The neural signature of language-based prediction errors in individuals with psychotic-like experiences

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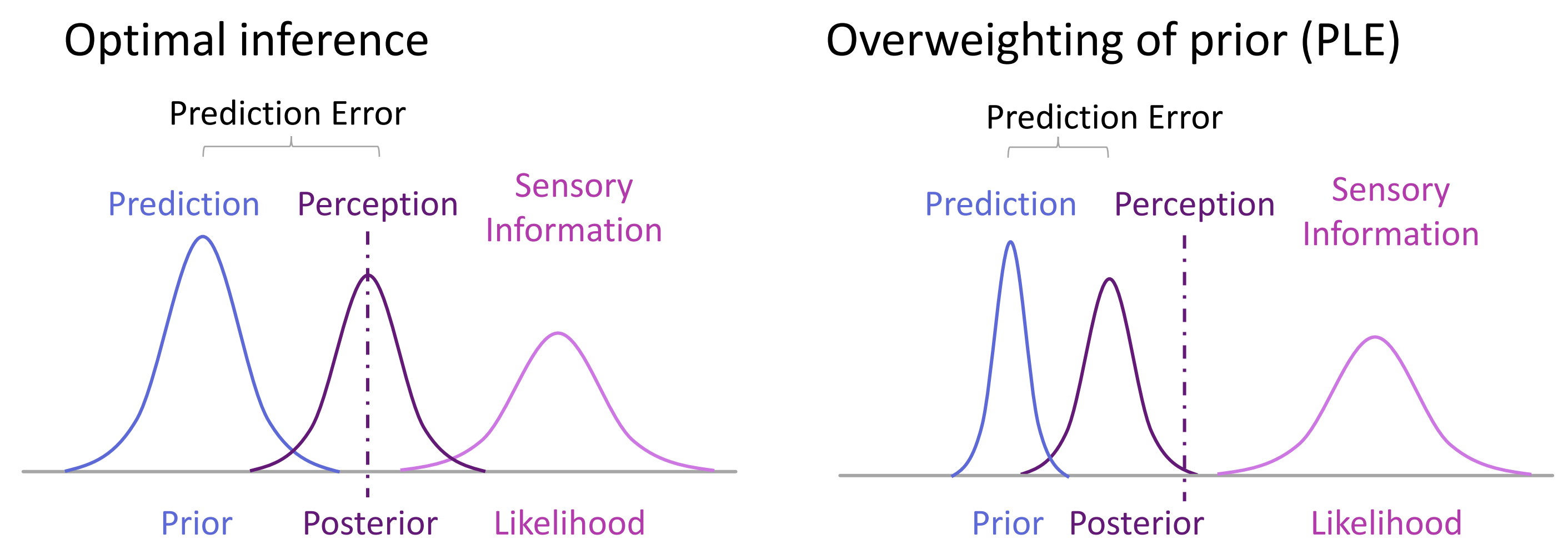Contact: franziska.knolle@tum.de

Introduction

- Hallucinations and misperception are a common occurrence in psychiatric illnesses such as psychosis and schizophrenia. However, psychotic-like experiences (PLE) can also be observed in healthy people.
- Predictive coding offers a possible explanation by postulating an imbalance between prior and sensory input
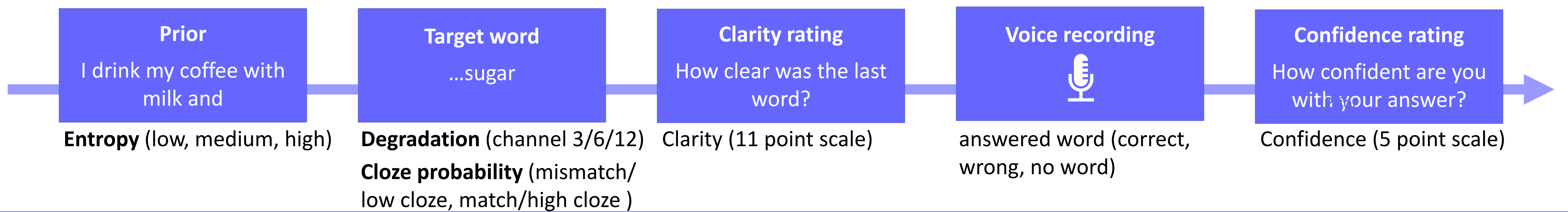
Goal

