently viewed test stimuli to be repulsed away from both directions. We tested this prediction experimentally by asking subjects to report the direction of a moving test stimulus using the method of adjustment, following a prolonged exposure to a stimulus composed of the superposition of a pair of drifting square-wave gratings (a plaid). We found that adaptation to plaids that are seen to be moving in a single coherent direction could not be explained as the superposition of the adaptation effects of the components. The perceived DoM was shifted away from the coherently perceived direction of the plaid. More surprisingly, we found that even when subjects were adapted to plaids that were perceptually transparent the effect was similar: perceived DoM was shifted away from the unique single direction corresponding to a physical translation of the plaid pattern. We infer from these results that even when an adapting plaid stimulus is perceived as transparent, the system retains a representation of the coherent motion direction, and the subpopulation of neurons underlying this representation form the primary locus of adaptation.

11:30 1108 Spatial frequency spectra of random dynamic glass patterns predict perceived motion direction

Linda Bowns[1] (lbowns@psychology.nottingham.ac.uk), Horace Barlow[2]; [1]School of Psychology, University of Nottingham., [2]Department of Physiology, Development and Neuroscience, University of Cambridge.

Distortions of the local spatial frequency spectrum caused by motion blur may be used by the visual system to improve motion analysis (Geisler,1999; Burr, 2000; Barlow & Olshausen, 2004). We tested this hypothesis by measuring the error of perceived motion direction of 50 pairs of dots that moved (motion signal) in the presence of 50 pairs of dots without coherent motion (background noise). By manipulating the type of background pairs we were able to produce four different types of spatial amplitude spectra. The results showed that error increased greatly when the background amplitude spectrum was similar to that of the motion signal, but when the background amplitude spectrum had an anisotropy consistent with the expected motion blur of the moving signal the error was greatly reduced. The error was reduced even more than when there was no background. Shifting the spatial frequency content away from that of the motion signal also reduced the error but not as much, even when there was an anisotropy consistent with motion blur. The orientation selective "simple cells" in V1 (Hubel & Wiesel, 1962) appear likely to contribute at least as much to determining the direction of image motion as they do to static image analysis.

11:45 1109 Distractors enhance target detection during smooth pursuit

Scott Watamaniuk[1] (scott.watamaniuk@wright.edu), Stephen Heinen[2]; [1]Department of Psychology, Wright State University, Dayton OH, [2]The Smith-Kettlewell Eye Research Institute, San Francisco CA

The presence of distractors in a visual scene typically impairs target detection. Here, we show that embedding a target stimulus in a field of dots improves observers' ability to detect a 'blink' in a moving target stimulus. The target stimulus was comprised of five, small (0.2 deg) bright spots arranged in a '+' configuration with a 6 deg horizontal and vertical extent. At the beginning of each trial, the target appeared and the observer fixated the center spot. After a random fixation period, the five-spot target began to move at a constant speed (10-30 deg/sec). At a randomly selected time, (between 100-500 msec), one of the 5 spots was dimmed briefly (170 msec) before returning to its original luminance. The observer's task was to identify which of the spots was dimmed. The five-spot target was presented either on a homogeneous gray background, or one composed of 500 dots of the same diameter, but with slightly lower luminance. Background dots were randomly positioned within a large rectangular aperture but excluded from the target area. When present, the background moved at the same velocity as the target. Surprisingly, target detection was improved by the presence of the moving background in that observers correctly identified the blinked target more frequently in this condition than when the target stimulus moved in isolation. This appeared at least partly due to enhanced smooth pursuit eye movements that were less variable and contaminated by fewer catch-up saccades in the background-on condition. This finding is consistent with our previous work on pursuit of random-dot cinematograms (Heinen & Watamaniuk, 1998). The results suggest that large, textured objects stimulate a different pursuit system than that previously studied using a single spot, which may have evolved to provide image stabilization to allow detection and discrimination of object features.

Acknowledgement: Supported by NIH Grant EY013886

12:00 1110 **Induced reappearance of invisible stimuli in motion induced blindness: uncovering interactions across the awareness boundary**

Yoram Bonneh[1] (yoram.bonneh@weizmann.ac.il), Alexander Cooperman[1], Dov Sagi[1]; [1]Department of Neurobiology, The Weizmann Institute of Science, 76100 Rehovot, Israel

Various studies show that visual stimuli that are not consciously accessible may retain their properties. Here we explored the interaction between such stimuli and stimuli that are consciously available. We used the phenomenon of Motion-induced-blindness (MIB; Bonneh et. al., Nature 2001) in which a salient static or slowly moving pattern (target) may disappear and reappear spontaneously in the presence of a global moving pattern (mask). Here we used a transient cue to induce reappearance (Kawabe et al., Conscious Cogn. 2006). In the experiments, a small target patch located at a fixed location (2 deg of eccentricity, usually in the upper left quadrant) was made invisible via a global moving rotating grid mask. Shortly after disappearance reported by the Os (100 ms), another small patch (cue) was briefly flashed (100 ms) and the whole trial was terminated after 200-800 ms by erasing both target and mask. The cue, which was clearly seen, often caused the reappearance of the invisible target within the limited trial time. Os reported target reappearance. In the first experiment, the target was a small (0.4 deg) bright patch and the cue was identical patch presented at different locations. We found that the amount of induced reappearance of the target depended on the target to cue separation and on the time window, with more reappearance for proximal cues and longer time windows. In the second experiment, we used a Gabor target and a Gabor cue of different orientations, distance and layout (collinear or orthogonal). We found higher reappearance rate for similar orientations, collinear configurations and proximal locations. The results show that invisible stimuli keep their location and orientation tags and demonstrates that grouping processes sensitive to proximity and similarity operate across the boundary of awareness.

Acknowledgement: Supported by grants from the National Institute for Psychobiology in Israel

Temporal Processing

Wednesday, May 16, 10:30 am - 12:00 pm,
Hyatt Ballroom North
Moderator: Preeti Verghese

10:30 1111 **Testing a multi-resolution clock model for temporal duration discrimination**

Michael Morgan[1] (m.morgan@city.ac.uk), Joshua Solomon[1]; [1]City University. London

Duration discrimination thresholds in the seconds range are approximately proportional to the standard duration (Weber's Law). So are those for spatial length discrimination. Why? For space, a multi-resolution 'rubber ruler' model has been proposed. We suggest a similar model for time, consisting of a clock that has an adjustable tick rate, but a finite size accumulator. Because of the latter, the tick rate, and thus the resolution, must be approximately proportional to the duration being timed. We predict that observers will be impaired if they do not know at the start of each trial whether they are going to have to time a short (~1 sec) or a long (~ 4 sec) interval; and we shall report that this is the case.

Acknowledgement: Wellcome Trust

10:45 1112 **Object Segmentation Cues Influence Perceived Temporal Variation**

Anthony D'Antona[1] (adantona@uchicago.edu), Steven Shevell[1]; [1]Visual Science Laboratories, University of Chicago

PURPOSE: Perception of temporally-varying light is strongly affected by temporally-varying surrounding light. Particularly, perceived modulation depth of a central light is suppressed by surrounding light varying at the same temporal frequency and phase as the central field. This suppression has been modeled by center-surround antagonism of receptive fields in the primate retino-geniculate pathway (Kremers et al, JOV 2004). Here, we question this explanation by showing that object segmentation cues (depth, illusory contours) alter perceived modulation.

METHOD: Observers matched the perceived modulation depth at the center of a 6° disc modulated in luminance at 2 Hz. In Experiment 1, the center of the field was contained within (1) 3 thin dark lines forming a triangle, (2) 3 'pac-men' forming an illusory triangle, (3) 3 'pac-men' rotated 180 degrees relative to (2) ('pac-men' control), or (4) nothing (control). In Experiment 2, the circular disc was viewed haploscopically and contained (1) a thin dark circular gap, (2) as (1) but with the gap perceived nearer than the circular field by stereo disparity (gap-only depth), (3) as (1) but with the gap and its interior both raised to the nearer depth plane (gap and interior depth), or (4) no gap (control).

RESULTS: In Experiment 1, perceived modulation depth was similar in the control and illusory-control conditions but clearly suppressed--almost identically--by the presence of either a real or illusory triangle. In Experiment 2, perceived modulation depth was suppressed greatest in the two conditions with the gap and its interior in the same depth plane. Suppression was reduced or abolished when only the gap was perceived in depth.

CONCLUSIONS: Suppression of perceived modulation by a temporally-varying surround cannot be explained by a simple receptive-field model. Cues to object segmentation (depth, real or illusory contours) modulate suppression, suggesting center-surround inhibition at the object level of visual processing.

Acknowledgement: Supported by PHS grant EY-04802

11:00 1113 **Evolution of a motion trajectory over time**

Preeti Verghese[1] (preeti@ski.org), James Coughlan[1]; [1]Smith Kettlewell Eye Research Institute, San Francisco CA

How does the evidence for the trajectory of a point moving in noise evolve over time? Observers were asked to track a linear motion trajectory presented in Brownian noise either by indicating the direction with one of 8 keys on a numeric keypad or by manually tracking the trajectory with a stylus on a digitizing tablet. The keypad task required a response after stimulus offset and was repeated at different stimulus durations to determine the duration that leads to reliable performance. The manual-tracking task had a fixed duration of 1000 ms and observers were asked to actively track the trajectory during stimulus presentation.

Data for three observers show that evidence for the trajectory increases with time, and that the time required for criterion performance is longer for high-noise than no-noise conditions. Interestingly, the amount of extra time needed to maintain performance in high-noise conditions was the same for both the keypad and manual tracking experiments, 60 ms. This additional time was constant despite an order of magnitude difference in the total stimulus duration before a response: 30 ms for the keypad and 300 ms (which included processing and decision delays as well as motor preparation time) for the manual tracking experiments.

More importantly, in both tasks the direction errors in the noise task form a broad distribution at short stimulus durations/latencies (indicating uncertainty about the trajectory), and the distribution narrows quickly over time to a steady state. The steady-state distribution peaks sharply at the true trajectory direction, consistent with a predictive filter model that incorporates local motion responses up to that point in time and feedback that favors smoothness.

Acknowledgement: Supported by NSF grant BCS0347051 to PV and NIH grants R21 EY017003

Wednesday Talks

11:15 1114 **Feature-specific Modulation of Gamma Oscillations in Visual Detection**

Soo Hyun Park[1] (suhyun84@snu.ac.kr), Sang-Hun Lee[1]; [1]Interdisciplinary Program in Brain Science, Seoul National University, Seoul, Korea

The visibility of a threshold-level target can be modulated by spatiotemporally neighboring stimuli (Kovacs & Julesz, 1994; Purushothaman et al., 2003). An abrupt-onset stimulus is known to elicit phase-locked gamma oscillations in the visual cortex (Juergens et al., 1999), suggesting that the visibility of a target might fluctuate as a function of time relative to a preceding stimulus in gamma frequency range.

To explore this possibility, we measured contrast thresholds for a brief (20 ms), small (s=.0916°) Gabor target, which followed a high-contrast Gabor stimulus ('trigger') at varying SOA (55 ~ 170 ms) in fine-grained (5 ms) time scale using the 2IFC task. The 45°-oriented target appeared in a fixed location (2° eccentricity in the lower-left visual quadrant) whereas the trigger, the position and orientation of which was collinear to the target, appeared at different distances to the target (0°, 1° and 2°).

The threshold of the target oscillated as a function of SOA in a broad range of frequency (20-70 Hz). Significant oscillations were limited to a narrow window of SOA, with the 'time to peak' and 'amplitude' of oscillations being systematically delayed and reduced with increasing trigger-target distance. When the orientation of the trigger was tilted away from the collinear axis, the amplitude of oscillations was reduced only in gamma frequency range, with amplitude at other frequency ranges intact. The spatiotemporal dynamics of gamma oscillations was remarkably consistent across sessions for each of three observers.

Our findings provide psychophysical evidence supporting the idea that waves of cortical excitability modulation evoked by external visual input can account for trial-to-trial variability in detection of the target following the trigger. Furthermore, the feature-specific nature of gamma oscillations implies that the observed modulation of visibility is likely to be mediated by orientation-specific horizontal connections within early visual cortex (Bosking et al., 1997).

Acknowledgement: supported by a grant(#M103KV010017-06K2201-01710) from Brain Research Center of the 21st Century Frontier Research Program

11:30 1115 **Spatial layout determines metacontrast masking**

Michael Herzog[1] (Michael.Herzog@epfl.ch), Varinthira Duangudom[2], Greg Francis[3]; [1]Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland, [2]School of Electrical and Computer Engineering, Georgia Institute of Technology (Georgia Tech), Atlanta [3]Department of Psychological Sciences, Purdue University, West Lafayette, IN

In visual backward masking, performance on a target is impeded by a following mask. In B-type masking, strongest masking occurs when the mask trails the target for about 30-80ms. To account for this century old result, all models propose an inhibitory interaction between mask and target based on their energy ratio. Here, we show strong counter-evidence to this proposition. We presented a vernier flanked by aligned verniers. Strongest B-type masking occurred when the flanks had the same length as the vernier. For longer (higher energy) and smaller (lower energy) flanks, performance improved. By further increasing the energy of the mask, we could even almost completely diminish masking. Hence, energy is not the key aspect in masking. We will suggest that the overall spatial layout of the mask is a much better factor to explain metacontrast masking.

11:45 1116 **Transcranial magnetic stimulation (TMS) of early visual cortex reveals a window of integration of substantial duration.**

Frank Scharnowski[1] (Frank.Scharnowski@epfl.ch), Johannes Rüter[1], Frouke Hermens[1], Jacob Jolij[2], Thomas Kammer[3], Michael H. Herzog[1]; [1]Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, [2]School of Psychology, University of Exeter, UK, [3]Department of Psychiatry, University of Ulm, Germany

How the brain achieves integration of temporally dispersed information is one of the enigmas in the neurosciences. By combining feature fusion with transcranial magnetic stimulation (TMS), we show that individual visual features are independently stored for several hundred milliseconds before condensed in a conscious percept. We presented two verniers with opposite offset directions in rapid succession at the same retinotopic location. Because of the short durations (30ms each) only one fused vernier is perceived. The perceived offset of the fused vernier is a combination of the offsets of the two verniers which themselves are consciously not accessible. First, we balanced performance at approximately 50%, so that neither the first nor the second vernier dominated the fused percept. We then applied TMS at different times after the onset of the first vernier over the occipital cortex to interfere with visual processing. When TMS was applied from 45ms to 120ms after the onset of the first vernier, the second vernier dominated. For later onset asynchronies of up to 370ms, the first vernier dominated. Hence, even though the individual verniers are not consciously accessible, they still can be manipulated by TMS for a period of more than 300ms. Our results demonstrate that the individual verniers are stored independently for several hundred milliseconds before they are condensed into a conscious percept. Thus, the brain collects and integrates feature information across a broad time window before consciousness.

Acknowledgement: This work was supported by the SNSF (Swiss National Science Foundation).

Poster Session J

Wednesday, May 16, 8:30 am - 1:00 pm, Municipal Auditorium

Locomotion II: Walking and Posture

Author Presents: 8:30 - 10:15 am

J1 1117 **The visual control of walking: do we go with the (optic) flow?**

Pearl S. Guterman[1] (pearljam@cs.yorku.ca), Robert S. Allison[1], Simon K. Rushton[2]; [1]Centre for Vision Research, York University, Toronto, Canada, [2]School of Psychology, Cardiff University, Wales, UK

What visual information guides locomotion? Optic flow, the global pattern of motion at the vantage point of the eye, specifies the direction of self-motion, and could be used to control walking. Alternatively, we could walk in the perceived direction of a target. Recent evidence suggests that the type of visual environment can influence steering behaviour. However, controversy remains as to whether this demonstrates direct, online use of flow or indirect influence on context and recalibration of direction. The current literature is complicated by methodological as well as theoretical differences between prism-based and head mounted display based studies. Both techniques have well-known limitations that have complicated comparisons across studies. Here we tested undergraduate students (n = 6) using an immersive virtual environment, where the heading specified by flow was displaced by 0°, ±5° and ±10° from the direction of the target through the virtual environment or prism displacement. Observers walked (stepped in-place) to a target in five virtual environments, which consisted of a plain gray or textured ground; blue sky; and zero, one, ten, or twenty objects in it. The distance to the target from the start position was 20 m, nearly double that of comparable studies. For all displacement conditions, observers walked in the perceived direction of the target, and there was no significant main effect of the environment. The findings suggest that egocentric direction is used to guide locomotion on foot, regardless of more or less objects that enhance flow in the environment.

J2 1118 **Compensation of the effects of eye and head movements during walking and running**

Michael von Grünau[1] (vgrunau@alcor.concordia.ca), Rong Zhou[1]; [1]Department of Psychology & CSLP, Concordia University, Montreal, Québec, Canada

Purpose: A consequence of human locomotion (walking, running) is the occurrence of related eye (EM) and head (HM) movements, which could potentially distort locomotion-produced flow field information. This information is normally used to guide many visual tasks. We were interested in comparing visual performance during locomotion and standing for various tasks. Methods: We recorded EM and HM (EyeLink II eye tracker with scene camera) when observers were standing, walking or running on a treadmill while observing flow fields or other stimuli for various visual tasks that were projected on a large screen. In one experiment, baseline data were collected for fixations and pursuit movements. In another, accuracy of target pursuit was determined. In others, velocity discrimination thresholds or visual search efficiency were measured. Results: We analyzed horizontal and vertical EM and HM and compared the results for standing to those for the locomotion conditions. In most cases, performance during walking and running was comparable, and sometimes even better, than during standing. This was true even though HM were only partially offset by stabilizing EM, leaving considerable amounts of noisy distortions of the flow fields. Conclusion: The fact that visual performance suffered little during locomotion suggests that there exist various mechanisms, in addition to extra-retinal feedback, that can compensate for the extra noise produced by locomotion.

Acknowledgement: NSERC, FQRSC

J3 1119 **Investigations of Real and Imagined Walking**

Benjamin R. Kunz[1] (benjamin.kunz@psych.utah.edu), Sarah H. Creem-Regehr[1], William B. Thompson[2]; [1]Department of Psychology, University of Utah, [2]School of Computing, University of Utah

A number of studies have suggested functional equivalence of real locomotion and imagined locomotion (Decety et al., 1989; Plumert et al., 2005; Courtine et al., 2004). We investigated the similarity between real and imagined walking to targets in a series of four experiments of mixed within/between-subject design. In each of four experiments, participants viewed a target located on the ground-plane at an egocentric distance of up to 8 meters and were instructed to form a mental image of the target and surrounding hallway environment. Participants were then instructed to walk blindfolded to the target while spatially updating their position or to imagine walking to the target while spatially updating their imagined position. As has previously been found by others, both imagined and real walking times increased with distance to the target. However, the experiments demonstrated that imagined walking to targets times were consistently faster than blindfolded real walking to the same targets, regardless of whether or not subjects knew which of these two types of tasks they would be performing prior to viewing the targets, regardless of the order in which the two types of tasks were performed and regardless of whether the imagined walk to target was performed with vision or while blindfolded. This is in contrast to previously published studies, which found imagined walking times to be similar to blindfolded walking times to the same targets. The experiments also found imagined walking times faster than eyes-open walking to the same targets, but by an amount less than the difference compared to blindfolded walking. In evaluating these results and in considering the large issue of the functional equivalence of real locomotion and imagined locomotion, it is important to note that the between subject variability of imagined walking time is much greater than the variability of blindfolded real walking.

Acknowledgement: Acknowledgments: This work was supported by NSF grant IIS-01-21084.

