FMRI Responses in Inferior Frontal Cortex are Associated with Prediction Error Signals in Bistable Perception

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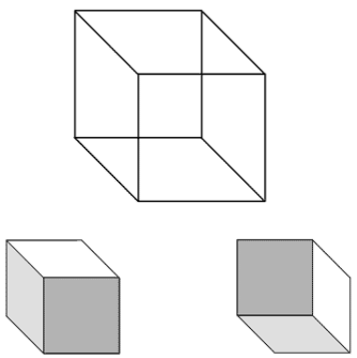
Bistable Perception

Spontaneous fluctuations between two alternative, mutually exclusive interpretations of a constant ambiguous sensory input.

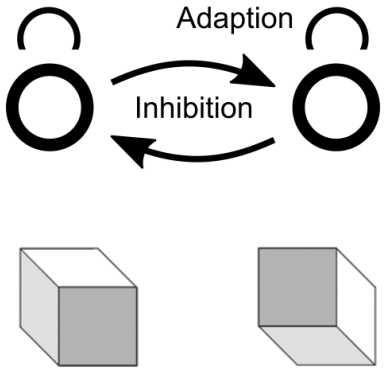


Research Questions

- What are the mechanisms behind endogenuous perceptual transitions?
- How do such mechanisms relate to measures of neural activity during perceptual bistability?

Models of Bistable Perception

- Oscillator models
- Attractor models
- Predictive Coding models



Mechanism

Mutual inhibition between slowly adapting neuronal populations coding for the alternative perceptual interpretations (Wilson 2007).

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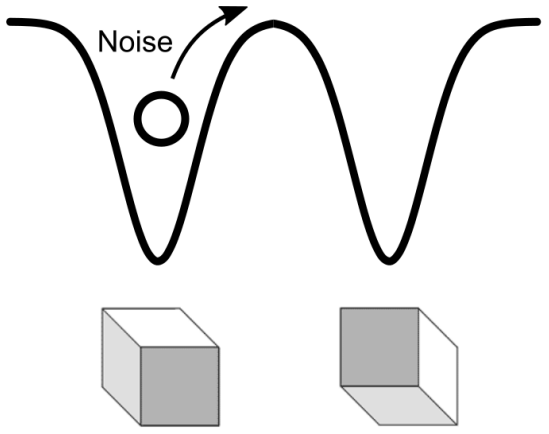

Mechanism

Internal and external sources of noise cause switches between two stable states of the neuronal dynamics (Moreno-Bote 2007).

Models of Bistable Perception

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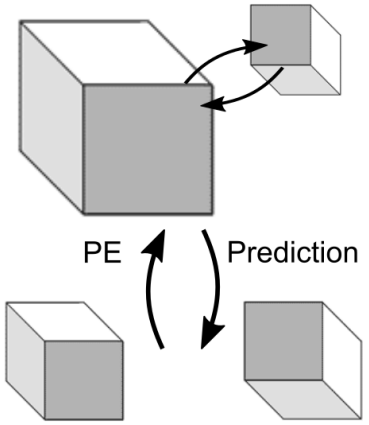


