Modeling Face Recognition in the Predictive Coding Framework: A Combined Computational Modeling and Functional Imaging Study

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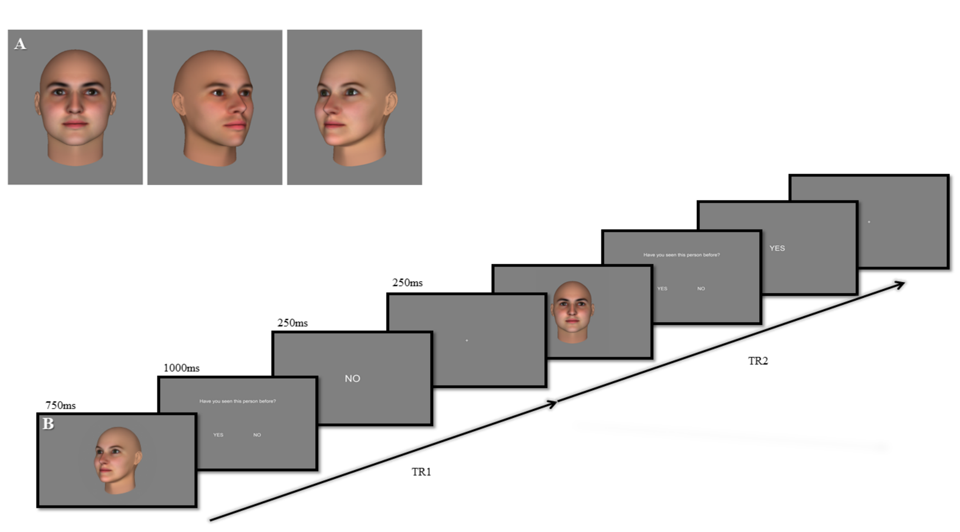
Introduction

Predictive processing has emerged as a unifying framework to create testable hypotheses of altered perception in autism spectrum disorder (ASD) both at the computational and the neural level. Within this framework, core abnormalities of ASD are considered a consequence of aberrant predictive processing. In the planned study, we combined computational modelling, behavioral assessments and functional neuroimaging to assess whether the brain activation pattern during face identity learning is associated with key parameters of the computational model describing the learning process. If our hypotheses (e.g., covariation of activity in the fusiform face area with the prediction error parameter) are confirmed, the paradigm can be used in follow-up patient studies to further uncover the neural mechanisms underlying altered perceptual inference in ASD. If our hypotheses are not confirmed, we will falsify an influential model describing the computational and neural processes underlying face identity learning.

Methods (1)

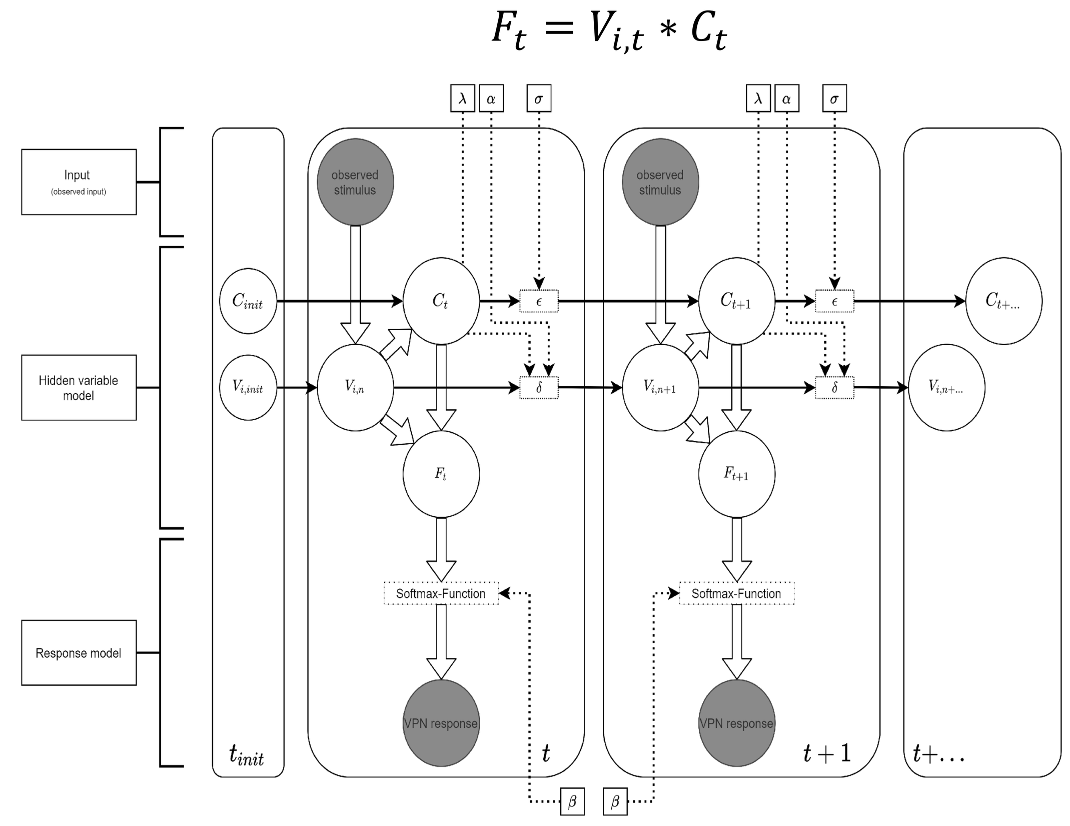
- N=3 (Pilot data)
- face identity learning task



