The emergence of gamma oscillations as a signature of gain control during context integration

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Summary: Perception and Neural Dynamics from a Mechanistic Model

Context integration is a fundamental attribute of the human visual system contributing to basic visual processing routines such as contour integration, visual pop-out, and texture segmentation. We sought to articulate the neural circuit mechanisms that contribute to both context-mediated perceptual effects and features of neural population dynamics in V1 during context integration. Our computational model is based on oscillatory recurrent gated neural integrator circuits (ORGaNiCs) and recapitulates both behavioral results from contextual illusions and oscillatory dynamics observed in local field potential (LFP) recordings.

Predicted Changes in Narrowband Gamma Oscillations2

Our model combines oscillatory recurrent gated neural integrator circuits (ORGaNiCs) with long range connectivity patterns. Membrane potential (v) of principal cells integrate feedforward inputs (u) and gated (i(t)+u(t)) recurrent drive ( disobedience). The dynamics of the gating variable (i) are driven by interactions with the normalization pool ( ). The normalization pool integrates recurrent activity via:

\[ i(t) = \frac{1}{1+a^2} ) \Delta i(t) = \frac{1}{1+a^2} \left( -i(t) + \frac{1}{1+a^2} \right) - \frac{1}{1+a^2} \left( \frac{1}{1+a^2} \right) \epsilon(t) \]

Connectivity matrix, \( W \), scales interactions between principal cells, \( \alpha \), and normalization pools, \( \beta \). \( W_{CRF} \) represents the recurrent connectivity between principle cells.

Long range projections extend between the classical receptive field (CRF) and extraclassical receptive fields (eCRFs) with facilitatory and suppressive domains.

Question: Can we capture both perceptual effects and neural population dynamics in the same mechanistic model?

Conclusions & Future Directions

- Model oscillations agreed with LFP recordings in regions V2/V3 and with psychophysics data for the tilt illusion
- Future work will investigate the relationship between nonlocal normalization and gamma oscillations

References