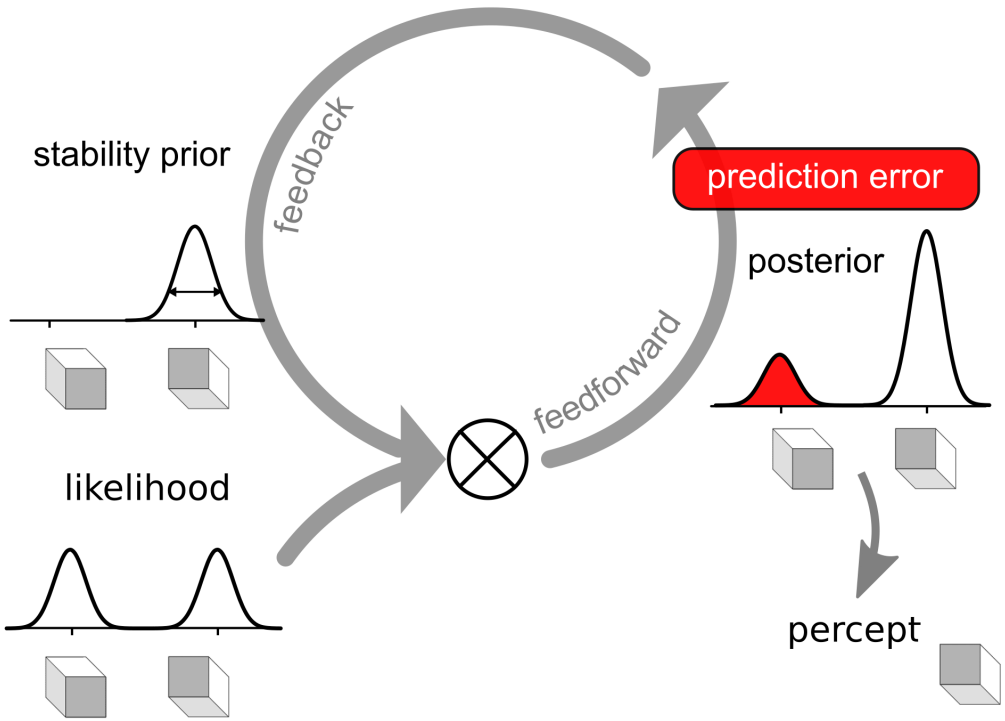
Mechanism

Hierarchical interaction of low-level sensory areas and high-level prediction areas (Hohwy, 2008).

Model Structure

Ambiguity

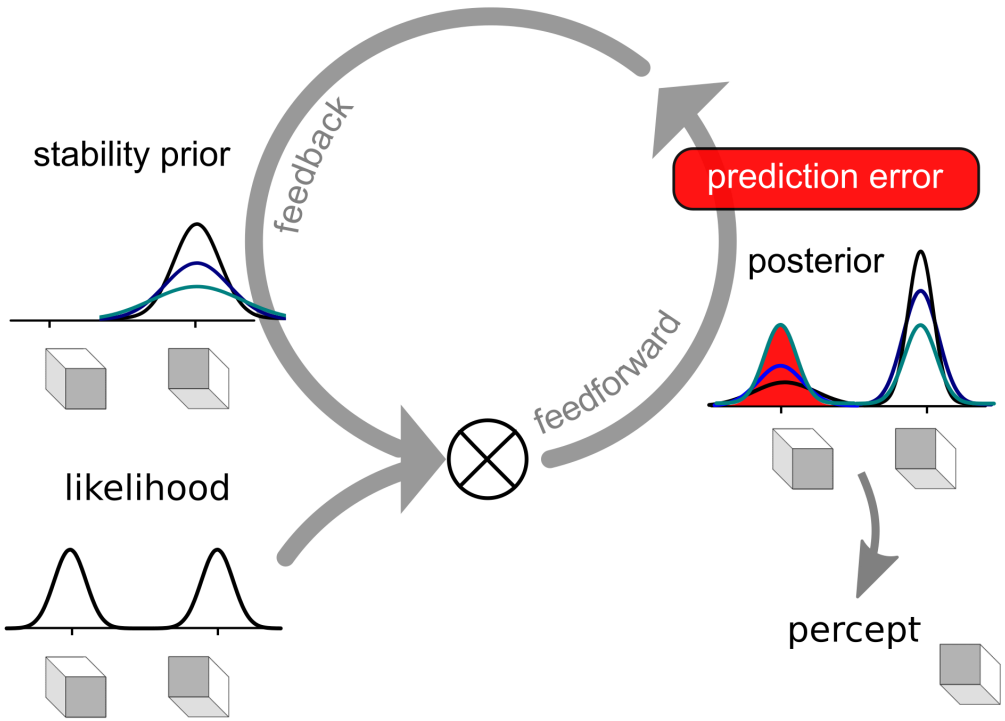
The bimodal likelihood is combined with a stability prior into a posterior with residual evidence for the alternative percept.