- The subjects were repeatedly shown faces whose identity was unknown at first. They had to judge whether a face has been presented before. Both stimulus familiarity (i.e., the number of times a face has been presented before, independently of the viewpoint) and contextual familiarity (i.e., the average of the familiarity of previously presented faces) were systematically varied, thus allowing to model the learning of facial identities based on both factors

Methods (2)

$$F_t = V_{i,t} * C_t$$



- **Computational Model:** The overall familiarity of a given stimulus is the product of its view-independent familiarity (V_{it})(i.e., perspective invariant face identity learning) and the contextual familiarity (C_t) (i.e., stimulus familiarity on preceding trials). Thus, total familiarity in this model is given by $F = V_{i,t} * C_t$

Methods (3)

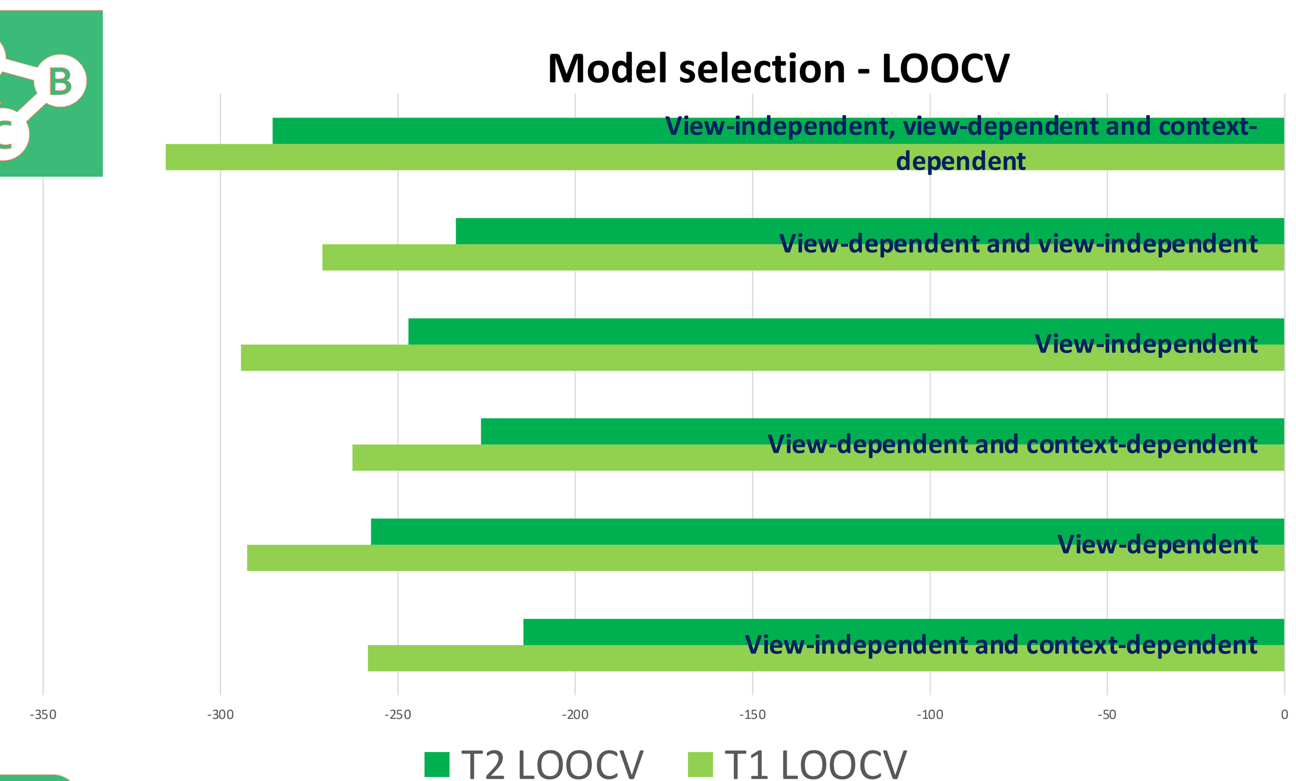
- **fMRI analysis:** We assessed whether brain activity at the time of face presentation is modulated by any parameters of the computational model. We expect, analogous to the results of the original publication, activity in the superior temporal sulcus (STS) varies with the context-dependent familiarity (C_t), and activity in the fusiform face area (FFA) covaries with the context-dependent prediction error (ϵ).
- To estimate this covariance we extracted beta parameters, subsequently a t-test assessed if these parameters significantly differed from zero.
- Our study is inspired by a study published by **Apps and Tsakiris (2013).** Our study will try to replicate these results in an independent sample of subjects. We applied a conceptual replication approach, refraining from using exactly the same experimental design, computational modeling approaches, and fMRI data analysis, but rather we introduced systematic changes.