J4 1120 **Visual control representations in locomotion: stair descent in adults and children**

Dorothy Cowie[1] (dorothy.cowie@psy.ox.ac.uk), Janette Atkinson[2], Oliver Braddick[1]; [1]Department of Experimental Psychology, Oxford University, [2]Department of Psychology, University College London

The use of visual information in controlling the detailed kinematics of manual actions has been extensively investigated. However, much less is known about the visual control of locomotor actions, in particular the demanding task of descending steps.

We have collected lower limb kinematic data during a 'one-step' task, in adults and 3-4 year old children. Using a single, variable-height step means that any dependence on step height must be mediated by visual information. Each participant was tested in three conditions: normal vision, blindfold, and 'open-loop'. In 'open-loop', after a 2-second viewing period participants had an auditory cue to close their eyes and step down immediately. For each condition we collected data with three step heights, set as 8%, 16%, and 24% of the participant's leg length.

Adult data with normal vision showed that flexion of the lead leg, anticipating contact with the lower step, occurred at a depth which scaled with step height. When blindfold, flexion position was independent of step height, confirming that the scaling reflected the use of visual control information. 3-4 year olds showed a similar scaling, suggesting that the use of such information in stair descent is remarkably mature at this age.

In the open-loop condition, adults scaled their leg movements to step height almost as well as with normal vision. This implies that stair descent does not depend on continuous on-line control, but on a visual control representation which persists at least briefly after visual information is removed. Evidence for a similar capability in the 3-4 year olds' data will be discussed.

Our findings provide a paradigm for extending current theories of action-perception systems into the locomotor domain. They suggest, for example, that the distinction between 'perception', 'planning' and 'control' (Glover, 2004) may be a useful one to apply to locomotor development.

Acknowledgement: Medical Research Council grant G7908507 MRC doctoral training award to DC Williams Syndrome Foundation UK.

J5 1121 **Choosing between competing goals during walking in a virtual environment**

Jonathan A. Cohen[1] (jonathan_cohen@brown.edu), William H. Warren[1]; [1]Department of Cognitive and Linguistic Sciences, Brown University

When a walker is faced with two competing goals, what determines route selection? Fajen & Warren's (2003) steering dynamics model suggests that relative distance and eccentricity should trade off in influencing the locomotor path. We presented participants with two stationary goals of equal valence but varying distance and eccentricity, and asked them to walk to the goal(s) as quickly as possible. The study was conducted in the Virtual Environment Navigation Lab, a 12m x 12m ambulatory virtual environment with a head-mounted display (60° H x 40° V) and a hybrid sonic/inertial tracking system (latency 50-70 ms). The goal objects were blue textured posts. In control trials, the two goals appeared at the same distance and the same target-heading angle (left/right) from the participant's initial heading. In experimental trials, one goal remained in the control position while the initial distance or target-heading angle of the other was manipulated. Preliminary results indicate that, on control trials, participants walk to one goal rather than between them, indicating a nonlinear competition between two goals. On experimental trials, when the initial target-heading angles are equal, participants walk to the closer goal; whereas when their initial distances are equal, they walk toward the goal with the smaller target-heading angle. These two variables appear to trade off. We seek to model these effects by elaborating a nonlinear steering dynamics model. Further experiments will investigate how an obstacle positioned in front of two competing goals influences route selection.

Acknowledgement: Supported by NIH EY10923

J6 1122 **Do walkers follow their heads? A test of the gaze-angle strategy for locomotor control**

Michael Cinelli[1] (Michael_Cinelli@brown.edu), William Warren[1]; [1]Cognitive and Linguistic Sciences, Brown University

What sensory information is used to walk toward a goal? Three basic steering strategies have been proposed, based on different sensory variables: (1) Optic flow strategy: null the visual angle between the heading specified by optic flow and the visual direction of the goal (Gibson, 1950; Warren, et al, 2001); (2) Egocentric direction strategy: null the angle between the locomotor axis specified by podokinetic information and the egocentric direction of the goal (Rushton, et al, 1998); (3) Centering strategy: fixate the goal and null the angle between the locomotor axis and the direction of gaze, based on proprioception about eye and head position (Wann & Land, 2001; Hollands et al, 2002). Our aim is to dissociate these strategies during goal-directed walking and investigate how they interact, by manipulating the following variables: (a) central or peripheral goal; (b) visual structure or lights off; (c) yaw head perturbation, active head rotation, or no head rotation. We analyze the time series of head orientation and walking direction to determine the effect of these variables on deviations in the path. If paths deviate with a head perturbation, it indicates a contribution of the centering strategy by involuntary head rotation. If the deviation is reduced by a visible goal, it indicates a contribution of the goal's egocentric direction. If the deviation is reduced in a visually structured environment, it indicates a contribution of optic flow. If the deviation is reduced with active head rotations, it indicates an override of the centering strategy. The results suggest an interaction between these three steering strategies.

Acknowledgement: Supported by NIH EY10923, CIHR MFE161734

J7 1123 **Optic flow and the maintenance of balance**

Brian Rogers[1] (bjr@psy.ox.ac.uk), Katherine Young[1], Shelley Tootell[1]; [1]Department of Experimental Psychology, University of Oxford, UK

Using their swinging room, Lee and Lishman (1975) reported that vision plays a dominant role in the maintenance of balance: observers swayed in synchrony with the room as if "hooked like puppets". While the optic flow from nearby surfaces does induce sway, we found that the induced sway was small when the swinging room had more typical room dimensions and observers stood on a firm surface (Rogers and Richards, Perception 2005). The first objective of the present study was to assess the relative effectiveness of the optic flow created by different surrounding surfaces: the floor, the side-walls and the facing-wall. Body sway was monitored using an overhead camera while observers stood in a real (suspended) swinging room (3m by 3m). The frequency content of sway patterns was analysed using discrete Fourier analysis. The gain of flow-induced sway (amplitude of body sway@room frequency ~ amplitude of room movement) was found to be < 0.4 when the floor and walls were visible. When only the floor surface was visible, (i) gains averaged ~ 0.2, (ii) sway was not always maximal at the room oscillation frequency and (iii) the phase of the sway was not closely coupled to the room movement. Our second objective was to investigate flow-induced sway under open loop conditions. Body sway was monitored while observers stood in a virtual swinging room (floor only) that could either (i) remain stationary or (ii) move in synchrony with the observer's natural sway (open loop condition), or (iii) move in the opposite direction to the observer's sway (enhanced flow condition). In Experiment 2, sway was only slightly greater under open loop conditions and only slightly less with enhanced feedback. Taken together, these results provide further evidence that optic flow is not necessarily the most important factor in the maintenance of balance.

J8 1124 Modulation of visual control of posture by extra-retinal information of eye-movement

Shin'ichi Onimaru[1] (onimaru@real.tutkie.tut.ac.jp), Hiroaki Shigemasu[2], Michiteru Kitazaki[1,2,3]; [1]Department of Knowledge-based Information Engineering, Toyohashi University of Technology, [2]Research Center for Future Vehicle, Toyohashi University of Technology, [3]Intelligent Sensing System Research Center, Toyohashi University of Technology

Heading perception is inaccurate when the optical flow contains radial and lateral (rotational) motions as in the presence of eye-movement. Observers perceive a curved path if they are not moving their eyes and the optical flow is simulated by visual motion. However, they accurately perceive heading direction when the lateral motion is generated by an actual eye-movement. Thus, the extra-retinal information of eye-movement is utilized to perceive heading (Royden, 1994). We aimed to see whether the process for visual control of posture utilizes the extra-retinal information.

A linear viewpoint motion was simulated in a cloud of dots. Participants observed its visual image motion on a 120 inch screen at 130 cm distance while standing on a force plate to measure postural sway. For the real eye-movement condition, a red marker was set slightly left or right of the heading direction in the cloud of dots, and observers were asked to pursue the moving red marker with eye-movement. For the simulated eye-movement condition, a virtual camera pursued the red marker and its image motion was simulated. Thus, the red marker to be fixated was constant at the center of the screen. The image motions were identical on the retina for both conditions.

Observers inclined in the opposite direction to the visual simulation of linear viewpoint motion in sagittal direction for both conditions. Lateral sway was stronger in the simulated eye-movement condition than in the real eye-movement condition.

Though the retinal image motions were identical and contained both the lateral and radial motions, the postural sway to be induced by the lateral motion was inhibited when the observers actually moved their eyes. It is suggested that the process for the visual control of posture does not only due to the retinal image motion, but utilizes the extra-retinal eye-movement information.

Acknowledgement: This study was supported by Nissan Science Foundation and MEXT Japan.

J9 1125 Development of visual control of posture in sensitivity function of motion frequency

Michiteru Kitazaki[1,2,3] (mich@tutkie.tut.ac.jp), Jun'ichi Katayama[3], Nobuko Komori[4], Shoji Itakura[4]; [1]Research Center for Future Vehicle, Toyohashi University of Technology, [2]Intelligent Sensing System Research Center, Toyohashi University of Technology, [3]Department of Knowledge-based Information Engineering, Toyohashi University of Technology, [4]Department of Psychology, Graduate School of Letters, Kyoto University

Purpose: Optical flow is utilized to control posture for infants as well as adults (Lee and Aronson, 1974). It is reported that infants' postural sway is induced by visual motion in a broad range of motion frequency (0.2-0.54Hz, Delorme, Frigon and Lagace, 1989; Schmuckler, 1997), but adults showed postural sway only for low-frequency motion (<0.3Hz, van Asten, Gielen and van der Gon, 1988). We aimed to investigate developmental change of visual control of posture in function of motion frequency.

Method: Thirty-nine children (5-15 years old) and ten adults (20-28 years old) participated. Linear viewpoint motions in a cloud of dots were simulated in lateral (leftward and rightward) or in sagittal (forward and backward) direction, and cyclic back and forth at 0.1-0.6Hz. Participants' posture was measured at 60Hz by a force plate during observing the stimulus on an 80inch screen at 100cm distance. We analyzed the postural-sway data using Fourier transformation and extracted the power of sway synchronized to the visual motion.

Results: Total power of postural sway decreased as the observer getting elder. Individual difference was very large when adults observed lateral motion. Young children showed stronger postural sway at 0.6Hz than the lower frequency, but it was opposite for adults, who were more sensitive to 0.1-0.2Hz than 0.6Hz. The effective/sensitive frequency was shifted to lower frequency as the observer getting elder.

Discussion: These results suggested that the process for visual control of posture develops in childhood and its sensitivity function of motion frequency gradually changes. Shift of sensitive frequency to the lower frequency indicates the inhibition of high-frequency motion. Since optical flow on the retina must be decomposed and interpreted as object motion and self-motion, and the high-frequency motion would often correspond to object motion, the developmental shift of sensitivity function in our finding is ecologically reasonable.

Acknowledgement: This study was supported by Nissan Science Foundation

J10 1126 Progressive lenses distortions effect on postural stability in virtual reality environment

Jean-marie Hanssens[1] (hanssens_jeanmarie@hotmail.com), Remy Allard[1], Jocelyn Faubert[1]; [1]Psychophysics and visual perception Laboratory, School of optometry, University of Montreal.

Background. In most cases, presbyopic vision is corrected using progressive lenses. In spite of the geometric advanced of such products, some progressive lens wearers have difficulty adapting to them because of the distortions perceived in the bottom of the lenses. The purpose of the present study was to evaluate the influence of the visual distortions induced by progressive lenses on the postural stability of the wearers.

Methods. In order to simulate the visual distortions induced by progressive lens wear, twelve young observers (22 to 35 years of age) were placed in a fully immersive virtual reality environment where the virtual floor, defined by a 10 x 10 m2 black and white checkerboard pattern, oscillated sinusoidally. The amplitude (1 to 4°) and temporal frequency (0.03 to 2.0 Hz) of the oscillation were systematically manipulated (for a total of 21 conditions). Postural reactivity, defined by the amplitude of lateral (side-to-side) sway and the instability index, was measured as a function of virtual checkerboard distortion using magnetic sensors placed at the head and close to the centre of mass of the subjects and transformed using Fourier.

Results. Results showed that postural instability increased with the amplitude of stimulation, suggesting a direct relationship between amount of postural movement and visual distortions. Furthermore, subjects gained stability as the temporal frequency of the distortions increased. However, even in the high temporal frequency conditions, postural reactivity depended significantly on the distortions. Our results suggest that the adaptation difficulties to the progressive lenses could be related to the visual distortions induced in the lower visual field. Participants reported feelings of "seasickness" during task execution for high temporal frequency conditions comparable to what some presbyopes feel during initial progressive lens wear.

J11 1127 Independence of Verbal and Blind-Walking Distance Estimate Errors

Robert Post[1] (rbpost@ucdavis.edu); [1]Department of Psychology, UC Davis

Prior research has indicated that verbal estimates of a target's distance may be dissociable from estimates of the target's distance assessed by walking to it with vision obscured (blind-walking). This study examined further the degree to which verbal and blind-walking estimates of distance are independent by investigating the relationship between errors made in verbal and blind-walking estimates. Subjects viewed targets placed at various distances between 10 and 80 feet. They estimated the distance to the target, shut their eyes and walked to the perceived distance of the previously seen target. Results demonstrated that verbal estimates were more variable than walking estimates. This finding indicates that the verbal estimates do not provide the basis for the walking estimate. Examination of data from individual trials showed that errors on the two measures were uncorrelated. This finding implies a high degree of independence between the substrates for the verbal and blind-walking distance estimates.

J12 1128 **The Effects of Optical Magnification/Minimization on Distance Estimation by Stationary and Walking Observers**

Jennifer Campos[1] (camposjl@mcmaster.ca), Patricia Freitas[1], Emma Turner[1], Michael Wong[1], Hong-Jin Sun[1]; [1]Department of Psychology, Neuroscience and Behaviour, McMaster University

When moving through space, both optic flow and locomotor (proprioceptive/efference copy, vestibular) information can be used to judge the extent of a traveled distance. To better understand how each of these cues is used to estimate the magnitude of self-motion, it is important to dissociate the relative contributions of each when both are available in natural, cue-rich environments. This study created a conflict between visual and locomotor distance cues by either magnifying (2.0x) or minimizing (0.5x) the information contained in the optic array using spectacle-mounted lenses. The experiment took place in a large, open, outdoor field with few landmarks in the distant periphery. Subjects viewed a static target in the distance (6, 8, 10, 12m) and reproduced this distance by walking. Three optical manipulations (OMs: 2.0x, 1.0x, 0.5x) occurred either: A) during the initially learned visual preview, B) during the walked response, or C) during both learning and responding (same OM in each phase). When wearing the 2.0x lenses during the visual preview subjects produced estimates that were shorter than those produced when wearing the1.0x lenses. The reverse effect was observed for the 0.5x lenses (significantly longer). Although these under/overestimations of static visual distance are significant in the predicted direction, the magnitude of the effect is less than expected considering the specifications of the lenses. In contrast, when the OM occurred during the walked response there were no lens-related effects, thus suggesting a reliance on locomotor cues. When the OM occurred during both learning and responding, lens-related effects were again observed in the expected directions, although were not as strong as when the OM occurred during the visual preview alone. Overall, the results suggest that locomotor information can be used effectively to reproduce a learned visual distance and appears to be the dominant cue when walking with magnified/minimized optic flow.

Acknowledgement: This work was supported by NSERC and CFI grants to HJS and an NSERC fellowship to JLC.

Processing of Objects

Author Presents: 8:30 - 10:15 am

J13 1129 **Fine-grained analysis of functional selectivity in human occipitotemporal cortex**

Chris Baker[1] (bakerchris@mail.nih.gov), Mark Williams[2], Leila Reddy[2], Lawrence Wald[3], Graham Wiggins[3], Brad Dickerson[4], Christina Triantafyllou[2], Nancy Kanwisher[2,3,5]; [1]Laboratory of Brain and Cognition, NIMH, NIH, [2]McGovern Institute for Brain Research, MIT, [3]Martinos Center for Biomedical Imaging, MGH, [4]Department of Neurology, MGH, [5]Brain and Cognitive Sciences, MIT

FMRI investigations of extrastriate cortex have reported regions responding selectively to faces (FFA), scenes (PPA), and body-parts (EBA, FBA), but not other visual object categories (Downing et al., 2006). However, individual voxels in these studies typically contain millions of neurons and partial voluming could obscure fine-grained patterns of neuronal selectivity. Here we used a custom-built 32-channel phased-array coil to investigate selectivity across occipitotemporal cortex at 1mm isotropic resolution. Four subjects viewed faces, body-parts, cars, chairs and vases in a blocked design. Split-half analyses of unsmoothed data i) identified voxels that responded significantly more to a given category than to the average of the other four ($p < 0.001$), and ii) tested whether the selectivity of these voxels replicated in the other half of the data. An average of 237 face and 663 body-part selective voxels per subject were found. These voxels included clusters corresponding to the FFA, EBA and FBA. Critically, face and body-part selective voxels replicated their strong selectivity in an independent test in the other half of the data. In contrast, an average of only 40 car and 65 vase selective voxels were found; the selectivity in these voxels was not replicated in the other half of the data. For chairs, an average of 226 voxels were identified, mostly in the region of posterior LOC; some weak selectivity was preserved in the other half of the data. Thus despite clear replication of face and body-part selectivity, we find few voxels strongly and reliably selective for other visual categories even at 1mm isotropic resolution. While increased resolution may yet reveal selectivity for categories other than faces and body-parts, our findings suggest that at least for cars, chairs and vases, any such selectivity is likely to be weaker than selectivity for faces and body-parts (in terms of clustering or magnitude).

J14 1130 **Sensitivity to Object-Centered Relations in LOC**

Irving Biederman[1] (bieder@usc.edu), Mark Lescroart[1], Kenneth Hayworth[1]; [1]University of Southern California

From a 200 msec masked presentation of a minimal scene, composed of two separated objects, one above the other, subjects can name both objects and report which one is on top. This capacity poses a challenge to feature hierarchy models (e.g., HMAX) which achieve translation invariant recognition by representing an object as a list of 'positionless' features. How are the features of each object kept separate, and how could their relative positions be known? Aggelopoulos & Rolls (2005) suggest a solution. They found that IT receptive fields shrink and shift when viewing scenes, allowing the identity and positions of multiple objects to be simultaneously encoded. Their results, however, leave open whether position is encoded retinotopically (implied by them) or in an object-relative manner. We tested this using a human fMRI-adaptation experiment.

While fixating, subjects were shown a 200ms S1 consisting of two separated objects (e.g., elephant over bus) followed by a 300ms blank and then a 200ms S2 defining one of four trial types: a) "Identical," the same pair in the same relation and position, b) "Translated," the same pair in the same relation but in a different position, c) "Relation," the same pair in the same position but with the relation switched (e.g., bus over elephant), and d) "Object," one of the previous manipulations where, in addition, one of the objects changed. The task was to detect Object trials.

Results: there was only a small release from adaptation for the Translated condition but a sizeable release for the Relations condition (the opposite ordering is predicted by retinotopic models). Thus LOC may encode an object-relative structural description of scenes. We hypothesize that the same neural mechanism, when engaged on a single object, could form a parts-based structural description supporting our ability to understand shape.