Model Structure

Perceptual Transitions

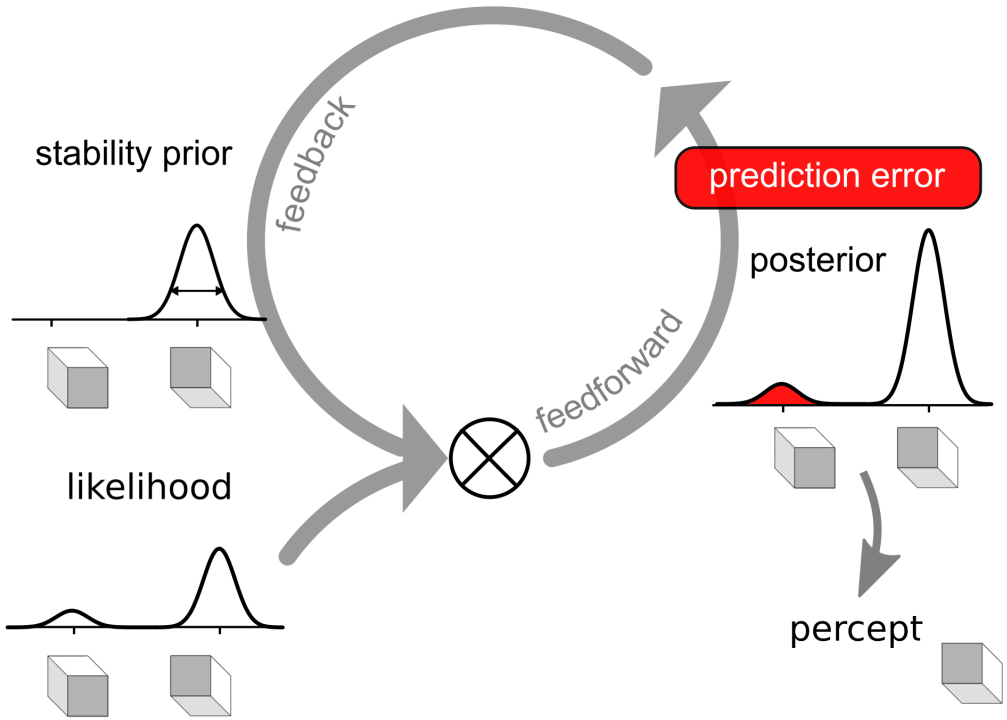
Escalating prediction errors decrease the precision of the stability prior accompanied by an increase in transition probabilities.



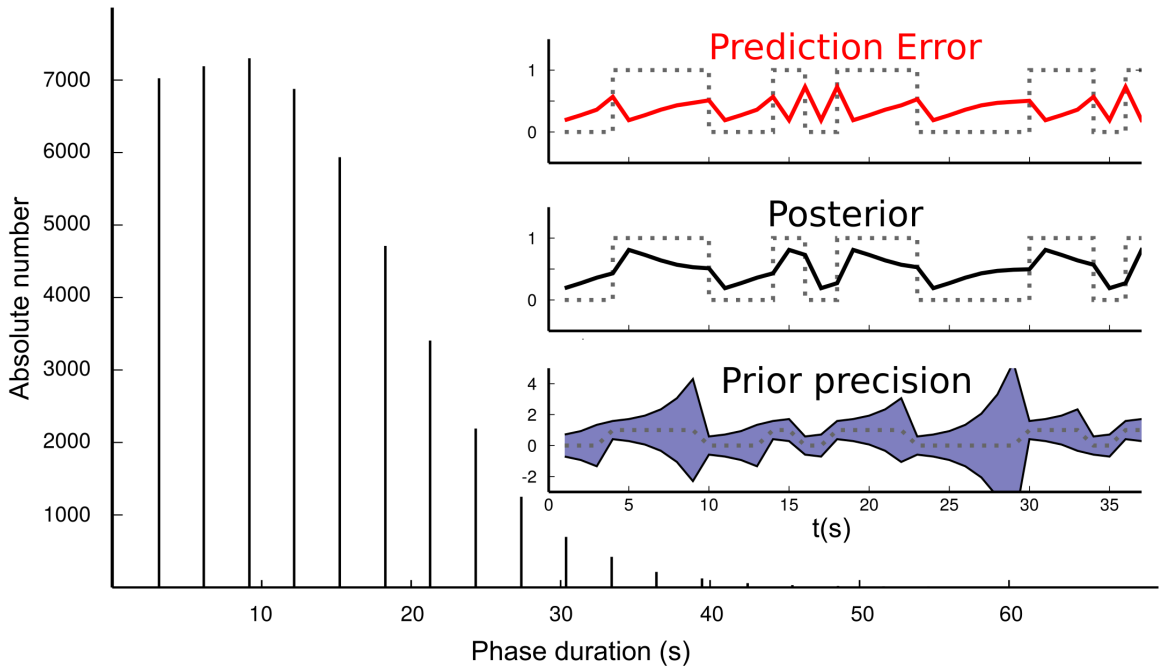
Model Structure

Disambiguation

With additional sensory evidence, prediction errors are reduced and spontaneuous transitions become less likely.