Results

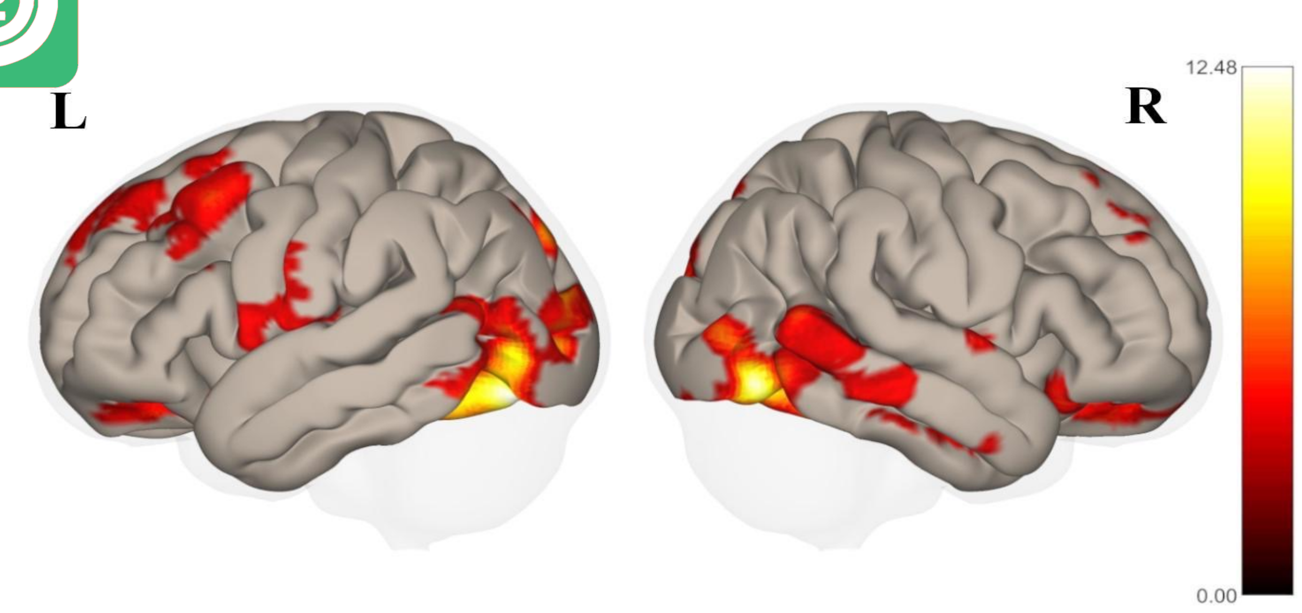
- **The results presented in this poster are pilot results submitted as Registered Report (in revision).**

		First 3 (1st ,2nd ,3rd) vs. last 3 (10th,11th,12th) stimulus presentations	
Timepoint		T1	T2
Mean p(yes) in 1st ,2nd ,3rd		.37	.43
Mean p(yes) in 10th,11th,12th		.90	.95
Two-sided paired T-test (1st ,2nd ,3rd vs. 10th,11th,12th)	t-value	20.23	7.79
	p-value	.002	.016
	Cohen's d	5.14	7.03
	BF10	13.48	4.91

Behavioral results from the face identity learning task (n=3 subjects, measured at two time points T1 and T2). Analysis of the learning effect occurring within each timepoint. Mean p(yes) denotes the mean proportion of 'yes' answers at specified number of previous stimulus presentations.



Computational models: We performed two separate between-subjects model-selection procedures (i.e., for T1 and T2) using multiple model-selection criteria. The pilot data supported for both time points model 1, i.e., the "view-independent and context-dependent model" as the winning model. This hints at successful replication of the original results at both time points. This figure shows the log-likelihood for each model, the closer to 0 is preferred.



Face identity learning task: Also for the face identity learning task, we were able to determine the key regions of the face perception network in all single subject activation patterns

Conclusion: The pilot results from the behavioral data, computational model and fMRI analysis thus far successfully replicate the results from Apps et al., 2013. A complete dataset needs to be acquired to confirm the model can be indeed replicated.

References

[Apps, M. A. J., & Tsakiris, M. (2013). Predictive codes of familiarity and context during the perceptual learning of facial identities. Nature Communications, 4, 2698.

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