Acknowledgement: Supported by NSF BCS 04-20794, 04-266415, 05-31177, 06-17699

J15 1131 **Precise discrimination of position in object-selective regions of human visual cortex**

Elizabeth Louie[1] (eglouie@ucdavis.edu), David Bressler[1], David Whitney[1]; [1]Center for Mind and Brain, Department of Psychology, University of California, Davis

Past studies have shown that the lateral occipital cortex (LOC) plays an important role in object recognition, and that a subdivision of LOC (LO) exhibits a coarse sensitivity to object position. Using fMRI, we studied the retinotopic precision of the LOC, the fusiform face area (FFA), and the parahippocampal place area (PPA) in six subjects. A region of interest (ROI) for the LOC was functionally defined for each subject as the area with the strongest activation while viewing images of intact objects versus scrambled objects. ROIs were similarly defined for FFA (faces minus houses) and PPA (houses minus faces). In separate runs, we presented flickering Gabors that were located in one of five different positions, ranging in eccentricity from ~8 to 10 deg. Within the ROIs defined above, we cross-correlated spatial patterns of activity generated by the Gabors in these different positions. We found that when two Gabors were within close proximity of each other, there was a high correlation in the pattern of activity in LOC. However, the correlation significantly decreased as the Gabors were shifted further apart, indicating that LOC was sensitive to differences in Gabor position of 2 deg or less. The FFA was also able to discriminate changes in position, but less precisely than the LOC. The PPA did not show any significant discrimination of object position. Our findings suggest that object sensitive regions including the LOC and the FFA carry surprisingly precise information about object position.

J16 1132 Perceptual expertise with cars leads to greater perceptual interference with faces but not objects

Thomas McKeeff[1] (tmckeeff@princeton.edu), Frank Tong[2], Isabel Gauthier[2]; [1]Department of Psychology, Princeton University, [2]Department of Psychology, Vanderbilt University

Perceptual interference can occur when observers discriminate a target among similar distractors. Recognition performance is poorer for subtle visual discriminations, suggesting that targets and distractors activate overlapping representations and thereby lead to capacity-limited processing. Previous studies have shown that the processing of different expert categories likely depends on shared processing resources (Gauthier et. al, 2003) even with visually distinct expert categories (e.g., faces and cars processed by car experts). Here, we examined whether the temporal limits of visual recognition might be altered by expertise with a particular object category, with greater interference occurring between object categories that depend on similar expertise processing strategies and thus common resources.

Car experts and novices viewed rapid serial visual presentations (RSVP) of heterogeneous images that required the identification of either: face targets presented among alternating images of face and car distractors or face and watch distractors, watch targets among watch and face distractors, or watch and car distractors. An adaptive staircase procedure was used to determine temporal thresholds for recognition. Car experts required slower presentation rates than novices to identify a face amongst irrelevant cars. The poorer performance of car experts could not be attributed to the capture of attention by objects of expertise, because they could identify a watch amongst irrelevant cars at faster rates than novices. In fact, the speed of face identification amongst car distractors was positively correlated with a quantitative measure of car expertise, whereas car expertise was negatively correlated with watch identification amongst car distractors. In control conditions where neither targets nor distractors were cars, the degree of car expertise was irrelevant. These results may reflect a multidimensional representation of object similarity in cortex that extends beyond simple measures of visual similarity. Expertise with an object category may alter the functional distance between object representations within this multidimensional space.

Acknowledgement: This work was supported by a grant to the Perceptual Expertise Network from the James S. McDonnell Foundation

J17 1133 Rapid object categorization without conscious recognition: aneuropsychological study

Boucart Muriel[1] (m-boucart@chru-lille.fr), Thorpe Simon[2], Kirschner Holle[2]; [1]University Lille2 CNRS, [2]University Toulouse 3 CNRS

Background: Kirchner and Thorpe (2006 Vision Research) showed that when two scenes are simultaneously flashed left and right of fixation human observers can reliably make saccades to the side containing the target (e.g., an animal) in as little as 120 msec. It is suggested that rapid object categorization can be performed without conscious recognition using highly automatic and data driven routines. This question was addressed in two patients with visual agnosia. Method: two agnostic patients and age-matched control participants were presented with photographs of natural scenes or isolated objects. Two scenes, one containing the target (an animal) were simultaneously displayed for 3 sec. In separate sessions participants were instructed either to locate the target with a keypress or to make a saccade toward the target. Results: Patients, who identified very few objects with unlimited exposure time were able to detect the target with 70% accuracy and saccade latencies of 250-300 ms in the categorization task. Performance was better with saccades than with keypress. For all observers accuracy was equivalent for objects in scenes and isolated objects but RTs were shorter for scenes . Conclusion: The results support the hypothesis that rapid categorization can be accomplished without conscious recognition.

J18 1134 fMRI-adaptation for articulated moving objects in ventral temporal brain areas

John Pyles[1] (jpyles@uci.edu), Javier Garcia[1], Emily Grossman[1]; [1]Department of Cognitive Sciences, University of California, Irvine

Purpose: We live in a world amidst complex, moving, articulated objects (such as bodies and machines). While a number of neuroimaging studies have clearly identified object selective brain responses in ventral temporal cortex (e.g. Grill-Spector, 2001), it remains unclear how dynamic objects are represented in these brain areas. These experiments investigate the neural representation of complex, articulating objects, both in motion and while stationary. Method: Two rapid event-related fMRI adaptation experiments compared neural responses to moving and static novel, articulating objects ('Creatures'; Pyles et al. 2005). Observers viewed 2 sec animations of novel locomoting objects with articulating parts; static stimuli were generated from still frames taken from the same animations. Trials consisted of paired movies or images, respectively, in the two experiments. The pairs were either: 1) identical, 2) different exemplars of the same object (i.e. in a different position and view), or 3) different objects. In each experiment, trials of a given condition were averaged together to compare the peak BOLD responses in object selective brain areas. Results: Replicating a number of previous reports, viewing repeated, identical static objects results in maximal fMR-adaptation in a number of object selective brain areas, including regions of the LOC. Viewing repeated, identical animations also yields maximal fMR-adaptation in those same brain regions. Additionally, some brain areas reveal fMR-adaptation for the 'different exemplar' condition (both moving and static), however this finding is variable across brain areas. Regions displaying fMR-adaptation are intermixed among others lacking adaptation, suggesting a patchy organization. Conclusions: Adaptation effects for static and animated objects in ventral temporal cortex is evidence for insensitivity to the configural changes of articulating objects over time.

J19 1135 Spaced out: good discrimination but poor memory for spacing differences in houses.

Rachel Robbins[1] (robbins@mcmaster.ca), Daphne Maurer[1], Terri Lewis[1]; [1]Department of Psychology, Neuroscience & Behaviour, McMaster University

Face recognition may differ from object recognition in being more affected by spacing between parts (e.g., distance between eyes) than by the features themselves. Here we examined adults' ability to discriminate and recognise houses in a design similar to that used previously with faces. Stimuli were photographs of houses in three conditions: houses that differed only in spacing between the windows and door; houses that differed only in features (the particular windows and door); and houses that were completely different. Subjects (N=24) completed a match-to-sample task followed by a 2AFC recognition memory task for each condition. The mean spatial frequency amplitude was matched across all sets. Overall, subjects were less accurate at the spacing task than the feature task (81% vs. 90%, $t(23) = 4.45$, $p < .001$ for discrimination; 47% vs. 89%, $t(23) = 4.95$, $p < .001$, for memory). Importantly, even for sets for which accuracy on the spacing and feature tasks were matched at the discrimination stage (81% vs. 84%, $t(11) = 1.15$, $p > .05$), memory for previously seen spacing was at chance (50%, $t(11) < 1$), while memory for particular features remained high (85%, $t(11) = 5.3$, $p < .001$). This contrasts with a previous study with faces in which adults remembered spacing information learned as part of another task at well above chance levels (Gilchrist & McKone, 2003). The current results for houses are consistent with different real-world processing demands for faces and houses. Facial features change as individuals talk, turn their head, or show facial expressions, and spacing information can be deduced relative to the same basic layout in every face. Houses, conversely, have constant features that can be distinctive and far fewer restrictions on basic structure (the door goes at the bottom but windows can go in any number of locations).

Acknowledgement: This work was funded by grants from CIHR.

J20 1136 The role of local feature processing in face and car detection

Hyejean Suh[1,2] (grisim@stanford.edu), Kalanit Grill-Spector[2,3]; [1]Department of physics, Stanford Universtiy, [2]Department of psychology, Stanford University, [3]Neuroscience program, Stanford Universtiy

One of the open questions in understanding human object recognition is the role of local features in object recognition. Is the processing of local features necessary for recognition of whole objects? Are local features processed independently?

Here, we tested human subjects' detection performance on whole object and partial object images containing 1, 2 or 3 features near perceptual threshold. For all image types, half of the stimuli contained gray level object images to which white Gaussian noise was added and the other half revealed the same regions in an image but contained only noise. The noise variance was adjusted in inverse proportion to the image area revealed such that the effective stimulus (Etot~ area/snoise) was constant across image types. Subjects were asked to judge whether images contained something (object or object part) or noise. Partial images contained either semantic or computer generated features. Two object categories (faces and cars) were tested (12 subjects each) with both types of feature sets.

For cars, we found that detection accuracy on partial images was higher than on whole images except for maximal Etot when subjects attained ceiling performance. For faces, performance on partial images was greater or equal to performance on whole images at low Etot. At higher Etot, however, the dynamics reversed and the performance on whole images was similar or better than the performance on partial images. When the location of features in partial images with 2 or 3 features was spatially rearranged, we found that the detection accuracy decreased for faces, but not for cars.

Overall, our results suggest that object detection near perceptual threshold is limited by the detection of local features. However, face detection seems to utilize, to a greater degree, global information enabled by non-independent processing of several local features.

J21 1137 Differential processing of salient regions, contours and shape in the human LOC

Joakim Vinberg[1] (joakimv@stanford.edu), Kalanit Grill-Spector[1,2]; [1]Psychology Department, Stanford University, Stanford, CA 94305, [2]Neurosciences Institute, Stanford University, Stanford, CA 94305

The human lateral occipital complex (LOC) responds more strongly to objects than scrambled objects and patterns. However, objects differ from patterns in several ways: they have a shape, contain a salient region and are delimited by contours. Here we examined the role of LOC in processing each of these types of information: salient regions, contours and shape.

We conducted two fMRI experiments (16 subjects) on a 3T GE scanner. Subjects viewed stimuli created by random dots (Stereo experiment: random dot stereograms; Motion experiment : random moving dots) which were matched for low-level visual information. Experiments contained five conditions: (1) random stimuli (random disparity dots, or randomly moving dots); (2) Two surfaces, creating two salient regions, but no contours; (3) Contours, generated by randomly scrambling object silhouettes, with no salient region; (4) Shaped holes; (5) Object silhouettes. Conditions 4 and 5 contained shaped salient regions with identical contours. Subjects were instructed to indicate whether the fixation was on the front or back surface (Stereo experiment) or if the motion was to the right or left (Motion experiment).

In both motion and stereo experiments, the object and hole conditions elicited significantly higher responses in LOC than contours, two surfaces or random conditions. In contrast, LOC activation to two surfaces without contours was not significantly higher than random noise. In posterior LOC, contours produced significantly greater activation than surfaces or random noise but less than objects and holes, suggesting that contours (even when they do not define an enclosed shape) contribute to posterior LOC activation. Anterior LOC did not show significant activation to contours vs. surfaces or random noise, suggesting that anterior regions process shape. These results provide evidence for a hierarchy of processing stages in LOC in which posterior regions processes both contours and shapes and anterior regions process shapes and objects.

Acknowledgement: Whitehall Foundation grant #2005-05-111-RES

J22 1138 Dynamic shape transformations influence the recognition of animals and objects

Quoc C Vuong[1,2] (q.c.vuong@ncl.ac.uk), Markus Graf[1,3]; [1]Max Planck Institute for Biological Cybernetics, Tübingen, Germany, [2]Division of Psychology, Newcastle University, Newcastle upon Tyne, UK, [3]Max Planck Institute for Human Cognitive and Brain Sciences, Munich, Germany

Several studies have shown that humans encode dynamic information such as rigid (e.g., rotations in depth) and non-rigid motion (e.g., facial expressions) for recognition purposes. Our goals in the present study were to extend previous work by using familiar objects which had a wide range of shapes and to determine possible influences of shape transformations on the encoding of dynamic information. We therefore tested the role of non-rigid shape changes in recognizing common animals and objects. To create these changes, we morphed between members of the same category (e.g., German shepherd and dachshund from the category dog). In a same/different categorization task, participants were shown a continuous morph sequence, followed by a static test image, and had to decide whether the image was from the same category as the morph sequence. Importantly, this paradigm does not presuppose that participants perform shape transformations. We found that participants responded more quickly if test images were sampled towards the end of the morph sequences, which replicates previous results with rigid rotations of objects and non-rigid facial expressions. This dynamic benefit was not a recency effect because it was eliminated when we scrambled the frame order of the morph sequences while preserving the continuity of the first and last 150 ms of the sequences. Overall these findings indicate that dynamic information plays a role in the recognition of diverse familiar shapes, and suggest a general mechanism that encodes continuous shape transformations.

J23 1139 Class information predicts activation by object fragments in human object areas

Yulia Lerner[1,2] (yulia.lerner@gmail.com), Boris Epshtein[1], Shimon Ullman[1], Rafael Malach[1]; [1]Computer Science and Mathematics, Weizmann Institute of Science, [2]Center for Neural Science, New York University

The ability of the human visual system to recognize and classify objects is one of the most impressive capacities and widely investigated topics in cognitive science. Such tasks are performed by the human brain with remarkable efficiency that exceeds that of any known artificial machinery. However, via what mechanisms are these individual objects classified and identified? Contemporary research relating to these problems provides a natural common ground for the convergence of two fields of study: functional brain imaging and computational modeling. Object-related areas in the ventral visual system in humans are known from imaging studies to be preferentially activated by object images compared with noise or texture patterns. It is unknown, however, which features of the object images are extracted and represented in these areas. Recent computational studies have shown the usefulness of selected object fragments as useful visual features for classification and recognition. In the present study we explored the extent to which the representation of visual classes used object fragments selected by maximizing the information delivered about the class. We tested fMRI BOLD activation of highly informative object features in low- and high-level visual areas, compared with non-informative object features matched for low-level image properties. Our results showed a significant correspondence between information content and activity in higher order object-related areas. That is, object-selective regions showed preferential activation for computationally acquired informative fragments as compared to non-informative ones - in the lateral occipital area (LO) and the posterior fusiform gyrus (pFs) activation by informative fragments was significantly higher for three object classes whereas activation in V1 was similar. Behavioral studies also revealed high correlation between performance and fragments information. The results show that an objective class-information measure can predict classification performance and activation in human object-related areas.

Acknowledgement: YL was funded by Charles Clore Fellowships. RM was funded by Benoziyo Center for Neurological Disorders, The Dominique Center and The Israeli Science Foundation Center of Excellence. SU was supported by Grant 7-0369 from the Israeli Science Foundation and EU Daisy Grant 015803.

J24 1140 Object-file, a static concept... using dynamic information?

Agnieszka Miskiewicz[1] (agnieszka.miskiewicz@chups.jussieu.fr), Stéphane Buffat[2], Anne-Lise Paradis[1], Jean Lorenceau[1]; [1]Cognitive Neuroscience and Brain Imaging Laboratory - LENA, CNRS UPR640, Université Pierre et Marie Curie-Paris 6, Paris, France, [2]Institut de Médecine Aérospatiale du Service de Santé des Armées, B.P 73-91223 Brétigny-sur-Orge Cedex , France

To study the relationship between the ventral and dorsal pathways in the processing of dynamic objects, we used structure from motion (SFM) stimuli composed of clouds of dots defining 3D shapes visible only when in motion.

In a first series of experiments, minimal presentation duration thresholds for the identification of shape and motion direction were measured for 3 shapes and 3 motion directions, embedded in motion noise sequences.

Duration thresholds range from 60ms (+-7.5ms) for motion identification to 100ms (+-26ms) for form identification, suggesting a temporal precedence of motion processing over form.

In a second series of experiment, the same class of stimuli was used with Rapid Serial Visual Presentation (RSVP) paradigm, designed to induce Repetition Blindness (RB), in order to determine whether the same hierarchical processes would be at work. If so, one would expect motion repetition to interfere with shape perception.

In different blocks of trials, observers (N=12) reported the number of occurrences they perceived of either 3D shapes (“shape task”) or motion directions (“motion task”). RSVP sequences were identical in both tasks.

We computed a repeated measure ANOVA with 3 factors: task, repetition over the task-relevant attribute and repetition over the irrelevant attribute.

In both tasks, we found a significant effect (F (1,11)=136. 4, p<.001) of the repetition of the relevant attribute (RB effect) and no significant effect of the irrelevant one.

We conclude that the RB effect, well known for static objects, can be found to 3D dynamic objects and that RB for motion direction also exists.

Despite the necessary processing of motion to perceive 3D shapes, under our conditions we did not find any interaction between motion and shape. These findings suggest that RB is task dependent and that Object files are goal directed entities rather than resulting exclusively from bottom-up processes.

Acknowledgement: supported by DGA/D4S/MRIS grant n× 06C0035
URL: http://cogimage.dsi.cnrs.fr

J25 1141 On the limits of feed-forward processing in visual object recognition

Gabriel Kreiman[1,2] (gabriel.kreiman@childrens.harvard.edu), Thomas Serre[3], Tomaso Poggio[3]; [1]Children's Hospital Boston, Harvard Medical School, [2]Center for Brain Science, Harvard University, [3]McGovern Institute, MIT

The primate visual system shows a high degree of selectivity while at the same time being robust to large transformations of the images. This remarkable degree of invariance and specificity can be achieved quite rapidly as evidenced by the short latency of selective spike responses in higher levels of visual cortex and also by psychophysics performance in rapid visual presentation tasks and backward masking tasks. The speed of processing in the visual system has led to the notion that feed-forward processing can account for several aspects of visual object recognition. Indeed, a purely feedforward computational model is very successful in explaining physiological responses in several areas of visual cortex from primary visual cortex through inferior temporal cortex and also several psychophysical observations where humans need to rapidly identify or categorize objects. Here we quantitatively explore the limits of feedforward processing by examining how well a purely feedforward model can perform identification and categorization tasks in images containing multiple objects or other scenarios where we parametrically vary the amount of clutter in the image. We first show that the performance of the model in response to isolated objects matches the electrophysiological properties of IT neurons in terms of their accuracy as well the robustness to changes in object scale and position. We then show that performance degrades with increasing number of objects or with increasing degrees of clutter in natural scenes. These results point to the limits of feedforward processing in visual object recognition and emphasize the role of attention in processing and interpreting complex natural scenes.

Acknowledgement: Ophthalmology Foundation Children's Hospital Boston, American Epilepsy Foundation, McGovern Institute
URL: http://www.childrenshospital.org/research/kreimanlab

J26 1142 It seems to turn away from me: Foreshortened front-back axes bias determination of depth orientation of familiar objects.

Ryosuke Niimi[1,2] (niimi@L.u-tokyo.ac.jp), Kazuhiko Yokosawa[1]; [1]The University of Tokyo, [2]JSPS Research Fellow

In daily visual scenes, familiar objects appear in various orientations, such as front, side, and oblique. How accurately can human vision determine these depth orientations? Since the extraction of the front-back axes of objects seems to involve the determination of object orientations, we predicted that the determination of object orientations would be relatively inaccurate when the front-back axes are foreshortened and difficult to extract (i.e., when the front-back axes are roughly aligned with the viewpoint). To examine this hypothesis, we presented pictures of familiar objects in various orientations (namely, azimuth angles) to participants and asked them to estimate the orientations of these objects. Ten orientations ranging from 9 to 171 degrees were tested (0 degrees indicates front orientation, and 180 degrees indicates back orientation). The objects were rendered into 2D stimulus images by using computer software and were presented on a vertical CRT screen that were placed at a distance of 500 mm from the participants’ viewpoint. This real-world 3D spatial relationship was simulated by computer software when the stimulus images were generated. The participants rotated a disk displayed on the horizontal LCD screen such that its front (marked by a dot) was oriented to the same azimuth angle as the stimulus objects. When the object orientations were less than 45 degrees or more than 135 degrees (the front-back axes were relatively foreshortened), the estimated orientations were biased toward 90 degrees (side orientation), i.e., participants overestimated the deviations from the front or back orientations. The determination of object orientations was biased because of the difficulty in extracting the front-back axes precisely. This result also suggests that human vision has adapted to determine whether or not the front-back axes of familiar objects are aligned with the viewpoint.