Simulation

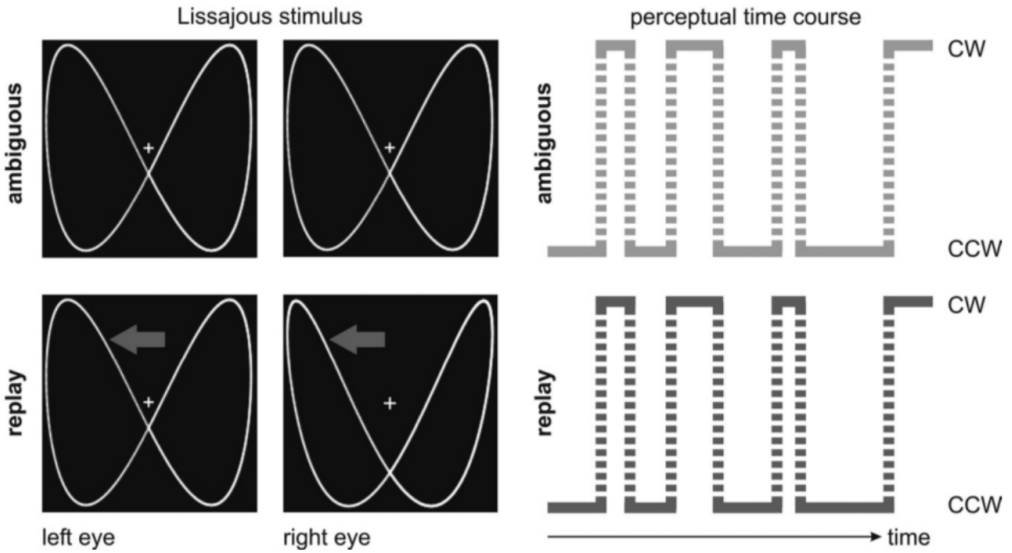


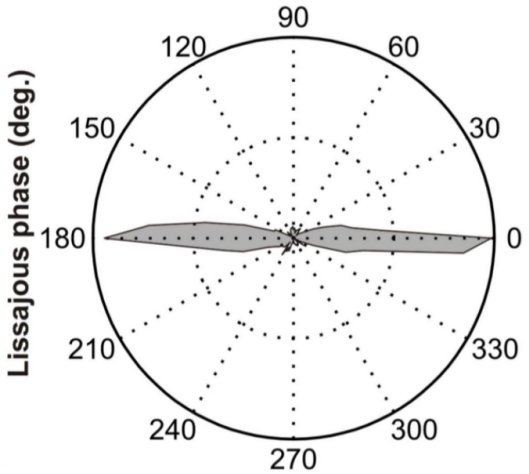
- The distribution of phase durations is characterized by a sharp rise and slow fall.
- Prediction errors increase over the course of a perceptual phase.

Model inversion

Paradigm

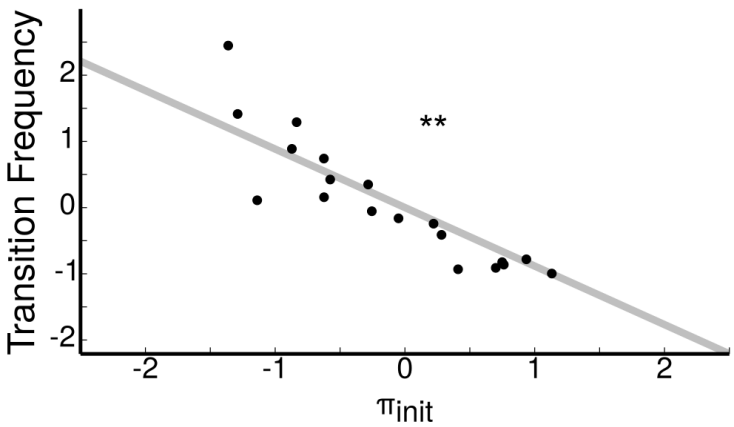
- Alternating blocks of bistable Lissajous figures and 'replay stimulation'
- Disambiguation with covertly introduced stereo-disparity
- Transitions at critical stimulus configurations ('overlaps').

