Predictive Processing Markers of Expectation Effects on Face Detection: A Bayesian Model-Based fMRI Analysis

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INTRODUCTION

- **DETECTION OF FACES:** Dependent on a mixture of **top-down** processes (i.e., contextual & expectancy-driven [2]) and bottom-up processes (i.e., stimulus-bound [1]).
- **PREDICTIVE PROCESSING:** Assumes the brain implements a hierarchical generative (Bayesian) model of the environment. [cf. 3]
- **ILLUSORY FACE DETECTION (IFD):** Can be described as a *"reality*

MODELING PIPELINE



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discrimination error" [5] or "the subjective belief to have perceived a face, in absence of bottom-up facial features in a ambiguous target stimulus"



Figure 1. Pure-noise illusory facedetection task as implemented by [1]. Subjects are instructed to *detect faces* (binary 2A forced-choice) and that in 50% of the upcoming stimuli faces will be visible. However, only B&W-noise stimuli are presented throughout the entire task. Plot adapted from [1].

GOAL OF THIS STUDY: (1) Formalize belief trajectories during IFD-task through cognitive-computational modeling. (2) Extract trial-level model-parameters for subsequent neuro-modeling. (3) Identify computationally specialized regions within the cortical IFD-network through **hierarchical linear** neuromodeling.

BEHAVIORAL RESULTS

0.6

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Figure 1. Median percentage of 'successful' illusory face detections **COGNITIVE COMPUTATIONAL METHODS**



SINGLE-TRIAL NEURO-MODELING RESULTS

Procedure

60k optimizer-steps with 3k

posterior samples

regularization priors



across all subjects (N=10) split by measurement time. No relevant contrasts within-subjects with $BF_{10} \leq$.309.



 $p_{overlap} < .05*$

Figure 3. Results of the hierarchical linear Bayesian neuro-modeling (hlBm). Separate hlBm estimated per <u>predictive processing component/ model-parameter</u> (e.g. prediction error). β_{MAP} denotes ROI-specific unstandardized maximum-a-posteriori random-slope regression weights in original scale. Fixed regression terms: 'measurement-time' := Baseline variability in BOLD-signal across measurement time. Random effect terms: '(1 + modelparameter ROI)':= Baseline BOLD variability with target effect variability across ROIs, '(1 + *modelparameter subject*':= Baseline BOLD variability with target effect variability across ROIs. *rIFG* denoted the right inferior frontal gyrus. *IOG* denotes the inferior occipital gyrus incl. OFA.

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COGNITIVE-COMPUTATIONAL RESULTS



Figure 4. Subject specific parameter estimates of the hierarchical Gaussian filter model (HGF, cf. [4]) split by measurement time (i.e. date). The HGF allows two type of estimable parameters: dynamic trial-level parameter (e.g. prior prediction, prediction error) and subject-specific parameters (i.e. μ_0^2 and ω^2). μ_0^2 can be interpreted as the subject-specific prior-belief (in probability space) <u>before</u> performing the first trial ($t_{=0}$) of the modeled task. ω^2 denotes the subjective time-invariant perception of environmental volatility (in arbitrary units) – relatively

CONCLUSION / DISCUSSION

- There appears to be a specialized network of ROIs that encodes specific computational aspects of IFD (Figure 3).
- Main explanatory predictive-processing variables of ROI-specific cortical activity: trial-level **prior uncertainty** and **prediction-errors**.
- Main involved cortical ROIs: right IFG scaling positively with prior uncertainty, left IOG scales negatively with prior uncertainty but positively with the prediction error, **right IOG** scales positively with the prediction error.
- **Further research:** High-powered replication, confounding variables exploration, Bayesian non-parametric hierarchical models, comparison of top-down and bottom-up computational networks.

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CMBB Day 2025, 09.05.2025, Clinic of Psychiatry and Psychotherapy