Acknowledgement: Supported by JSPS

J27 1143 Spatiotemporal averaging along a moving trajectory

R. Dirk Beer[1] (rdbeer@ucsd.edu), Erin A. Krizay[1], Donald I. A. MacLeod[1]; [1]Department of Psychology, University of California, San Diego

We find that changes in luminance are detected with impaired sensitivity when they belong to an object in apparent motion. A disc was viewed in an orbit around the point of fixation. It appeared sequentially in eight locations at 45 degree intervals around fixation. Luminance modulation was introduced by increasing luminance on the major axes and reducing it on the diagonals, or vice versa. Vivid large-scale apparent motion results at intermediate interstimulus intervals, but not at very short or very long ISIs.

In one experiment, subjects matched the luminance of the lighter, or the darker, disks of a fixed-modulation stimulus using a central disc. The difference between the matches is a measure of the apparent luminance modulation. The apparent modulation was reduced at ISIs that gave strong apparent motion.

In a second experiment, subjects matched the diagonal to the major axis discs, effectively adjusting the luminance modulation to zero. The reciprocal of the standard deviation of the settings is a measure of modulation sensitivity. By this criterion, modulation sensitivity was sharply reduced at ISIs that gave strong apparent motion. Also, the task of making the setting was experienced as far more difficult in the presence of the motion.

We conclude that detectability of a spatial luminance modulation can be severely compromised when the luminances compared appear to belong to a single moving object. The large visual angle between successive discs in our experiment precludes spatio-temporal averaging in the afferent pathways or V1, so evidently high-level vision incorporates a bias toward constancy in the properties of moving objects. The constancy assumption is usually correct, and allows economy in representation.

Scene Perception II

Author Presents: 8:30 - 10:15 am

J28 1144 Rapid categorization of Natural or Man-made scene contexts : different effects with amplitude and phase alterations.

Olivier Joubert[1] (olivier.joubert@cerco.ups-tlse.fr), Denis Fize[1], Guillaume Rousselet[2], Michèle Fabre-Thorpe[1]; [1]CerCo, Université Toulouse 3, CNRS Toulouse, France., [2]Department of Psychology, Centre for Cognitive NeuroImaging, University of Glasgow.

The physical features used when human subjects are categorizing natural images on the basis of their context are still poorly known. It is usually believed that amplitude informations are sufficient to categorize scenes.

In the present study, we first equalized amplitude and furthemore modified phase informations in a rapid categorization task in which 1440 achromatic naturals images were categorized as “Man-made” or “Natural”. In a first experiment, phase information was preserved but amplitude information was equalized by applying the amplitude spectrum averaged across the two categories on each stimulus. Twelve subjects were tested. In a second experiment using the amplitude equalized scenes, new stimuli were built by mixing a variable percentage of random noise phase with the original scene phase, creating 10 new sets of stimuli from 0-99% random noise phase by 11% steps. Ten human subjects were used to counterbalance all conditions. Each subject saw every scene at only one noise level. In both experiments, subjects were performing a go/no-go rapid visual categorization task; scenes were flashed for only 26 ms, subjects were responding with a finger lift to targets and kept pressing a button with distractors. They performed successively two blocks of context categorization, using either “Man-made scene” or “Natural scene” as targets.

When amplitude spectrum is equalized, a very little impairment (greater with manmade targets) is seen on performance. When noise was gradually added to phase components, performance was not gradually affected. It remained stable up to 66% of normal phase where a sharp performance decrease was observed with 55% added noise and up to 99% added noise. With high noise conditions subjects were inhibiting their go responses, a biais that was even stronger in the "Man-made" task.

Categorization can be done with enough phase information when no amplitude information can be used.

J29 1145 Objective Assessment of Improved Visibility with Digital Image Enhancement for the Visually Impaired

Ming Mei[1] (m2mei@uwaterloo.ca), Susan Leat[1]; [1]School of Optometry, University of Waterloo

Purpose: Observers with visual impairment show subjective preferences for pictures that are digitally enhanced with generic filters and specially-designed filters. The purpose of this study was to use a measure of performance to demonstrate improved visibility of images that have been enhanced.

Methods: Nine subjects with maculopathy were recruited. The range of digital filters included generic filters (high pass or un-sharp mask, contrast enhancement, Sobel edge enhancement, DoG convolution), and custom-devised filters (Peli contrast enhancement and filters based on contrast sensitivity and supra-threshold contrast matching results). The filters were applied to two groups of images (14 faces and 14 general scenes). Using subjective comparisons and ratings of perceived visibility of filtered images compared to unfiltered images, the best two filters were obtained for each subject. These two best filters were applied to another two groups of images (32 faces with four facial expressions and 7 general scenes). For the face images, subjects were required to recognize facial expressions (anger, disgust, fear, or sadness). Eight questions were generated for each general scene image. Percent correct was calculated for both sets of images comparing filtered and unfiltered images.

Results: Image enhancement improved performance both with facial expression recognition (paired t-test, $p = 0.004$) and questions about general scenes (6 or 7 out of 9 subjects show significant improvement - paired t-test, $p<0.05$).

Conclusion: This study demonstrates that it is possible to measure improvements in visibility with digital image enhancement and that digital enhancement with a variety of generic and custom-devised filters improves visibility measured both subjectively and objectively for people with maculopathy.

J30 1146 Position-Invariant fMRI Adaptation Effects in Scene-Selective Regions

Sean MacEvoy[1] (macevoy@psych.upenn.edu), Russell Epstein[1]; [1]Center for Cognitive Neuroscience, University of Pennsylvania

Complex visual scenes preferentially activate several areas of the human brain, including the parahippocampal place area (PPA), a portion of the retrosplenial complex (RSC), and a region near the transverse occipital sulcus (TOS). Many basic response properties of these regions remain unknown, including the extent to which they are visuotopically organized. Recent fMRI studies have shown that PPA and TOS are particularly sensitive to stimuli presented in the visual periphery (Levy et al. 2001, 2004), consistent with the idea that neurons in these regions possess large receptive fields that integrate information from across the visual field. To test this hypothesis directly, we adapted an fMRI approach employed recently to analyze visual topography in the object-selective lateral occipital complex (LOC) (McKyton and Zohary 2006). We compared activity evoked by sequences of photographs of indoor and outdoor scenes confined to either the left or right visual hemifields, as well as the magnitude of adaptation produced by identical preceding stimuli in the same or opposite hemifield. We found that RSC responses did not distinguish between stimuli falling in either the ipsi- or contralateral hemifields, while PPA and TOS displayed small but significant preferences for contralateral stimuli. However, in all three areas, adaptation effects were position-invariant: responses to stimuli in one hemifield were equivalently reduced following adaptation to stimuli in either the same or opposite hemifield. In contrast to LOC, where a prior study observed adaptation between stimuli appearing in the same hemifield only, these results indicate that scene-selective neurons in PPA, RSC and TOS possess receptive fields covering large regions of visual space that include significant portions of both hemifields.

Acknowledgement: Supported by NIH R01 EY-016464.

Wednesday Posters

J31 1147 Two kinds of fMRI repetition suppression?

Whitney Parker[1] (wparker@alumni.upenn.edu), J. Stephen Higgins[1,2], Alana Feiler[1], Russell Epstein[1]; [1]Department of Psychology, University of Pennsylvania, Philadelphia, [2]Department of Psychology, University of Illinois at Urbana-Champaign

In many cortical regions, the fMRI response to a repeated stimulus is reduced compared to the response to a novel stimulus. This phenomenon, known as fMRI repetition suppression, or fMRI adaptation, has been used as a tool to study neural representations at the subvoxel level. However, many aspects of fMRI adaptation are not understood. For example, it is unclear whether reductions caused by immediate repetition of a stimulus index the same representations as reductions caused by repetition after a longer interval. We examined this issue by measuring the effects of both kinds of repetition within the same experimental session. In the first half of the experiment, immediate (within-trial) repetition effects were examined by presenting two visual scenes in each trial, which could either be identical images (no change), different views of the same place (viewpoint change), or different places (place change). In the second half of the experiment, cross-trial repetition effects were examined by presenting subjects with single scene images which could either be identical to those presented in the first half of the experiment (old view), previously-unseen views of the places shown in the first half of the experiment (new view), or previously-unseen places (new place). Consistent with previous results, within-trial repetition effects in scene-responsive regions were entirely viewpoint specific: response reduction was only observed when a place was repeated from the same view (no-change) but not when a place was repeated from a different view (viewpoint-change). Surprisingly, however, cross-trial repetition effects were primarily viewpoint invariant: strong response reduction was observed when places were repeated from different views (new view). These results raise the possibility that within-trial and across-trial fMRI repetition effects may be generated by different neural mechanisms, as suggested by recent neurophysiological studies (Sawamura et al., 2006). Alternative interpretations of these results will also be discussed.

Acknowledgement: This research was supported by the following grants: NIH R01 EY-016464, Whitehall Foundation 2004-05-99-APL.

J32 1148 The map in the brain: Distributed cortical representations of large-scale space

Alana M. Feiler[1] (feiler@psych.upenn.edu), Russell A. Epstein[1], Geoffrey K. Aguirre[2]; [1]Center for Cognitive Neuroscience, University of Pennsylvania, [2]Department of Neurology, University of Pennsylvania

Humans and animals encode representations of the large-scale spatial structure of the environment that allow them to understand the spatial relationships between real-world locations and to navigate accurately between them. We used a continuous carry-over fMRI design to probe the neural concomitants of these hypothesized cognitive "maps" in humans. Subjects were scanned with fMRI while viewing images of 16 locations from a familiar college campus. Four images were acquired for each location; these images depicted the views one would see facing Northeast, Northwest, Southeast, or Southwest. On each of many trials, subjects were presented with one image and a reference direction (North, South, East, or West), and reported whether one would rotate left or right to face the reference direction. This task encouraged subjects to recover geographic place information, but did not require them to explicitly manipulate information about allocentric (map) position. We determined how (1) trial-by-trial fMRI adaptation and (2) the distributed pattern of fMRI response to each place varied as a function of distance between locations. Distance was defined both in physical space, and also psychologically by querying subjects about the perceived distances between locations in a separate behavioral session. Preliminary results indicate that the differences in the spatially distributed patterns of fMRI response to different locations varied significantly as a function of the physical and psychological distances between these locations. These results indicate that fMRI can be used as a tool to query the cortical representations of large-scale space.

Acknowledgement: This study was supported by NIH R01 EY-016464 and Whitehall Foundation 2004-05-99-APL

J33 1149 Normative representation of objects and scenes: Evidence from predictable biases in visual perception and memory

Talia Konkle[1] (tkonkle@mit.edu), Aude Oliva[1]; [1]Brain and Cognitive Sciences, MIT

Objects and scenes can be viewed at almost any distance, and so can subtend any visual angle. However, we propose that for a given visual stimulus there exists an input size that maximizes visual information needed for a given task. We term this size the “norm”, and present initial evidence suggesting that (1) perception is implicitly sensitive to the norm, and (2) memory for visual information is biased toward this norm. First, observers were presented with a picture of an isolated object (experiment 1a) or a scene (experiment 1b) and were told to adjust the visual angle of the object or the viewing distance of the scene until the image was at the “right place” to see the object or scene. Despite the subjectivity of the task, the selected size for each stimulus was remarkably consistent across observers. Second, the norms from experiment 1 were used in a boundary adjustment task. In the classical boundary extension paradigm, subjects tend to remember pictures of scenes as farther away than they were originally viewed. However, if memory is biased toward a norm point, then a view of an object should show both boundary extension and boundary compression, depending on where it is relative to the norm. Observers were presented with pictures of objects (experiment 2a) or scenes (experiment 2b) taken from different distances and displayed for 5 seconds each. Afterwards, participants adjusted the size of the object or scene so as to match the size viewed at learning. The remembered objects and scenes showed a systematic bias towards the normative size. Finally, using a change detection paradigm, we show that a change towards the norm is harder to detect then a change away from the norm, providing converging evidence that memory is biased toward a perceptual norm.

Acknowledgement: TK is funded by an NDSEG fellowship

J34 1150 Statistical learning of temporal predictability in scene gist

Timothy F. Brady[1] (tfbrady@mit.edu), Aude Oliva[1]; [1]Department of Brain and Cognitive Sciences, MIT

One of the primary goals of the visual system is to extract statistical regularities from the environment to build a robust representation of the world. Recent research on visual statistical learning (VSL) has demonstrated that observers can implicitly extract joint probabilities between objects during streams of visual stimuli (Fiser & Aslin, 2002). Typically, these VSL studies include the same stimuli throughout training and test. In the real world, though, temporal predictability exists at both exemplar and categorical levels: whatever office you are in, the probability that you will step out in a zoo is much lower than the probability that you will enter a corridor. Here, we tested to what extent people are sensitive to the learning of categorical temporal regularities based on the gist of natural scenes.

Observers performed a one-back task, viewing a 7-minute familiarization sequence of pictures drawn from 12 scene categories (mountain, kitchen, street, etc). Other than the one-back repeats, none of the same pictures were ever repeated. During the stream, the joint probability between triplets of scene categories was manipulated (for instance, a bathroom would always precede a mountain which would always precede a forest). After familiarization, observers completed a series of 2AFC familiarity judgments between triplets of novel pictures that either maintained or ignored the temporal regularities present during the learning phase. Results showed that observers more often choose the sets of pictures whose categories had predictably followed one another. Importantly, nothing about scene category was mentioned to the observers, and none of the tasks required extracting the semantic category of the scenes. The results suggest that the gist of a scene is automatically extracted even when it is not task-relevant, and that implicit statistical learning can occur at a level as abstract as the conceptual gist representation.

J35 1151 Is Unlocalized Amplitude Information of Any Use for Scene Gist Recognition?

Lester Loschky[1] (loschky@ksu.edu), Daniel Simons[2], Scott Smerchek[1], Elise Matz[1], Benjamin Bilyeu[1], Laura Artman[1]; [1]Psychology Department, Kansas State University, [2]Psychology Department, University of Illinois at Urbana-Champaign

What information do people use to recognize scene gist? Recent computational scene classification models have proposed that scenes' unlocalized amplitude information, their distribution of spatial frequencies and orientations, is useful for recognizing gist. Our previous research (Loschky et al., 2005; Loschky et al., 2006) has contradicted these claims, showing that phase randomization greatly hinders scene gist recognition. Experiment 1 tested the hypothesis that unlocalized amplitude information is more useful for the perceptually primitive "natural" vs. "man-made" superordinate category distinction than for the basic level distinctions previously tested, using Oliva and Torralba's (2001) 2 superordinate and 8 basic level categories. With full phase randomization, subjects were slightly above chance for basic level distinctions, but at chance for the "natural" versus "man-made" distinction. These results suggest that unlocalized amplitude information is minimally useful for making even the most primitive scene gist distinctions.

How can such results be squared with those of Guyader, et al. (2004), who showed that unlocalized amplitude information is useful for priming gist? Experiment 2 replicated their main finding, that phase randomized scenes can prime gist just as effectively as normal scenes do, in a task using two basic level categories ("coast" and "tall building") with orthogonal dominant orientations (horizontal versus vertical), though the effect size was small. Experiment 3 tested the hypothesis that a scene's dominant orientation, while somewhat useful in priming a scene category, does not sufficiently constrain gist interpretations--there are many predominantly horizontal scenes (beaches, fields, highways, etc.), and many predominantly vertical scenes (tall buildings, trees, etc.). The results were generally consistent with this idea, with phase randomized "tree trunks" and phase randomized "tall buildings" both priming "tall building" scenes about equally effectively. Thus, unlocalized amplitude information, including the dominant orientation of an image, appears to be of limited use for recognizing scene gist.

J36 1152 Spatial judgments are facilitated by layout cues but not by recall cues

Carmela Gottesman[1] (cvgottesman@sc.edu); [1]University of South Carolina, Salkehatchie

Do people create spatial layout representations that are distinct from other representations of scenes? Previous research has shown that a preview of a natural scene could facilitate distance judgments even in areas of the scene that were not visible in the preview. Several processes could cause this facilitation. It is possible that the viewer extracted a spatial layout representation from the preview and that this representation was extended beyond the preview's perimeter. However, it was also possible that the preview simply helped viewers anticipate which scene would appear next and retrieve memories of the scene. In order to differentiate between these two processes participants in this study were asked to judge the distances in eight pictures on 576 trials. On each trial the target picture was preceded by one of four possible primes: a full version of the target picture with the to-be-judged objects removed, a section of the target picture that did not show the areas where the to-be-judged objects would be, a verbal label the defined the target picture and would help the viewer predict which picture would appear next, and a control image that provided no information about the upcoming target picture. Reaction time was compared in the four prime conditions. The two pictorial primes facilitated distance judgments compared to the control but the verbal primes did not. Therefore, knowing which picture will appear based on a verbal label was not helpful in this type of task. A prime was only useful if it relayed spatial information needed for activating a mental representation of scene layout.

J37 1153 Encoding of different environmental features with or without spatial updating

George S W Chan[1] (changsw@mcmaster.ca), Yvonne Chang[1], Hong-Jin Sun[1]; [1]McMaster Unviersity

Wang and Spelke (2000) have shown that certain features of an environment are encoded egocentrically, whereas others are encoded allocentrically. We studied directional judgments of environmental features (objects and corners) from viewpoints that were either aligned or misaligned with the originally learned viewpoint. Further, we explored the role of spatial updating in determining the type of spatial processing.

Subjects were brought to a learning position in a four-sided, irregularly shaped room and learned the locations of four corners and four different objects. They were then blindfolded and led to the centre of the room either along a direct path (providing spatial updating) or along a disorienting path. They were then required to point in the directions of the corners and objects while imagining themselves at one of two testing viewpoints (aligned or misaligned with the learning viewpoint).

The results showed that absolute error for both corners and objects was higher from the misaligned viewpoint compared to the aligned viewpoint regardless of whether subjects were disoriented or not, suggesting a tendency for egocentric processing. However, for configuration error, when subjects were not disoriented, both corners and objects showed no difference between viewpoints. This discrepancy in results between absolute and configuration error when subjects were not disoriented suggests that subjects can maintain the relative layout of the features but not the absolute direction of the features when the testing viewpoint changed. When subjects were disoriented, configuration error was higher from the misaligned viewpoint compared to the aligned viewpoint for corners but not for objects.

The manner by which different features are processed can be conceptualized as falling on different positions along a continuum between pure egocentric and pure allocentric spatial representations. Overall the availability of spatial updating and the type of spatial features can both impact the characteristics of spatial representations.

Acknowledgement: supported by NSERC and CFI grants to HJS
URL: http://vr.mcmaster.ca/lab/

Search II

Author Presents: 8:30 - 10:15 am

J38 1154 A measure of relative set size for search in clutter

Mary J Bravo[1] (mbravo@crab.rutgers.edu), Hany Farid[2]; [1]Rutgers-Camden, [2]Dartmouth College

Visual search performance is typically measured as a function of set size, but it is unclear how to determine set size in cluttered scenes. Previously, we claimed that in such scenes, set size corresponds to the number of segmentable regions rather than the number of objects (Bravo & Farid, 2003). We supported this claim by showing that distractors with multiple regions produce steeper search functions than distractors with a single region. Our goal this year was to quantify this relationship by using a computational model to count the regions in our clutter stimuli.