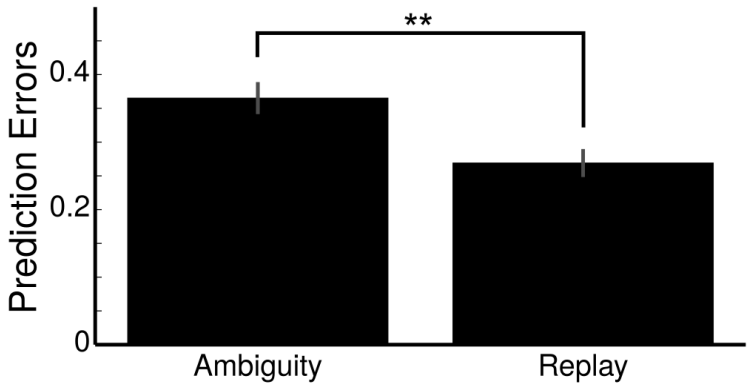




Model inversion

- Stability prior precision correlated with transition frequencies
- Reduced prediction errors during 'replay' stimulation





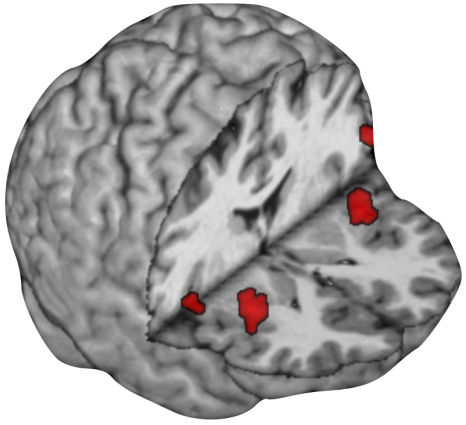
Imaging analysis

Individual prediction error timecourses as parametric regressors in model-based fMRI.

Model-Based fMRI

Prediction error timecourses correlate with

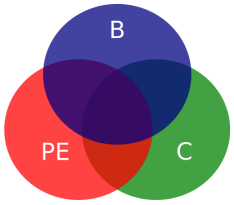
- bilateral inferior frontal gyrus
- bilateral insula ($p < 0.05$, FWE)

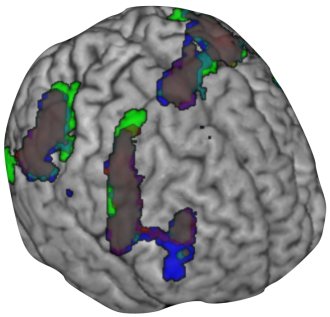


PE vs baseline, p<.05

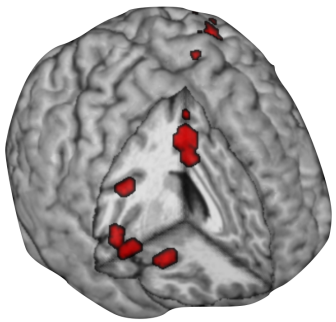
Control models

- Block model (B): Ambiguity vs replay as parametric modulator
- Conventional model (C): Ambiguous vs replay transitions (event-related)





Transition vs baseline



PPM (99.99% e.p. for PE)

Discussion

Summary

- Spontaneous perceptual transitions during bistable perception can be parsimoniously described by a Bayesian predictive coding model.
- Simulated timecourses reveal close similarities between model predictions and key temporal characteristics of perceptual bistability.
- Inverted models successfully describe the dynamics of bistable perception in individual observers.
- Model-based fMRI shows a correlation between prediction errors and inferior frontal gyri and anterior insulae in line with the hybrid model of bistable perception.

Thank you for your attention!

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