Knowledge about the recent past affects human gaze patterns

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Introduction
We constantly receive visual information and usually the current visual input follows naturally from immediately preceding visual input. This temporal continuity enables the accumulation of knowledge about the environment. We investigated the role of such recently-gained knowledge in oculomotor control. Specifically, we examined if people viewed images differently, depending on the presence or absence of relevant knowledge about the events immediately preceding the events shown on these images.

Methods
We recorded gaze patterns from 48 individuals who freely viewed 80 sequences of movie frames. In each N-frame sequence, frames from N to N-1 served as a 'context' for the last frame, called a critical frame (see below). There were two experimental conditions: Continuous and Discontinuous. In the Continuous condition, the context frames came from the same movie as the critical frame and depicted a course of events from which the content of a critical frame 'naturally' followed. In the Discontinuous condition, the context frames came from a different movie and were unrelated to the critical frame's content. Each participant viewed all critical frames (half in each condition, counterbalanced between groups). Attention-check questions about frame content were presented after the critical frames to keep participants engaged. All frames were presented for two seconds and were preceded by a gaze-contingent fixation dot.

Analysis 1 – standard characteristics of oculomotor behavior

Analysis description
We used generalised linear mixed-effects models to compare five standard characteristics of oculomotor behavior between the conditions. Panels from A) to E) show the results.

- Continuous Condition
- Discontinuous Condition

![Continuous Condition](image1.png)
![Discontinuous Condition](image2.png)

Analysis pipeline
For each critical frame, we assessed how well scanpaths recorded on it could be classified into the two conditions. Specifically, we modelled the scanpaths as HMMs, reduced their dimensionality using PCA, and obtained the percent of correct classifications from a Linear Discriminant Analysis (LDA) classifier – see the plot. This analysis was implemented in SMAC with HMM toolbox (Coutrot, Hsiao & Chan, 2018).

Analysis 2 – classification based on hidden Markov models (HMMs)

HMMs for scanpaths
Modeling a scanpath with HMM involves 1) assuming that each data sample belongs to one state (Region of Interest, ROI) and 2) finding HMM's parameters for which the HMM is most likely to generate the sequence of states constituting the scanpath. Panels from A) to C) show the elements of HMM scanpath model. A) Ellipses indicate ROIs corresponding to states. Dots indicate raw gaze data (the scanpath being modelled). B) Transition matrix, determining the probabilities of transitioning between states. C) Prior, determining model's 'starting point' in a probabilistic fashion.

Conclusion
How people look at identical images depends on their knowledge about the recent past. When this knowledge is irrelevant (as in the Discontinuous condition) people exhibit more exploratory behavior. This effect is observable both at the level of individual oculomotor characteristics (Analysis 1) and whole scanpaths (Analysis 2).