There are many computational models for segmenting an image into regions; of these, graph-based approaches have shown particular promise. We employed one such algorithm (Felzenszwalb and Huttenlocher, 2004) to count the number of regions in our 2003 stimuli. We then used this measure of set size to replot the search time data. Using the number of segmentable regions as the measure of set size produced a better fit (R^2=0.995) than did using the number of distractor objects (R^2=0.916).

Like all computational models of image segmentation, the output of the algorithm is highly scale-dependent. By adjusting the algorithm's parameters, a single image can be segmented into 50 regions or 500 regions. This variability is not a limitation of the algorithm; it reflects the scale ambiguity inherent in image segmentation. To determine whether our choice of parameters was fortuitous, we explored the parameter space and found that nearly every set of values produced an excellent fit to our data. Evidently, the number of regions in our stimuli is roughly proportional over a wide range of scales. We have confirmed that this proportionality also holds across many natural images.

We conclude that computational models of image segmentation can provide a good measure of relative set size in cluttered stimuli.

J39 1155 Dividing the labor of search: It's not just space anymore

Xin Chen[1] (xichen@ic.sunysb.edu), Gregory Zelinsky[1]; [1]Stony Brook University

People can collaborate during a search task (Zelinsky et al.; VSS 05), but how does this collaboration translate into a division of search labor? Previous work demonstrated a spatial division of labor, but did this finding hinge on the availability of information in the task? To discover whether other coordination strategies might spontaneously emerge, we had groups of 2, 3, or 4 people engage in 3 collaborative search tasks: (1) searching for an oval dot among 494 black circular dots, (2) a color version of Experiment 1 having red, blue, green, and black dots partially segregated into non-geometric regions, and (3) a multiple-target task in which subjects searched for 1, 4, or 8 possible targets in 14-item displays (photo-realistic objects). We quantified division-of-labor by correlating the targets' properties (e.g., location, color, identity) with the responses of individual searchers from a collaborating group. Consistent with previous work, subjects in Experiment 1 divided the search labor spatially, either splitting the display in two (2-person condition) or by quadrant (4-person condition). Experiment 2 produced very different results. Despite an identical configuration of dots, subjects now divided the search labor by feature, with each member of a 4-person group searching a different distractor color. Experiment 3 yielded evidence for yet another form of division-of-labor. Subjects divided the task by target rather than by space or feature, with searchers in the 4-person group each taking responsibility for a different potential target from the 4-object target preview. We conclude that subjects do indeed use spatial division-of-labor collaborative strategies as originally reported, but only when the task does not allow for more meaningful divisions of search labor. When the distractor set is multi-colored, or when the task requires searching for multiple targets, simple spatial division-of-labor strategies are replaced by collaborative strategies based on feature and target information.

Acknowledgement: This work was supported by National Science Foundation grant 0527585

J40 1156 Cutting Through the Clutter: Searching for Targets in Evolving Realistic Scenes

Mark Neider[1] (mneider@uiuc.edu), Samantha Brotzen[2], Gregory Zelinsky[2]; [1]Beckman Institute, University of Illinois at Urbana-Champaign, [2]Stony Brook University

Search in the real-world is often carried out in highly cluttered environments. Although several studies have explored the relationship between search and scene clutter, this effort has been hampered by a lack of stimuli varying systematically along the clutter dimension. We had observers search through quasi-realistic scenes created with the game Sim City, with each scene representing a different time in a city's evolution. The target in each scene was a visually designated building that was always present. The search task terminated when the target was fixated and confirmed with a button-press. There were three cities (rural, suburban, and urban), with 30 screenshots obtained for each scene type. Importantly, these 30 images captured a given city as it grew over time within the game (e.g., urban image 1 was an open field with some roads; urban image 30 was a bustling metropolis). Both between and within scene estimates of clutter were validated using independent raters, allowing us to examine how systematic changes in clutter affect search. We found longer RTs and more fixations in the heavily cluttered urban city (~7s) compared to the minimally cluttered rural city (~4s). Search in the suburban city produced an intermediate result (~5s). Within city analyses revealed a similar pattern. As cities grew and became more cluttered, search became more difficult, a relationship reflected in the slope of the RT x Time in Game (TIG) and fixation number x TIG functions. Moreover, slopes were steepest in the urban city and shallowest in the rural city, indicating that clutter levels evolved at different rates according to city type. These data are broadly consistent with the view that search efficiency declines as scene clutter increases, and suggests that our Sim City stimuli may serve as a benchmark dataset for the evaluation of models of visual clutter.

Acknowledgement: This work was supported by grants from the NIH (R01 MH63748) and ARO (DAAD19-03-1-0039).

J41 1157 In What Ways Does Visual Search Benefit From a Spatial Cue?

Shahab Ghorashi[1] (ghorashi@psych.ubc.ca), Vincent Di Lollo[2]; [1]University of British Columbia, [2]Simon Fraser University

An attentional blink (AB) deficit is an impairment in the perception of the second of two rapidly sequential targets. It has been shown that during the AB, an exogenous spatial cue can be perceived and thus trigger orienting of attention towards the target in a search task (Ghorashi, Di Lollo, & Klein, 2006). Therefore, the cue caused an improvement in search performance. However, since the number of elements in the search array (i.e., set size) was not manipulated, it was not clear which aspect of the search was improved: was it the intercept or the slope of the search function (performance x set size)? In three experiments we sought to answer this question by maintaining the same methodology and varying the set size. Hence, in keeping with Ghorashi et al. (2006), the first target was always a white letter among black letter distractors. The second target was a search array in which observers identified the tilt of a letter T among rotated letter Ls. The search display was followed by a mask and was preceded by an informative spatial cue. In experiment 1, a dynamic staircase method was used to obtain the critical exposure duration of the second target that yielded 80% correct responses. The cue affected the intercept but not the search slope. In experiment 2, the search array was not masked but remained on the screen until the observer's speeded response. Reaction times revealed significant effects of the cue on both slope and intercept. In experiment 3 we found that the same results as in experiment 2 are obtained even when the search is performed as a single task. Collectively, the results are explained in terms of the exogenous cue causing a reduction in the effective set size of the search array.

Acknowledgement: Supported by a Discovery Grant and by a post-graduate scholarship from the National Sciences and Engineering Research Council of Canada

J42 1158 Both Identity and Location CAN Be Learned Quickly in Repeated Search

Emily Skow[1] (eskow@u.arizona.edu), Mary Peterson[1]; [1]University of Arizona

The role of memory in repeated search tasks is contentious. Wolfe et al. (2000) contend that participants cannot learn the locations of items in repeated scenes because search time continues to increase with display size despite hundreds of repetitions. In contrast, Chun and Jiang (1998, 1999) showed that search is more efficient for repeated versus new scenes and that this learning occurs for either spatial layout or identity, but not both. We show that participants can learn that a particular item is more likely to occur in a particular location and that this learning of "bound entities" occurs rapidly. In Experiment 1 participants searched through an 8-item display for one of two targets that were present on 50% the trials. When present, each target occurred in one, high frequency (HF) location with 75% probability, and in the other target's HF location with 25% probability (low frequency, LF, location). Participants verified target presence 28-ms faster for targets in their HF versus LF locations, $p<.001$. On target-absent trials, a foil (different for each target) was present in the HF or the

Wednesday Posters

LF location. Participants accurately reported target absence 17-ms faster for foils in HF versus LF locations, p<.005. These differences were evident in the first block (62 trials); hence, bound entities can be learned quickly. In Experiment 2 we tested 4 targets; for each target, one location was more informative than another. Participants verified target presence (21 ms) faster for more informative locations, p<.01. In addition, RTs were longer in Experiment 2 than Experiment 1 indicating that, even when bound entities are learned, search slows with increased target number. Thus, increases in search time with target number (identical to display size in Wolfe's experiments) cannot be taken as evidence that learning has not occurred.

Acknowledgement: UA SBSRI grant and APA dissertation award to ES and NSF BCS 0418179 to MAP

J43 1159 Cross-modal contextual cueing: Auditory andvisual association guides spatial attention

Jun Kawahara[1] (jun.kawahara@aist.go.jp); [1]National Institute of Advanced Industrial Science and Technology

Under incidental learning conditions, a spatial layout can be acquired implicitly and facilitate visual searches (the contextual cueing effect). Recently, Ono, Jiang, and Kawahara (2005) found that the spatial context acquired in one trial influences the visual search in the next trial and proposed the ubiquitous statistical learning account, in which the visual system is sensitive to all kinds of statistical consistency. The present study examined whether a contextual cueing effect can develop from the association between auditory events and visual target locations. In the training phase, participants heard a meaningless auditory stimulus for 2 sec, and then performed a visual search in which they searched for a T among Ls. In every trial, the target location could be reliably predicted from the preceding auditory stimulus. In the testing phase, the auditory/visual pairings were disrupted, so that the initial auditory stimulus did not predict the target location. We examined how the search performance (reaction time) improved during the training phase and whether the improvement disappeared when the association was removed in the testing phase. Given the ubiquitous statistical learning account as a governing rule, search performance should be improved in the training phase and impaired in the testing phase. As a control condition, the association between auditory and visual stimuli was maintained in the testing phase. The results indicate that visual search performance was impaired in the testing phase in the experimental condition only. None of the participants noticed the auditory/visual association. Experiment 2, in which the auditory stimuli were presented 1 sec before the visual display, replicated the cueing effect. These results suggest that visual attention can be guided implicitly by cross-modal association and extend the ubiquitous statistical learning account in that our cognitive system can acquire consistency in multi-modal domains.

J44 1160 Local Spatial Layout Consistency affects Strategies but not Memory during Visual Search.

Melissa Beck[1] (mbeck@lsu.edu), J. Gregory Trafton[2]; [1]Louisiana State University, [2]Naval Research Laboratory

Serial visual search is efficient in that participants rarely revisit previously examined items. This efficiency is partially due to the ability to remember the spatial locations of previously examined items. The current experiment examined the extent to which the consistency of local spatial layout contributes to search efficiency. Participants completed two blocks of trials. In one block, the search items were arranged in a grid layout such that the distance between any given item and its nearest neighbor was consistent. In the other block, the search items were arranged in a random layout such that the distance between an item and its nearest neighbor varied randomly. Although there was variability of the local spatial layout between the grid and random layout conditions, the global spatial layout (area/number of items) did not differ. Participants were asked to search 8, 12, or 16 icons for the presence or absence of a particular icon (e.g., Document A). For target presence trials in block 1, there was no effect of spatial layout on search RTs. However, on the target absent (TA) trials, search was significantly slower on the random layout trials than the grid layout trials. Eye movement analysis revealed that a higher number of fixations in the random layout TA trials was not due to an increase in revisits to previously examined items. This suggests that search is slower for the random layout on TA trials because participants are using a stricter stopping rule. Therefore, local spatial layout consistency affects search termination strategies but not memory during search. In addition, the relationship between random and grid layouts on TA trials reversed in block 2. This suggests that the stopping rule established in block 1carries over to block 2 even though the local spatial layout has changed.

J45 1161 In search of the hidden: contextual processing in parietal cortex

Elizabeth Walter[1,2] (ewalter1@uoregon.edu), Paul Dassonville[1,2]; [1]Department of Psychology, University of Oregon, [2]Institute of Neuroscience, University of Oregon

In the Hidden Figures Task (HFT), observers must search for a simple shape hidden inside the context of a more complex figure. Surprisingly, performance in the HFT is known to be negatively correlated with susceptibility to illusions of spatial orientation in the Rod-and-Frame Task (RFT; Witkin & Asch 1948) and the Roelofs effect (Dassonville, Walter & Lunger, VSS 2006); that is, an observer who struggles with the HFT will tend to have high illusion susceptibilities. This relationship suggests that similar mechanisms are responsible for processing the contextual cues provided in the respective stimuli of these very different tasks. Using fMRI, we have previously demonstrated that regions in intraparietal sulcus (IPS) and superior parietal cortex are involved in the contextual processing associated with the Roelofs effect (Walter & Dassonville, VSS 2006). In our current study (using the same participants), we sought to determine whether these same regions are also involved in contextual processing in the HFT. In the current event-related design, participants were asked to either perform a variant of the HFT, or to match a simple shape to a figure that "popped out" of a complex line drawing. We found a number of areas in superior parietal cortex and IPS that were selectively involved in this hidden figures search task (but not the "popout" matching task). Importantly, some of these areas overlapped with those found to be associated with contextual processing in the Roelofs task. Control studies indicate that the activations in these areas of overlap are not simply caused by differences in the patterns of eye movements across the various tasks. We propose that these parietal areas are selectively involved in processing visuospatial contextual information in these tasks.

Acknowledgement: Telemedicine and Advanced Technology Research Center (TATRC) and NIH Systems Physiology Training Grant (5-T32-GMO7257)

J46 1162 Training and Transfer in Search for Camouflaged Real-World Targets

Walter Boot[1] (wboot@s.psych.uiuc.edu), Mark Neider[1], Arthur Kramer[1]; [1]University of Illinois at Urbana-Champaign

The majority of visual search studies have focused on finding a target that is dissimilar from the background (e.g., finding a white T on a black background). Here we investigate the ability of participants to find a target that is similar to the background: search for a camouflaged target. Participants searched for a target (a particular toy among distractor toys) either on a blank background, or a background consisting of tiled sections of the target. Feedback was provided and participants were encouraged to decrease RTs while maintaining a high degree of accuracy. As expected, the camouflage search task proved to be extremely difficult, with RTs in the range of several seconds. However, RTs for camouflaged targets decreased and accuracy increased with training (much more so than for non-camouflaged targets). Given the high level of featural similarity between the target and the background, the optimal strategy would involve searching the background rather than distractors objects. However, in the camouflage condition participants fixated objects at rates similar to those in the blank background condition. We interpret this as an object bias; participants preferred to fixate salient objects when searching even when those objects shared fewer visual features with the target than the background. Importantly, with training this object bias decreased, likely resulting in the improvements in RT and accuracy. After training, participants were transferred to a camouflage search task in which both the target object and the camouflage background were novel. No costs were observed when participants trained to find a camouflaged target were asked to search a novel camouflage scene, suggesting transfer of training. In contrast, search times increased sharply when participants who were trained to search for non-camouflaged targets were asked to search for a camouflaged target. Practical and theoretical implications are discussed.

J47 1163 Conceptual grouping effects in visual search: categories matter (and named categories matter more).

Gary Lupyan[1] (glupyan@cnbc.cmu.edu); [1]Carnegie Mellon Department of Psychology and the Center for the Neural Basis of Cognition

A well-known result in visual search is that targets are found more quickly among familiar distractors than among novel distractors (e.g., Wolfe, 2001, Percept & Psychophys). In such tasks, familiarity is confounded with category membership; more efficient search through familiar distractors may be due not only to their greater familiarity, but their being grouped together as members of the same conceptual category. The present experiments (1) manipulate category membership while controlling for novelty and perceptual similarity, and (2) investigate the role of auditory labels in category effects in visual search.

Participants searched for a letter-like symbol among distractors that were either within-category (B and b), or between-category (B and p). Stimuli were presented in a within-subject mixed-trial design. Despite being matched precisely for perceptual similarity, targets were found more quickly among within-category distractors (Bb) than within-category distractors (Bb). A 90° rotation of the stimuli such that they no longer resembled letters eliminated the effect. Control conditions determined that rather than being a result of long-term practice grouping B's and b's into the same category, the conceptual grouping effect seems to emerge on-line, possibly due to differences in the inter-item competition for attention.

In a second series of experiments, it is shown that search for a known target (e.g., a 2 among 5s), is made easier by actually hearing the target label ("two") even though participants already know what they are searching for. Labeling the distractors ("ignore fives") produces a similar facilitation. Labels had no effect on rotated 2s and 5s.

Together, these experiments suggest that controlling for novelty and perceptual similarity, conceptual relations affect visual search performance, and verbal labels further enhance the degree to which categories penetrate perceptual processing.

Acknowledgement: Supported in part by the NSFGRF

J48 1164 Previewing features in visual search: The effects of bottom-up and top-down processing

Kenith Sobel[1] (k.sobel@mac.com), Matthew Pickard[1]; [1]Department of Psychology and Counseling, University of Central Arkansas

Consider one of the many visual search tasks that often confronts each of us, such as searching for your own car among a sea of other cars in the parking lot. If you were given a preview of the colors or the shapes of the cars before launching into an actual search, could you more efficiently locate your car than if you had no feature-based preview? It seems clear that a preview would enable you to isolate the group of cars that has the same feature as your car, then restrict your search to just this subset of cars, and without the preview you wouldn't have this head-start on your search. Nevertheless, a recent study (Olds & Fockler, 2004) found little response-time advantage for a feature preview relative to no preview. We thought that these puzzling results may have arisen from bottom-up factors interfering with participants' ability to use the information from the preview to impose top-down control over their searches. In a series of experiments we found that the effectiveness of feature preview varies with the strength of bottom-up factors.

J49 1165 Using color to guide attention to subsets of stimuli in visual search

Satomi Amster[1] (amster.2@wright.edu), Allen Nagy[1]; [1]Psychology Department, Wright State University

The purpose of this study was to investigate the use of color to guide attention to subsets of stimuli in search tasks. Previous work from our lab and others suggests that color information can be used efficiently to select subsets of stimuli to be attended. A12-alternative forced choice method was used. 12 stimuli were presented briefly (200msec.) on a white background at randomly jittered locations within an annular region centered on a fixation point. On each trial the target stimulus was assigned a higher S chromaticity and appeared slightly bluer than the rest of the stimuli. Observers were asked to indicate the bluish target by placing the cursor at its location and depressing the mouse button. In experimental conditions either 2. 4. or 6 randomly chosen stimuli were white and the remaining stimuli were assigned a saturated red (high L) chromaticity. Observers were instructed that the bluish increment would be added to one of the white stimuli and that the red stimuli could be ignored. Psychometric functions obtained by plotting percent correct against the magnitude of the S increment in these conditions were compared with psychometric functions obtained in control conditions in which only 2, 4, 6, or 12 white stimuli were presented. Results showed that 4 observers could successfully ignore the red stimuli in the experimental conditions. An irrelevant red distractor was selected as a possible target location on less than 3% of trials. Psychometric functions in experimental conditions were very similar to those obtained in control conditions of the same set size. Results suggest that the use of feature information to guide attention is more flexible than suggested by the spotlight or zoom lens analogies of visual attention, which suggest that attention can only be directed to a unitary spatial area.

J50 1166 Knowledge about target category: A dissociation between categorization and search

Joshua Hartshorne[1] (jharts@fas.harvard.edu), Timothy Vickery[1], Yuhong Jiang[1]; [1]Department of Psychology, Harvard University

Search can be accomplished by categorizing each item into target and distracter categories and applying the single-object categorization procedure multiple times. To what extent is human visual search consistent with this notion? To answer this question, we applied two different categorical mappings on a single set of stimuli, and compared performance under these two mappings during search or categorization tasks. The stimuli were diamond-shaped objects missing one corner segment or a portion of one side segment. One categorical mapping (the component mapping), placed "corner-missing" objects into one category and "side-missing" objects into another category, while the other mapping (the orientation mapping) placed objects with either the top corner or a segment of the two top lines into the "top" category and objects with the bottom corner missing or a segment of the bottom lines missing into the "bottom" category. When searching for a target among multiple distracters, subjects responded most quickly when cued by the exact target, less quickly when told only which component category the target belonged to, and least quickly when told which orientation category the target belonged to. However, when categorizing single stimuli in the absence of distracters, subjects were significantly faster categorizing the stimuli according to the orientation mapping than the component mapping. Thus, the component cue appears to be more helpful than the orientation cue for guiding visual search, while the converse was true when a single stimulus was categorized. We conclude that human search performance is not consistent with the notion that search is accomplished by employing single-object categorization multiple times.

Acknowledgement: Supported by NIH 071788 and NSF 0345525.

J51 1167 The effects of target foreknowledge on visual search performance and strategy

Kelly Steelman[1] (ksteelm2@uiuc.edu), Jason McCarley[1]; [1]University of Illinois at Urbana-Champaign

Wednesday Posters

Though target foreknowledge has generally been found to improve visual search performance (e.g., Vickery, et al., 2005), a study of one particularly difficult form of visual search, a simulated baggage x-ray screening task, found no benefit of familiarity to oculomotor scanning (McCarley et al., 2004). The present experiment investigated the role of target foreknowledge in a simulated baggage x-ray screening task more closely by 1) comparing performance under conditions of target certainty and uncertainty and 2) measuring the accuracy of predictive metacognitive ratings of the difficulty of target detection. After familiarizing themselves with the search task and stimuli, participants viewed target knives one at a time and rated the expected difficulty of finding each one if it was hidden in a baggage x-ray. Following this, participants performed 180 trials of the visual search task. On half of all trials, a cue informed the participant to search for a specific target knife. On the remaining trials, the participant was cued to search for any of the five potential targets. Eye movements, accuracy, and response time were recorded. Correlations between RTs and predictive metacognitive ratings of detection difficulty indicated that searchers used target foreknowledge to modify their stopping policy on target-absent trials, and oculomotor data revealed that target foreknowledge increased the detection rate of targets after they were foveated. However, the speed and likelihood with which observer's fixation landed on the target object were similar for cued and uncued trials, indicating that target foreknowledge did little to enable attentional guidance or otherwise improve oculomotor scanning. Data indicate that foreknowledge can improve target recognition and alter strategic components of visual search performance, but suggest that high levels of clutter may limit the capacity for top-down attentional guidance in some tasks.

J52 1168 Visual Search for Emotional Faces is Not Blind to Emotion

Cory Gerritsen[1] (cjgerrit@yorku.ca), Alexandra Frischen[2], Daniel Smilek[3], Adam Blake[1], John Eastwood[1]; [1]Department of Psychology, York University, Toronto, Canada, [2]Macquarie Centre for Cognitive Science (MACCS), Macquarie University, Sydney, Australia, [3]Department of Psychology, University of Waterloo, Waterloo, Canada

A series of visual search tasks revealed more efficient search for threatening compared to peaceful faces when the target faces were embedded in neutral face distractors. A search advantage for threatening faces was observed in an initial experiment and replicated in a follow up experiment but not observed in a third experiment. Meta-analytic methods were employed to evaluate data from across the three experiments, confirming the presence of a small but significant advantage in search for threatening faces among neutral faces. Importantly, the design of the current experiments unequivocally ruled out interpretations based on the physical properties that defined target emotion. This was accomplished by using identical sets of stimuli to represent threatening and peaceful target faces. Different emotional meanings were conditioned to these target faces among different groups of observers. This way, the physical differences could be collapsed during data analysis, ensuring that observed differences in efficiency are solely the result of differences in emotional meaning between target faces. The results support the hypothesis that the visual system is capable of determining a face's emotional valence before it becomes the focus of attention and that emotional valence is used by the visual system to determine subsequent allocation of attention. However, in the present context, emotional valence only accounted for a small amount of variance in search efficiency.

J53 1169 The effect of shared parts and spatial configuration on visual search performance in young children

Gina Shroff[1] (gshroff1@binghamton.edu), Jenna Nelsen[1], Georgia Reilly[1], Kelly Dickerson[1], Peter Gerhardstein[1]; [1]Binghamton University, Department of Psychology

To investigate the processing of complex shapes in the visual system, Arguin and Saumier (2004) employed a visual search task requiring adult subjects to identify a three-dimensional abstract target object among distractors. They varied whether the distractor and target stimuli shared both internal components and spatial organization, internal components alone, spatial organization alone, or neither. It was found that with respect to reaction time, the individual effects of sharing components and sharing spatial configuration were strictly additive. The current study investigated the developmental track of this ability, comparing 2-5 year-olds to adults. A previously developed touch screen procedure for measuring visual search abilities in children (Gerhardstein & Rovee-Collier, 2000) was employed. For each of three experimental sessions, subjects were required to identify a different target item among 2, 4, or 8 distractor objects. Performance trends in adults were similar to the previous study, but results from younger subjects did not indicate an additive effect of shared spatial organization and internal components; trends were non-zero in all cases. Further research is currently underway to investigate older children's performance.

Attention: Object-Based Selection

Author Presents: 10:30 am - 12:15 pm

J54 1170 Size matters in object-based attentional selection

Marco Neppi-Modona[1,2] (neppi@andrew.cmu.edu), Lars Strother[1], Sarah Shomstein[1], Marlene Behrmann[1]; [1]Department of Psychology, Carnegie Mellon University, [2]Department of Psychology, University of Torino (Italy)

To extract relevant information from a visual scene, selective attention can be deployed between objects or within a single object. It is well established that within-object attentional shifts are faster than between-object shifts. However, it is not known whether attentional shifts are influenced by the metric properties of objects. We manipulated object width in a visual target discrimination task similar to that of Egly et al. (1994). Subjects were presented with one of two types of displays: (1) two parallel rectangles or (2) two trapezoids, with both objects presented vertically or both horizontally. Rectangles were identical and of two possible widths ('thin' or 'thick'). Trapezoids were identical but inverted in orientation, with the 'thin' base of one object adjacent to the 'thick' base of the other. One end of an object was cued and then participants performed a target discrimination task (target letters T or L). The cue was either valid (cue and target at same location) or invalid (cue and target at different locations within the same object or between objects). Faster RTs were observed for valid vs. invalid trials, and for within- vs. between-object locations. Interestingly, however, the object-based effect was modulated by object size. Moving attention within or between 'thick' objects or toward the 'thick' end of objects, resulted in significantly faster RTs than the corresponding shifts of attention involving 'thin' objects or 'thin' object parts. These results demonstrate that object width influences the distribution of spatial attention. We discuss our findings in the context of sensory enhancement and prioritization accounts of object-based attention. We also examine the relationship between attentional selection and movement execution, suggesting that deployment of object-based attention plays a role in determining how target size and distance constrain the time required to move from a starting position to a final target (Fitt's Law).

Acknowledgement: This work was supported by a Fulbright Research Scholarship to the first author

J55 1171 Object similarity modulates object-based attention and attentional faciliation in the surround

Dwight Kravitz[1] (kravitzd@mail.nih.gov), Marlene Behrmann[2]; [1]LBC, NIMH, National Institutes of Health, [2]Psychology, University of Toronto

In a recent study we demonstrated that the consequences of object-based attention (OBA) extended beyond the boundaries of the attended object into its surround. RTs to detect targets in the surround were found to vary as a function of distance from the center of mass of attended object even when distance from the cued location was held constant. The current study investigated the effect of an unattended object on the pattern of attentional facilitation across the visual scene. Participants were presented with two objects and then cued to attend to a location within one of them. Shortly after the cue, a target appeared either at the cued location (valid) or in one of four equidistant invalid locations: at a different location within the cued object (within-object), within the uncued object (between-objects), or in one of two locations outside of both objects which differed only in their average distance from the cued object (near-object, far-object). In the first two experiments the unattended object was either the same as the attended object (identical) or differed along one dimension: color, geometry, or category (non-identical). In all three experiments, between-objects targets which appeared in an identical uncued object were detected faster than those presented in a non-identical uncued object. We replicated our previous finding as RTs to the near-object targets were faster than those to the far-objects targets. Finally, we found that identical uncued objects had a far greater impact on the pattern of facilitation in the surround than non-identical objects. Taken together, this pattern of results suggests that far from being an all or none mechanism, OBA interacts with many different perceptual dimensions to give rise to a graded pattern of facilitation across a visual scene.

J56 1172 Can spatial attention be "shrink-wrapped" to attended objects?

James Hoffman[1] (hoffman@udel.edu), Matthew Doran[1], Jason Reiss[1]; [1]Department of Psychology, University of Delaware

Visual attention can be allocated to an empty region of space (space-based attention) or to an individual object (object-based attention), even when that object overlaps with other, irrelevant, objects. What is the relationship between these two modes of attention? Previous research has suggested that both types of selection reflect a single underlying spatial attention mechanism that can either be allocated to a region of space, analogous to a spotlight, or can be "shrink-wrapped" to conform to object contours or surfaces. We evaluated this single-mechanism account by measuring the N1 component of the event-related brain potential (ERP), which is larger for flashes that appear at attended versus unattended locations. If the spatial attention system can conform to object boundaries, then object-based attention should produce a larger N1 component when a flash appears on an attended object compared to an unattended, overlapping object because the latter would be outside of the shrink-wrapped "attentional spotlight". In the current task, participants were simultaneously presented with a pair of overlapping objects located to the left and to the right of a central fixation point. Individual objects were briefly flashed in a rapid, random, sequence while participants continuously attended to a designated object in order to respond to occasional target events. As expected, we found larger N1 amplitudes when the flash appeared on the attended object compared to a flashed unattended object located in the opposite visual field. Importantly, however, we also found larger N1 amplitudes for flashes of attended objects compared to unattended, overlapping objects. These results suggest that the spotlight of attention can be shrink-wrapped to the contours of attended objects, largely excluding irrelevant, overlapping objects.

J57 1173 Object-based attention to holes and wholes

Alice Albrecht[1,2] (aliceralbrecht@gmail.com), Alexandra List[1,2], Lynn Robertson[1,2]; [1]University of California, Berkeley, [2]Veterans Administration Northern California Health Care System

Object-based effects of visual attention were reported by Egly Driver and Rafal (1994) using a modified Posner cueing paradigm. In a two-rectangle (i.e., "object") display, they cued one end of one rectangle on each trial. Targets were most likely to appear at the cued location. In invalid-within conditions, the target appeared in the same object as the cue, but at the opposite end. In invalid-between conditions, the target appeared in the object opposite the cue. Importantly, invalid targets appeared the same distance away from the cue in both within- and between- conditions, holding space constant. When comparing the two invalid conditions, within-object targets were detected faster than between-object targets, i.e., RTs showed object-based facilitation. In a set of similar experiments, we replicated these effects when the objects were white but, surprisingly, not when they were black. To investigate the disappearance of the object-based effect, the present study attempted to manipulate the rectangles so that they were either perceived as "holes" or as objects whether they were black or white. The logic was that black may more likely be perceived as background and thus processed as "holes". The data partially supported our hypothesis: we found a trend for an interaction between object-based effects and the holes/no-holes manipulation. However, debriefing questions suggested that not all participants perceived the stimuli as expected. To further investigate this issue, we manipulate stereoscopic depth cues (using stereographic goggles) to test the same hypothesis: that the perceptual organization of objects as "holes" or "wholes" can determine the presence of object-based attention effects.

J58 1174 The Role of Object Discontinuity in Object-based Selection

Ashleigh M. Richard[1] (ashleigh-richard@uiowa.edu), Shaun P. Vecera[1], Andrew Hollingworth[1]; [1]Department of Psychology, University of Iowa

The effect of objects on attentional selection has traditionally been conceived as a cost associated with either dividing or switching attention between discrete object representations. However, in a modification of the Egly et al. task, we have recently found significant effects of object perceptual structure on target discrimination across a gap in a single object. Such an effect could not be attributed to dividing or switching attention across objects, because there was only one object. In the present study, we examined whether a local object discontinuity (i.e., a gap) can account for the entire object effect in the Egly et al. paradigm. Participants were presented with circular tube-shaped stimuli. In the two-object condition, two gaps in the tube created two perceptual objects. Invalidly cued targets appeared either in the same object as the cue or in the different object. The standard same-object benefit was observed. In the one-object condition, the stimuli were identical, except there was a single gap in the tube stimulus and thus a single object. Invalidly cued targets appeared either along the continuous extent of the object or across the gap. The magnitude of the object effect (i.e., the decrement in target detection performance when the target appeared across the gap) was the same as in the two-object condition. These results suggest that local discontinuity is the primary cause of object-based effects. The data are consistent with the grouped-array theory of object-based attention, which holds that object perceptual structure constrains the spatial distribution of attention, limiting the spread of attention to continuous object regions and retarding the spread of attention across object boundaries.

J59 1175 How does attention spread across the surface of an object oriented in depth?

Irene Reppa[1] (i.reppa@swansea.ac.uk), Daryl Fougnie[2]; [1]Department of Psychology, Swansea University, Wales, UK, [2]Department of Psychology, Vanderbilt University

Previous evidence suggests that exogenous spatial attention spreads in perceived three-dimensional (3D) space as determined by binocular disparity and occlusion. In this study we asked whether spatial attention spreads across the surface of a 3D object that is oriented in depth in terms of actual or perceived space.

To examine this question, we employed a spatial cueing paradigm in which one of four corners along the front plane of a 3D object was exogenously cued with 75% validity. On invalid trials, the target would appear in a corner adjacent to the cued corner. Importantly, on some trials we manipulated the perceived depth of the object by rotating it 45½ to either the left or right. Rotation affected the actual distance (i.e. the distance between corners as drawn in 2D space) but did not affect the perceived distance. We examined whether invalid RT costs were affected by depth rotation. If attention spreads across the perceived length of a 3D object surface than invalid RT costs may be independent of the object?s orientation in depth. Otherwise, invalid costs may reflect the actual distance between the cued and target locations. Depth rotation would produce smaller costs for horizontal shifts while vertical shift RTs would depend on whether the shift occurred in the close or far depth plane.

In two experiments (one with static images and a second with objects that appeared to rotate), there was no significant difference in RTs between front and rotated views for vertical or horizontal shifts. In the rotated condition, invalid RT costs were smaller in the horizontal far-to-close condition compared with the horizontal close-to-far condition, replicating previous findings. The results show that (a) attention spreads across the perceived surface space and (b) the orientation of the object in depth affects the way attention spreads across its surface.

J60 1176 Effects of bottom-up input and top-down expectation on object-based attention

Ming-Chou Ho[1] (mingchou@csmu.edu.tw), Su-Ling Yeh[2]; [1]Department of Psychology, Chung-Shan Medical University, Taichung, Taiwan, [2]Department of Psychology, National Taiwan University, Taipei, Taiwan

Bottom-up input and top-down expectation of objects are usually intertwined to contribute to the occurrence of object-based attention. The current study demonstrates the dissociation of influences of bottom-up object input and top-down expectation on the same-object effect by using the double outlined rectangles of Egly, Driver, and Rafal (1994). One of the two rectangles was first cued, and the participants were asked to detect a target shown on the target frame. The same-object effect refers to the result of faster responses when the cue and target appears on the same object than on different objects. We manipulated the presence probability of (1) rectangles and an empty space, or (2) rectangles and a new object in the final target frame. The new object is an outlined boomerang whose orientation varies with the cue location in a way to either reduce or enhance same-object effects when the double rectangles are in the target frame. When the double rectangles are absent in the target frame, no same-object effects are observed, regardless of the probability of rectangles presence. The dependence of same-object effects on the presence of the attended object indicates the effect of bottom-up object input. However, the ever occurrence of the boomerang, even with a probability of appearance as low as 20%, influences the same-object effects when in fact it is the rectangles that appear in the target frame. That is, the expectation of the presence of the boomerang has influence on the same-object effects while the rectangles are present. Although bottom-up input usually interacts with top-down expectation, their dissocation revealed in this study sheds light on their respective roles in object-based attention.

Acknowledgement: Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020

J61 1177 On the Relationship Between Object-Based andFeature-Based Attention

Bobby Stojanoski[1,2] (stojanoski@utsc.utoronto.ca), Naseem Al-aidroos[2], Jay Pratt[2], Matthias Niemeier[1,3]; [1]University of Toronto at Scarborough, Toronto, [2]University of Toronto, Toronto, [3]Centre for Vision Research, York University, Toronto

Attention allows for selective processing of information from the visual field. Studies of this selection process often investigate how attention can be focused on specific spatial regions. Attention, however, can also be focused on spatially invariant properties of the visual world, such as objects or features (e.g., orientation). Although object- and feature-based attention have often been viewed as distinct mechanisms, some functional relationships between the two have been found. For example, features comprising an object have been shown to be processed during object selective attention. It is, however, unclear whether feature- and object-based attention interact, or if they function independently. To address this issue, we simultaneously manipulated both object- and feature-based attention. We presented subjects with two objects, similar to Egly et al. (1994), and had them: 1) attend to one corner of one object and 2) monitor that corner for the appearance of a predetermined feature (a line segment of a specific orientation). On certain key trials, a second line segment, either congruent or incongruent with the attended feature, appeared either within, or outside, the attended object, and subjects were asked to detect this line segment as quickly as possible. As expected, both an object-based (faster detection responses for lines at attended objects) and a feature-based (faster responses for congruent lines) effects were observed. Importantly, however, these two effects did not interact. Rather, the facilitatory effects of object- and feature-based attention were additive. This finding suggests that these two attentional systems work independently in determining what portions of the visual field are selected for deeper processing.

Acknowledgement: NSERC

J62 1178 Investigating the role of the magnocellular pathway in object- and location-based attention.

Megan C.. Boyd[1] (mboyd@uga.edu), Benjamin A. Guenther[1], James M. Brown[1]; [1]Department of Psychology, University of Georgia

Purpose: Studies of spatial and temporal resolution have indicated covertly cuing visual attention emphasizes parvocellular (P) relative to magnocellular (M) processing at cued locations and P on M inhibition at those locations. Cuing studies investigating object-based attention have shown the cost for shifting attention between objects is greater than for equidistant shifts within objects and that this object effect may be due, in part, to disengaging object-based attention from one object to shift to another. We explored whether P on M inhibition may contribute to the disadvantage for shifting attention between objects by comparing achromatic conditions with equiluminant and diffuse red light background conditions expected to inhibit M pathway activity. If the object effect is due, in part, to P on M inhibition related to disengaging attention, then the object effect may be less under conditions where M activity is reduced. Method: Objects were pairs of rectangular bars presented vertically and horizontally. Cues and targets appeared at the ends of the bars and were equidistant from a fixation point. Targets appeared 80% of the trials, and trials where targets appeared were valid 60% of the time. White-on-black (Exp. 1), black-on-red & black-on-green background (Exp. 2), and psychophysically equiluminant red-on-green and green-on-red (Exp. 3) conditions were tested. Results: Overall reaction times were longer under psychophysically equiluminant conditions indicating reduced M activity. The object effect for the achromatic condition (Exp 1) was two times that found in the equiluminant and red background conditions. Conclusion: The object effect was greatest under conditions where P on M inhibition related to attention would be the greatest. The difficulty shifting between objects was lessened under conditions where M activity was reduced, therefore decreasing the opportunity for P on M inhibition. The results suggest P on M inhibition plays a role in disengaging object-based attention.

J63 1179 Selection and distribution of attention across the visualfield

Alexa B. Roggeveen[1] (alexar@interchange.ubc.ca), Lawrence M. Ward[1]; [1]University of British Columbia

Visual attention has been conceptualized as being a mechanism of selecting a target location or object (e.g. Intriligator & Cavanagh, 2001), and as a medium that can be distributed across a span of the visual field (e.g. Eriksen & Hoffman, 1974). These two approaches to understanding attention, however, have typically been investigated separately. We asked whether the effects of selecting a location in the visual field would be mediated by the way attention was distributed across possible target locations. To answer this question, subjects performed a letter identification task while orienting their attention endogenously to one of several squares on a computer screen. In Experiment 1, eight squares were presented in a line, four on either side of fixation, increasing in size toward the periphery to account for cortical magnification. The line of squares could be oriented on the vertical or horizontal meridian, or at intercardinal locations halfway between the cardinal meridians. If invalidly cued (30% of trials), the target would always appear on the opposite side of fixation, in order to require subjects to distribute their attention across the entire display to the extent needed to maintain high levels of performance. In Experiment 2, the same stimulus configuration was used, but rather than a fixation cross at center, there remained the possibility that a target might appear in a centrally-located box at fixation. Results showed that maintaining attention at fixation, as in Experiment 2, facilitated performance closer to fixation to a greater extent than in Experiment 1, revealing an attentional gradient anchored at fixation. Across the two experiments, attentional facilitation was anisotropic across the visual field, especially in the right visual field on the horizontal meridian. Our findings reveal an intriguing interplay between distribution of attention across possible target locations and the ability to attentionally select a target location.

Attentional Capture

Author Presents: 10:30 am - 12:15 pm

J64 1180 Static items involuntarily capture attention in a dynamic environment.

Yaïr Pinto[1] (y.pinto@psy.vu.nl), Chris Olivers[1], Jan Theeuwes[1]; [1]Cognitive Psychology, Vrije University, Amsterdam

Everyday experience gives us the intuition that dynamic items capture attention. Therefore, ambulances are equipped with flashlights, advertizers use blinking neon signs, and we start waving when we want to be noticed in a crowd. Research has indeed confirmed that dynamic items can guide or capture attention. However, Pinto, Olivers and Theeuwes (2006) showed that there are limitations to the attractiveness of dynamic items. In a visual search task where all items, except one, were dynamic, the dynamic items could be ignored and the static item could be efficiently detected. In the present research we investigate if attention is automatically drawn to the static item, or that attention only prefers the static item with the right attentional set. A series of experiments, employing the irrelevant feature search task, reveals that attention is involuntarily captured by the static item. This result is at odds with most of the current theories on attentional capture, including the influential 'new object' hypothesis. The current study indicates that features in contrast to the environment, rather than features by itself determine to where attention is drawn.

J65 1181 Grabbing attention without knowing: Automatic capture of attention by subliminal spatial cues.

Manon Mulckhuyse[1] (M.Mulckhuyse@psy.vu.nl), Durk Talsma[1], Jan Theeuwes[1]; [1]Vrije Universiteit Amsterdam

Attention can be focused and shifted voluntary, but attention can also be captured by salient stimuli in the environment. For example, in exogenous cueing experiments typically an abrupt onset presented in the periphery will capture attention automatically. Because of this reflexive shift of attention, targets that follow immediately after the cue at the same location are more efficiently processed. Contrary to this facilitation effect, less efficient processing of the target is manifested at the cued location when time between cue offset and target onset is delayed. Here we show that stimuli that are not salient or even visible can capture attention automatically; in fact, we show that attention can be captured by stimuli that are not even consciously perceived. We employed a new paradigm to present subliminal stimuli without masking them in a manual detection time task. The observation of the classic biphasic effect of facilitation followed by inhibition of return (IOR) suggests that the subliminal cue captured attention in a purely exogenous way. Since IOR can be observed only as a result of an exogenous, stimulus-driven shift of spatial attention, it is unlikely that top-down control settings or other non-attentional effects played a role. Whereas previous research has shown that attentional effects are only found when subliminal cues are task relevant, we show that subliminal cues can cause a reflexive shift of spatial attention, resulting in attentional facilitation followed by inhibition at the cued location.

Acknowledgement: This research was funded by a grant from Human Frontier Science Program (HSFP-RGP39/2005) to Jan Theeuwes.

J66 1182 Temporal properties of task-irrelevant events: attentional capture is not purely bottom-up.

Jeroen Benjamins[1] (j.s.benjamins@fss.uu.nl), Hinze Hogendoorn[1], Ignace Hooge[1], Frans Verstraten[1]; [1]Experimental Psychology, Helmholtz Institute, Utrecht University

Recent studies have examined the temporal properties of distractor events leading to attentional capture. These studies seem to indicate that attentional capture is absent when the distractor event is either not temporally unique (Von Mühlenen et al., 2005) or when its occurrence is expected (Lamy, 2005).

Von Mühlenen used a critical range of intervals of -150 to 150 ms between target onset and distractor event (SOAs), which resulted in absence of capture at 0 ms SOA. However, this range of SOAs makes it impossible to distinguish between both theories. At a SOA of 0 ms the distractor event is not temporally unique and occurs at the expected moment.

In the current experiment, Von Mühlenen's paradigm was adapted to make this distinction. A range of -150 to 50 ms SOA (steps of 50 ms) was tested on attentional capture in 9 observers. Temporal uniqueness would predict absence of capture at 0 ms SOA, while an expected occurrence account would predict absence of capture at -50 ms SOA.

When a task-irrelevant colour change occurs in the target, at or after target onset (0-50 ms SOA), reaction time to the target is shorter in comparison to a colour change in non-targets at the same SOAs. This rules out temporal uniqueness. However, when the colour change precedes target onset (negative SOAs; including the expected SOA of -50 ms) no reaction time differences are found; this implies that the theory of expected occurrence is unlikely as well.

Attentional capture by task-irrelevant events appears to depend on the temporal characteristics of task-relevant events (target onset); before task-relevant events occur, task-irrelevant events can be ignored. However, once the task-relevant event has occurred, distractor events influence our percept. This suggests that attentional capture is not purely bottom-up, but is mediated by top-down processes as well.

J67 1183 Identity Change and Oculomotor Capture

Anne Hillstrom[1] (anne.hillstrom@port.ac.uk), Jason Wong[2], Matthew Peterson[2]; [1]University of Portsmouth, [2]George Mason University

Abrupt onsets of new objects draw attention. Although the transients involved play a role, they appear not to be able to account for the degree of attention capture typically seen. Therefore, it has been proposed that the appearance of new conceptual and structural information in an otherwise old display captures attention by involuntarily triggering the reestablishment of an object file (Hillstrom & Yantis, 1994). To test this, a series of recent studies have shown that information change without the normally accompanying perceptual transients disrupts object-based attention (e.g., Hillstrom, Wong & Norris, under review). The information change was accomplished by morphing the object from one identity into another. In the study reported here, we tested whether morphs would produce oculomotor capture like abrupt onsets do. Observers were presented with a ring of objects. At the same time that the target was indicated by means of a color change, either a new object onsetted in the display or one of the objects morphed into a new object. Observers made a judgment about the target that required them to fixate it. Previous studies have shown that onsets produce oculomotor capture -- on a substantial proportion of trials, the first saccade is to the onsetting nontarget rather than to the target (Theeuwes, Kramer, Hahn, & Irwin, 1998). In this study, not only was oculomotor capture by morphs much less common than oculomotor capture by onsets, morphs may not have drawn the eyes at all. A control experiment showed that the morph was detectable.

Acknowledgement: Funded by NSF grant BCS0424919

J68 1184 Object action captures attention: A test of the behavioral threat hypothesis

Jeffrey Lin[1] (jefflin@shaw.ca), Steven Franconeri[2], James Enns[1]; [1]University of British Columbia, [2]Northwestern University

An object that suddenly appears among other objects is given perceptual priority, even when it seems irrelevant and non-predictive of the task of searching for a particular shape. There has been considerable debate over whether attentional capture of this kind is a function of the control settings the viewer is using to perform the task (e.g., carefully monitoring a display for changes in luminance may make the viewer vulnerable to the onset of new objects) or whether there is truly task-independent attentional capture. Recent evidence favoring the task-independent position shows that capture occurs when a pre-existing object looms (grows in size) but not when it recedes (shrinks in size), suggesting that attentional capture may index the rapid visual evaluation of task-irrelevant behavioral threat (Franconeri & Simons, 2003).

Here, we report on several new tests of the behavioral threat hypothesis. In Experiment 1, we found that search for targets near the center of a display was disrupted more by looming in the periphery than looming near the center. In Experiment 2, we manipulated the direction of looming relative to the participant, finding that attentional capture was stronger for looming objects when they were on a collision path with the viewer than when they were not. An unexpected finding consistent with the behavioral threat hypothesis was the finding of strong capture when looming objects were moving away from the viewer's head but toward the viewer's torso. In Experiment 3, we compared the capture strength of objects that loomed or receded predictably versus unpredictably to evaluate the role of top-down expectations in attentional capture for looming objects.

These results imply that perceptual priority is not solely determined by task-relevant features of a task, suggesting that task-irrelevant actions of objects in displays are constantly monitored with regards to their possible threat to the viewer.

J69 1185 Asymmetry of stimulus-driven attentional capture by flash and color distractors

Hsin-I Liao[1] (f91227005@ntu.edu.tw), Su-Ling Yeh[1]; [1]Department of Psychology, National Taiwan University, Taipei, Taiwan

Folk, Remington, and Johnston (1992) proposed that attentional capture by task-irrelevant stimuli occurs only when they share with the target its defining feature; namely it is impossible for a non-contingent stimulus to capture attention. Nevertheless, in Folk's series of studies supporting this hypothesis, only 4 items were used in the target display. We test the generality of this hypothesis by using larger set sizes and different SOAs since previous results suggest that increasing set size enhances stimulus salience and stimulus-driven activation is highest around the time the stimulus appears. The target was defined by either a color or a flash, and a distractor preceded the target that either had the same color, or also was a single flash. The target feature or location was never contingent on the distractor, and participants were instructed to ignore the distractor. Our results show that a stimulus that is not contingent on attentional control settings can also capture attention, especially in displays with large set size, and this capture effect occurs early and decreases with SOA. However, only non-contingent flash distractors capture attention, and color distractors do not. In conclusion, purely stimulus-driven attentional capture by a flash does occur and the asymmetrical results in the capture effect by flash and color distractors suggest that flash and color play different roles in capturing attention.

Acknowledgement: Supported by the National Science Council of Taiwan, NSC95-2752-H-002-007-PAE and 95-2413-H-002-020

J70 1186 Attentional Capture by Incongruent Cues: An Analysis of Individual Difference

Peggy Chen[1] (pzc112@psu.edu), J.Toby Modrkoff[1]; [1]Dept of Psychology, Penn State University

Previous research has shown that salient, exogenous cues that do not contain the target's defining attribute usually do not cause a spatial cuing effect in mean RT. This is most readily explained by the Contingent Capture hypothesis under which incongruent cues do not capture attention at all. However, we've observed data that do not conform to the strict version of this hypothesis in that we have found small, but reliable, spatial cuing effects on trials with incongruent cues. In particular, we have found spatial cuing effects on incongruent trials that are about one third as large as those on congruent trials. One possibility is that a subset of our subjects happened to approach the task in a different way from the others. That is, approximately one third of the subjects may have set their attention to be captured by the most salient stimulus or singleton (which would produce effects for both congruent and incongruent cues), while the others were set for the specific feature that defined the target (and would only produce effects for congruent cues). To test this possibility, we examined the data on a subject-by-subject basis, instead of conducting our analyses on the grand averages. If the idea put forth above is true, then the data should exhibit a clear separation between those who were set for any salient singleton and those who were set for the target (only). However, this pattern was not found. Rather, scatter plots of the congruent vs incongruent cuing effects were homogenous, suggesting that incongruent cues capture attention on at least some trials for all subjects, or weakly on every trial.

Acknowledgement: This project has been supported by Grants-in-Aid of Research for Doctoral Dissertations awarded by Sigma Xi, and Dissertation Support awarded by the College of Liberal Art, the Pennsylvania State University.

J71 1187 A new object captures attention

Fook K. Chua[1] (fkchua@nus.edu.sg), Muhammad Khaidir Ismail[1]; [1]Psychology, National University of Singapore

When a new object onsets abruptly, it captures attention. But is this capture due to the onset transients, or to the onset object's status as a new entity? Franconeri, Hollingworth, & Simons (2005) examined this question using a procedure that introduced a new object without simultaneously introducing onset transients. Observers had to search for one of two target letters. At the start, an opaque annulus surrounded several static placeholder objects. The annulus shrank progressively, obscuring the placeholders at some point, whence the placeholders were turned into letters. On some trials, an additional letter was introduced here. As this new letter appeared whilst obscured by the annulus, there were no accompanying onset transients. The annulus then shrank further and the letters, including the new object, were revealed. At issue was whether attention engaged this new object first. Search set size was varied. The additional object may be a target, or a distractor, letter. If it captured attention, and it was the target, search times should be independent of set size. Franconeri et al.'s results showed no prioritization of the additional object, suggesting that a new object failed to capture attention. Yet crucially, for the additional object to be coded as new, it must be discriminable from the old objects which, in this task, meant that observers had to encode implicitly the old objects' locations. We showed in 5 experiments that, when encoding of locations was facilitated, the additional object succeeded in capturing attention. But when location encoding was disrupted, the new object failed to capture attention.

Acknowledgement: supported by NUS Grant R-581-000-042-112

J72 1188 Driven to less distraction: rTMS of the right parietal cortex reduces attentional capture in visual search by eliminating inter-trial priming.

John Hodsoll[1] (j.hodsoll@bham.ac.uk), Carmel Mevorach[1], Glyn Humphreys[1]; [1]Department of Psychology, University of Birmingham

In visual search, the presence of a highly salient color distractor in a display slows search for a shape target, consistent with an attentional shift to the distractor. We investigated the role of the parietal cortex in attentional capture by a singleton using rTMS. Following disruption to the right parietal cortex by sustained TMS, the RT cost of the singleton distractor was diminished. Moreover, at least part of this reduction of singleton distraction was due to the elimination of priming effects between target and distractor singletons on consecutive trials. This is consistent with previous work positing the representation of salience in the right parietal cortex (e.g. Corbetta and Shulman, 2002) and further suggests a role for the right parietal cortex in the integration of bottom-up salience information with top-down information about the role of salient items in prior trials.

Acknowledgement: MRC, UK

J73 1189 **Motion-induced attentional capture enhances induced gamma-band activity**

Kathrin Ohla[1] (ohla@uni-leipzig.de), Thomas Gruber[1], Velitchko Manahilov[2], Matthias M. Müller[1]; [1]University of Leipzig, Institute of General Psychology, [2]Glasgow Caledonian University, School of Life Sciences, Department of Vision Sciences

Different visual features are known to be processed in separate parts of the brain. It is still unclear by which mechanisms these features are combined into an integrated percept. Several results point to an important role of gamma-band oscillations (20-100 Hz) in binding separate features of objects in the correct combinations. However, attention might also facilitate the perception of coherent objects. It was suggested that coherent percepts are more likely to catch attention than incoherent ones. Only recently, it was proposed that grouping and attention rely on a common implementation process: synchronized activity in the gamma-band range. Thus, we investigated whether or not a figure popout, which attracts focal attention, is linked to increased cortical activity in the gamma band. If induced gamma band responses (iGBRs) represent feature binding, enhanced iGBRs should be observed whenever a coherent figure is presented. Furthermore, this effect should be more pronounced when the figure is induced by motion due to enhanced figure saliency. We conducted three experiments in which participants discriminated figures from non-figures under different conditions of figure saliency and popout. We investigated the role of figure properties by means of motion coherency of random dots in experiment 1. In experiment 2, stimuli were arrays of oriented Gabor patches which could either form a salient geometric figure or no coherent figure. In experiment 3, a sudden change from one array of Gabor patches to another induced apparent motion, but only when a figure was present. We found elevated iGBRs in response to figures accompanied by apparent motion in experiments 1 and 3, which may point to stronger attentional recruitment. No effects between figures and non-figures were found for patterns with immediate onset in Experiment 2 which suggests that low level feature binding is not sufficient to study the oscillatory activity of cortical networks.

Attention: Temporal Selection

Author Presents: 10:30 am - 12:15 pm

J74 1190 **Transient attention when detecting pictures in RSVP search**

Mary C Potter[1] (mpotter@mit.edu), Rijuta Pandav[1], Brad Wyble[2]; [1]MIT, [2]University of Kent at Canterbury, UK

When searching for two target in a rapid serial visual presentation (RSVP) viewers often miss the second target (T2) if it appears soon after T1, an effect termed an attentional blink. When T2 appears immediately after T1, however, it is relatively easy to report (lag 1 sparing). Wyble, Bowman, & Potter (2006) propose that detection of a target in an RSVP sequence generates a brief burst of transient attention lasting about 150 ms that benefits both the target and any immediately following stimulus appearing at the same location. Most previous experiments used simple stimuli such as letters, digits, or words; we asked whether lag 1 sparing would be found for more complex targets such as pictures of objects in a specified category. (Evans & Treisman (2005) found an attentional blink for picture targets, but they did not include lag 1.) Sequences of 8 color photographs were presented for 107 ms/picture. Subjects looked for two targets from a category such as fruit, birds, or furniture. Subjects reported the names of the two targets, e.g., bed, chair. No pictures were repeated. T1 was reported correctly on 82% of the trials. Given a correct T1, T2 was correct on 78% (lag 1), 56% (lag 2), and 81% (lag 4) of the trials, main effect of lag, $p < .001$. Thus, transient attention generated by detection of the first target benefits a second target appearing within 107 ms, but there is an attentional blink 213 ms after the onset of the first target (lag 2). In a second experiment with two adjacent streams the two targets appeared in either the same or different locations. The transient attention hypothesis predicts a lag 1 benefit in the same stream only.

Acknowledgement: MH47432

J75 1191 **Working Memory and the AB: Disscociable Effects of Working Memory Mainenance and Scanning Operations.**

Stephen Johnston[1] (s.johnston@bangor.ac.uk), Kimron Shapiro[1]; [1]Centre for Cognitive Neuroscience, School of Psychology, University of Wales, Bangor, UK

The limitation in the temporal availability of attentional resources is most commonly studied using the attentional blink ('AB'; Raymond et al, 1992) paradigm. The AB paradigm requires participants to identify or detect the presence of two targets separated by only a short temporal interval, often as part of a rapid serial visual presentation (RSVP). The common finding is that if the second target (T2) occurs within 500ms of the first (T1) it is often missed or incorrectly identified. The inability to perform the T2 task has been linked most consistently to a failing at the level of working memory (WM) as a result of insufficient attentional resources. However, studies that have examined the impact of concurrent WM maintenance operations on the AB have so far failed to find any interaction. In the current study we attempted to find an interaction of WM and the AB using a different WM operation which we term 'memory scanning'. The participants' T1 task was to match either one or three items from a WM array to the first target (match/no-match); the T2 task was to detect the presence of an 'X'. The results show that as the number of potential matches increases, so does the size of the attentional blink. To further dissociate the results of this 'memory scanning' operation from those previously found for maintenance operations we created a second experiment where both WM maintenance and memory scanning operations could be examined. The results show that whilst maintenance operations impact on overall T2 performance, only memory scanning operations impact on the AB itself. These results are explained in terms of the shared resources between WM and the AB.

J76 1192 **Concurrent task demands determine whether personal names survive the attentional blink**

Barry Giesbrecht[1] (giesbrecht@psych.ucsb.edu); [1]University of California, Santa Barbara

Whether conversing with a colleague in a crowded poster session or with a friend at a busy restaurant, people can selectively attend to only one voice at a time while ignoring the surrounding cacophony (e.g., Cherry, 1953). However, personal experience tells us attention can be disrupted from one's current conversation if one's own name is mentioned within earshot (e.g., Moray, 1959). This 'cocktail party effect' suggests that high-priority information is processed without attention. Consistent with this view, studies of the attentional blink phenomenon (AB, Raymond et al., 1992) -- an impairment in the detection or identification of the second of two masked targets presented in rapid succession -- have found that in contrast to other names and mundane objects, detection of personal names and other salient information is not impaired during the AB (e.g., Shapiro et al., 1997; Mack et al., 2002). In contrast to these studies of the AB, studies of spatial attention suggest that the extent to which high priority information is processed without attention depends on task load (Harris & Pashler, 2004; Pessoa et al., 2002). The purpose of the present study was to test whether the extent to which personal names survive the AB also depends on concurrent task demands. Subjects were presented with two masked targets in rapid succession. The difficulty of the first target task (T1) was manipulated and the second target (T2) was either the participant's own name or someone else's name. Consistent with the hypothesis that concurrent task demands modulate the extent to which high-priority stimuli are processed, when T1 was easy, there was no AB if T2 was the participant's own name, but when T1 was difficult, the AB for one's own name was as large as the AB for someone else's name.

J77 1193 **Evidence in favor of a Resource Depletion Account of the Attentional Blink**

Paul E. Dux[1] (paul.dux@vanderbilt.edu), Christopher L. Asplund[1], René Marois[1]; [1]Dept of Psychology, Vanderbilt Vision Research Center, Center for Integrative and Cognitive Neuroscience, Vanderbilt University

The attentional blink (AB) refers to subjects' impaired ability to detect the second of two different target stimuli in a rapid serial visual presentation (RSVP) stream if they appear within 200-600 ms of one another. Traditionally, theoretical accounts of the phenomenon have postulated that the AB occurs due to limited attentional processes (such as the consolidation of information into working memory) being devoted to the first target at the expense of the second target (Resource Depletion accounts, e.g., Chun & Potter, 1995). Recently, however, several other mechanisms have been proposed to be responsible for the effect. One prominent alternative account is the temporary loss of control hypothesis (Di Lollo et al., 2005; Kawahara et al., in press), which proposes the AB occurs due to subjects' inability to maintain the current attentional set when presented with distractors. Here we tested whether resource depletion contributes to the AB. In Experiments 1 and 2, subjects viewed RSVP (100 ms/item) streams containing three sequentially presented letter targets amongst digit distractors. Across blocks the Target 2 stimulus was either drawn form the same category as Targets 1 and 3 (uniform condition) or from a different category (digits, varied condition). Replicating Di Lollo et al. (2005), we found that Target 1 and Target 3 performance differed in varied trials, but not (no AB) in uniform trials. However, an AB was observed under the uniform conditions when we increased the processing resources devoted to the first target, either explicitly by emphasizing Target 1 accuracy or implicitly when Target 1 was the first of the three targets featurally distinct from the distractors. A third experiment demonstrated that this AB was not due to a deficit in maintaining multiple targets in working memory. These results suggest that resource depletion does indeed contribute to the AB.

Acknowledgement: This research was supported by an NIMH (R01 MH70776) grant to R.M.

J78 1194 **Failure of distractor inhibition in the Attentional Blink**

Irina Harris[1] (irina@psych.usyd.edu.au), Paul Dux[2]; [1]School of Psychology, University of Sydney, Australia, [2]Department of Psychology, Vanderbilt University, Nashville

We investigated whether a failure of distractor inhibition contributes to the magnitude of the attentional blink (AB). In an earlier study, Dux, Coltheart and Harris (2006) demonstrated that when the distractors immediately before and after Target 1 (T1-1 and T1+1) were identical, the magnitude of the AB was reduced. This distractor repetition effect was interpreted as evidence of distractor inhibition – i.e., if the T1-1 distractor had been successfully inhibited, then this stimulus would be easier to suppress again when it appeared in the T1+1 location and thus, would interfere less with T1 processing, leading to an attenuated AB. The present study tested whether this distractor repetition effect is dependent on attention. Here, subjects viewed dual-target rapid serial visual presentation (RSVP) streams containing two letter targets amongst digit distractors, where the distractors that directly preceded and succeeded Target 2 (T2-1 and T2+1) were either identical to each other or different. Distractor repetition again attenuated the AB, but this effect only occurred at Lag 2 or, in other words, when the T2-1 stimulus appeared in the Lag 1 position. It is well known that items presented at Lag 1 often undergo attentive processing, resulting in Lag 1 sparing. Thus, our results demonstrate that the distractor repetition effect is dependent on attention and that a failure to inhibit distractors contributes to the AB.

Acknowledgement: Funded by Australian Research Council grant DP0557590.

J79 1195 **Investigating an inhibitory account of the Attentional Blink**

Daniel Loach[1] (dloach@maccs.mq.edu.au), Alexandra Frischen[1]; [1]MACCS, Macquarie University

The attentional blink refers to a performance decrement in correctly detecting or identifying the second of two targets, if those targets (T1 and T2) are presented within approximately 500 milliseconds of one another. Di Lollo, Kawahara, Ghorashi and Enns (2005) demonstrated that the atttentional blink is contingent upon the presence of a distractor stimulus presented between T1 and T2. When T1 and T2 were separated by another target, the AB was extinguished. They have argued that the distractor causes disruption to the attentional set and the concomitant failure to fully encode T2. On the contrary, Loach and Marí-Beffa (2003) have suggested that T2 is encoded but is subsequently inhibited as part of a temporal binding strategy. They showed that post-target distractors in an RSVP stream are inhibited such that they negatively prime a related probe. In this context, it could be argued that the presence of the distractor in Di Lollo et al.'s study is what initiates this inhibition. When there is no distractor, there is no danger of selecting the wrong stimulus and thus, no need to inhibit anything. Here, we examine this notion in a hybrid AB-negative priming paradigm where we manipulate whether T1 and T2 are separated by a distractor or another target.

J80 1196 **Investigating the Attentional Blink With Predicted Targets**

Wah Pheow Tan[1] (wahpheow@iastate.edu), Veronica J Dark[1]; [1]Department of Psychology, College of Liberal Arts and Sciences, Iowa State University

Extant attentional blink (AB) theories implicitly assume serial processing in which first target (T1) identification impedes second target (T2) identification when T1-T2 lag is short (200-500 ms). Most AB studies report T2 identification conditionalized on T1 identification (T2|T1). Tan and Dark (2006) also examined T1 identification conditionalized on T2 (T1|T2). Prior to each trial, they cued T1 identity with 50% validity (valid vs. invalid cue); subjects were categorized according to whether they used or ignored the cue (confirm vs. ignore strategy). They found lag effects on both T2|T1 (the AB) and T1|T2, suggesting a more dynamic view of target processing. The AB effect was attenuated and the T1|T2 lag effect was eliminated for "confirm" subjects on valid trials, i.e., when T1 consolidation should be facilitated. We further examined this effect by varying T1 identity cue validity. Cue validity was low (25%) for Experiment 1 and high for Experiment 2 (75%). Both the AB and the T1|T2 lag effect were attenuated when cue validity was high but not when it was low, regardless of the subjects' strategy. However, because subjects knew T1 identity in the condition showing attenuation, the attenuation could be a task artifact. Therefore, we cued T2 identity with 50% validity in Experiment 3. If attenuation of the T1|T2 lag effect were due to a task artifact associated with knowing T1 identity, one predicts that cueing T2 identity would not affect T1|T2. We found that both the AB and T1|T2 performance were worse for "confirm" subjects on invalid trials. If more attentional resources are devoted to identifying T2 when the cue is being used but is invalid, the results suggest that devoting resources to T2 identification is detrimental to T1 identification. We propose a model in which T1 consolidation and T2 selection compete dynamically for a higher-order attentional resources.

URL: http://www.psychology.iastate.edu/faculty/vjdark/LAB%20WEBSITE/index.htm

J81 1197 **Inter-trial suppression of selective attention in RSVP streams**

Katerina Polychronopoulos[1] (polychro@uiuc.edu), Brian Levinthal[1], Jun-ichiro Kawahara[2], Alejandro Lleras[1]; [1]Psychology Department, University of Illinois at Urbana-Champaign, [2]Cognition and Action Research Group, Institute for Human Science and Biomedical

In a color oddball visual search task, reaction times to finding the oddball target are slower when the target's color in the current trial was used as the color of the distractors in the preceding target-absent trial, a robust effect known as the distractor previewing effect (DPE). The DPE has been repeatedly demonstrated in the spatial domain using a variety of target-defining features, such as color, shapes, motion, and the gender of faces. Recently, Lleras et al. (under review, see also, Wan and Lleras, submitted) proposed a theory of the DPE which describes the effect in terms of an inter-trial inhibition of focused attention to the no-go (i.e. target-absent) feature. As such, the DPE should not be limited solely to the spatial domain. Participants were presented with RSVP streams of upper- and lower-case letters and were asked to report the case of the uniquely colored letter in the stream (and withhold responding when all letters were of the same color). Participants were asked to focus primarily on accuracy in this experiment, though response times were also recorded. Compared to an achromatic baseline, participants' accuracy was improved when the color of the distractors in the target-present stream was the same as the color of distractors in the preceeding target-absent stream. Furthermore, accuracy was significantly reduced when the color of the target in the target-present stream was the same as the color of distractors in the preceding target-absent stream. The magnitude of the accuracy effect was 17%. The finding of a DPE in the temporal domain is consistent with the inhibition of focused attention theory of the DPE and reveals a general biasing mechanism of attention in selection tasks.

J82 1198 Category-based and item-based processes in rejecting distractors in RSVP

Atsunori Ariga[1] (ariga@L.u-tokyo.ac.jp), Katsumi Watanabe[1,2]; [1]The University of Tokyo, [2]ERATO, Japan Science and Technology Agency

Presenting a distractor that is similar to a pre-defined target in a rapid serial visual presentation (RSVP) task deteriorates the detection performance of the target. This is most likely because observers prepare for top-down attentional sets (or templates) to reject distractors and accept the target. In this study, we investigated whether the rejecting process of distractors is influenced by pre-knowledge about what to reject: category or individual item. Observers identified an alphabet letter embedded in the RSVP stream of nonsense line patterns. Before the target onset, a digit appeared as the distractor to be rejected at various distractor-target timings. In category-cueing condition, we presented "#" as the cue indicating that any digit distractor would appear. In item-cueing condition, we presented a specific digit (e.g., "5") as the cue indicating the specific digit would appear. In both the cueing conditions, we found substantial deficits in target letter identification. Evidently, the distractor was processed automatically, which in tern hindered the performance. Interestingly, the time-course of performance deterioration implied that the rejecting process can be commenced only after the expected distractor is registered; the performance reduction started later in the item-cueing condition than in the category-cueing condition. The present results suggest that the visual system can arrange an attentional set for a stimulus category and reject a distractor without item individuation. Nevertheless, it appears that the visual system cannot help using a template for individual items when an informative cue indicates which specific distractor item would come.

J83 1199 Cognitive control during shifts of attention and task-set

Yu-Chin Chiu[1] (yuchin@jhu.edu), Steven Yantis[1]; [1]Psychological and Brain Sciences, Johns Hopkins University

Previous studies have revealed transient reconfiguration signals in the superior parietal lobule (SPL) that are time-locked to shifts of attention between spatial locations, features, or sensory modalities (Yantis et al., 2002; Liu et al., 2004; Shomstein & Yantis, 2004). We investigated the generality of this mechanism for congitive control during non-perceptual shifts in task-sets. Subjects monitored one of two RSVP streams for letter cues and digit targets (embedded in other distractor letters) to perform a magnitude or parity task. The four letter cues instructed subjects to (a) hold attention at the current location, (b) shift attention to the location in the opposite visual field, (c) hold the current task-set, or (d) switch to the other task-set. Brain regions associated with attention shifts and task-set switches were identified and compared. Both distinct and common patterns of activation were observed. For example, bilateral posterior intraparietal sulcus (IPS) exhibited transient increases in activity duirng attention shifts but not task switches. However, medial superior parietal lobule produced transient signals for both attention shifts and task switches. This result suggests that these two types of cognitive control may recruit domain-specific as well as domain-independent cortical mechanisms for cognitive reconfiguration.

Attentional Modulation of Early Vision

Author Presents: 10:30 am - 12:15 pm

J84 1200 Differential effects of endogenous and exogenous covert attention on texture segmentation

Barbara Montagna[1] (barbara.montagna@nyu.edu), Yaffa Yeshurun[3], Marisa Carrasco[1,2]; [1]Psychology, New York University, [2]Neural Science, New York University, [3]Psychology, University of Haifa, Israel

Goal: Transient attention, considered to be automatic, improves or impairs performance in a texture segmentation task constrained by spatial resolution (Yeshurun & Carrasco, 1998). Would endogenous (sustained) attention, considered to be voluntary, also impair performance? While keeping stimuli and task constant, we compared the effects of these two types of attention in this texture segmentation task. In this task, performance peaks at mid-peripheral locations, where spatial resolution is optimal for the texture scale, and decreases towards the periphery and center, where spatial resolution is either too low or too high. Transient attention improves performance in the periphery, where spatial resolution is too low, but actually impairs performance at central locations, where spatial resolution is already too high (Yeshurun & Carrasco, 1998). This counterintuitive central attentional impairment indicates that transient attention increases spatial resolution even when it is detrimental to performance, and suggests that it does so by default. If sustained attention is a more flexible mechanism, can it either increase or decrease spatial resolution depending on task demands?

Methods: In a 2-IFC task, observers indicated which of two texture displays contained a target varying in eccentricity. Observers were assigned to either the endogenous or the exogenous attention condition. To manipulate transient attention, peripheral precues appeared adjacent to the target location; to manipulate sustained attention, symbolic precues indicated to the observers where to voluntarily allocate their attention. Attentional effects were evaluated against a neutral cue.

Results: Transient attention impaired performance at central locations (replicating Yeshurun and Carrasco, 1998). In contrast, sustained attention benefited performance at all eccentricities. These results are consistent with the possibility that sustained attention increased spatial resolution where it was too low (periphery), and decreased resolution where it was too high (central locations), and suggest that sustained attention is flexible and adjusts to task demands to optimize performance.

Acknowledgement: Grant 25-91551-F5461 from the United States-Israel Binational Science Foundation (BSF), Grant 1 R01 EY016200-01A2 from NIH

J85 1201 Using foils to measure spatial tuning functions for visual attention

John Palmer[1] (jpalmer@u.washington.edu), Cathleen M. Moore[2]; [1]Department of Psychology, University of Washington, [2]Department of Psychology, Pennsylvania State University

Our goal is to measure the spatial extent of visual attention using a psychophysical method that can be compared across behavior and physiology. To do so, we employ a selective attention task in which observers try to detect a visual target while ignoring a nearby foil that is identical to the target except for location. We vary both the contrast of the foil and the separation between the foil and the relevant location. The appropriate way to quantify spatial selectivity in this task depends on how attention modulates the effect of contrast. Two of the most common hypotheses for attentional modulation are contrast gain versus an all-or-none mixture. In contrast gain, the effect of the foil is attenuated by scaling its effective contrast; in all-or-none mixtures, the effect of the foil is completely blocked on some trials but not others. Contrary to prior studies that have been consistent with contrast gain, our results clearly disconfirm the predictions of the contrast gain hypothesis. Instead, the results are consistent with the all-or-none hypothesis. One possible reason for this discrepancy is a difference in the task. In most prior studies, the relevance of different locations was varied in a divided attention task; in this study, the foil was completely irrelevant in a selective attention task. We are now using this selective attention task to measure the spatial tuning function of visual attention.

J86 1202 Foveopetal are easier to detect than foveofugal motions: the effect of attention

Jose Barraza[1,2] (jbarraza@herrera.unt.edu.ar), Andres Martin[1]; [1]Departamento de Luminotecnia, Luz y Vision, Universidad Nacional de Tucuman, Argentina, [2]Consejo Nacional de Investigaciones Cientificas y Tecnicas, Argentina

Studies about flash-lag effect revealed that the perceptual latency is shorter for foveopetal than for foveofugal motions. The same tendency was found in subsequent experiments showing that the reaction time for detecting a stimulus is shorter when it moves towards the fovea than when it moves away. We wondered whether this anisotropy holds for motion detection in the periphery and whether attention is involved in this phenomenon. We performed an experiment in which subjects had to indicate by pointing with the mouse which of four simultaneously displayed patches contained a coherent motion (test). Stimuli were random dot patterns. In the test, dots moved coherently in one of four possible directions (Northwest, Northeast, Southeast, and Southwest). In the dummies they underwent Brownian motion. The independent variable of the experiment was the proportion of test dots moving incoherently (noise). The patches positions were top-left, top-right, bottom-right, and bottom-left respect to the fixation point. Both motion direction and position were randomized along trials. We determine for each condition the proportion of correct answers as a function of the test noise (4AFC) and computed the noise threshold for a performance of 82%. Three subjects performed the experiment. Motions were grouped to compute the thresholds in three categories: foveopetal vs foveofugal, clockwise vs counterclockwise, and tilted to the left vs to the right. For example, a Northeast motion in the top-left position is clockwise, but the same motion in the bottom-left position is foveopetal. Results show that thresholds for foveopetal motions are higher (less sensitive to noise) than for foveofugal motions. This anisotropy does not appear in the other classifications. Interestingly, when subjects are told about what motion is going to appear in each trial (foveopetal or foveofugal) the anisotropy disappears, which would suggest that some mechanism of selective attention is favoring foveopetal motions.

Acknowledgement: PIP Grant 4948 CONICET to JFB and PICT1315190 ANPCyT to AM and JFB

J87 1203 Feature-based attention: Effects of eccentricity

Sharon L. Sally[1] (ssally@ruccs.rutgers.edu), Zoltan Vidnyanszky[3], Thomas Papathomas[1,2]; [1]Laboratory of Vision Research, RuCCS, Rutgers University, Piscataway, NJ 08854, [2]Department of Biomedical Engineering, Rutgers University, Piscataway, NJ 08854, [3]Neurobiology Research Group, Hungarian Academy of Sciences - Semmelweis University, Budapest, Hungary

PURPOSE: Feature-based attention modulates visual processing such that attending to a particular attribute or feature increases the sensitivity to that feature throughout the visual field. The goal of the present study was to examine the magnitude of feature-based attention as a function of eccentricity in a dual-task orientation discrimination procedure.

METHOD: Stimuli were high-contrast Gabor patterns of different sizes presented at 2.5°, 5°, 10° and 15° on both sides of fixation in the horizontal plane. All Gabors were magnified versions of each other. The stimulus size presented at each eccentricity was selected to equate single-task orientation discrimination performance for a small Gabor target at the closest eccentricity. The dual-task procedure consisted of a primary orientation discrimination task that remained constant (e.g., thresholds for vertical stimuli in the primary aperture) while interleaved horizontal and vertical orientation thresholds were measured for the secondary task in the other aperture. Single-task performance was measured using stimuli identical to the dual task.

RESULTS: Single task horizontal and vertical orientation thresholds were similar. In all cases, orientation thresholds increased markedly in the dual task paradigm, particularly for the secondary task. On average, thresholds increased by a factor of 1.46 for the primary task and by a factor of 2 for the secondary task. Performance was not as severely degraded on the secondary task when the primary and secondary tasks involved the same orientation. This indicates an effect of feature-based attention on thresholds. We found proportionately smaller threshold elevations for the secondary task with increasing eccentricity in the same-orientation condition.

CONCLUSION: The effects of feature-based attention on orientation discrimination become more pronounced with retinal eccentricity. This might be explained by inhibitory attentional mechanisms that lead to spatial suppression surrounding the focus of attention.

Topic Index

Below is a list of talk and poster sessions by topic. Parentheses indicate which abstracts are included in each session.

Author Index

Entries are indexed by abstract number, not page number; **bold** entries indicate first author abstracts.

A

B

I

J

K

N

O

P

Q

R

S

T

U

V

W

X

Y

Z