Exploring neural correlates of prediction, prediction error and task induced hallucinations during language processing in individuals with PLE

Predictive Coding

Optimal inference — Overweighting of prior (PLE)

Language Paradigm

Prior	Target word	Clarity rating	Voice recording	Confidence rating
I drink my coffee with milk and	…sugar	How clear was the last word?	🎤	How confident are you with your answer?
Entropy (low, medium, high)	Degradation (channel 3/6/12) Cloze probability (mismatch/low cloze, match/high cloze)	Clarity (11 point scale)	answered word (correct, wrong, no word)	Confidence (5 point scale)

Pilot study

- Online study format of the language paradigm
- n = 109
- Mean SPQ score: 13.41 (SD=11.06, range: 0-49)
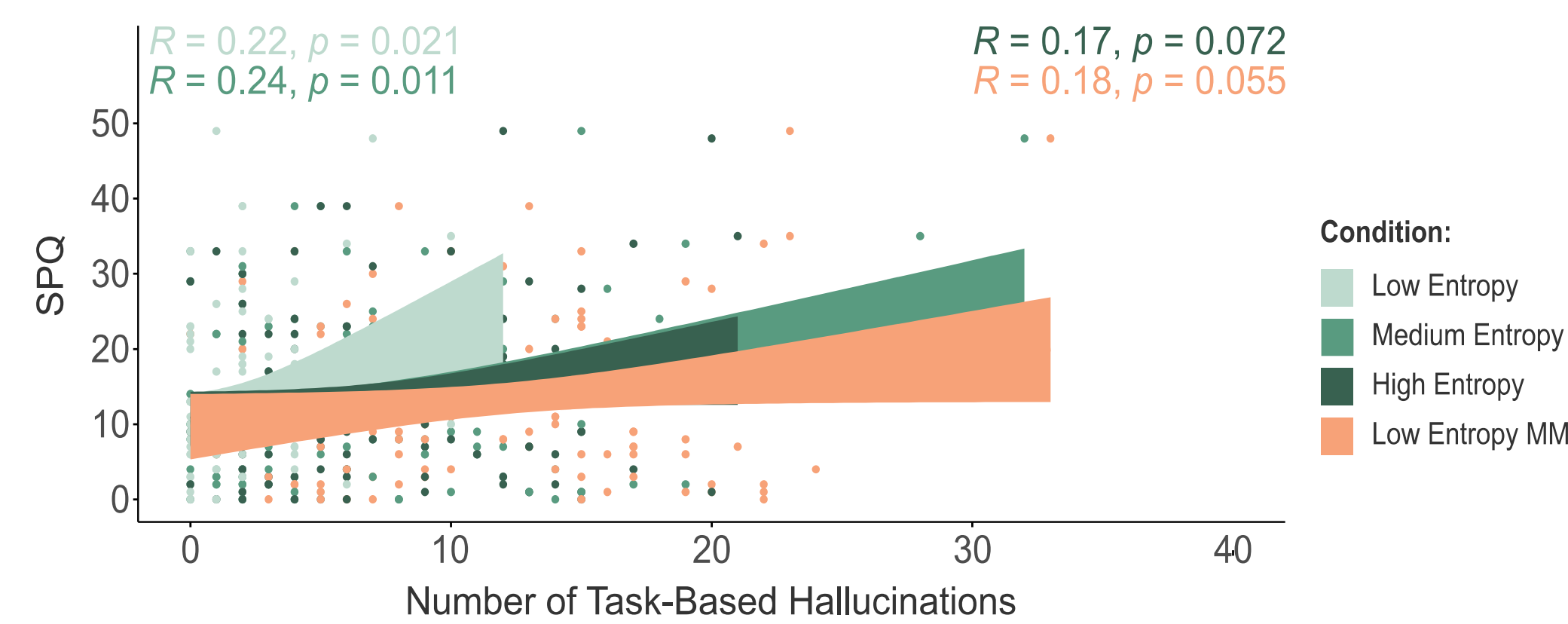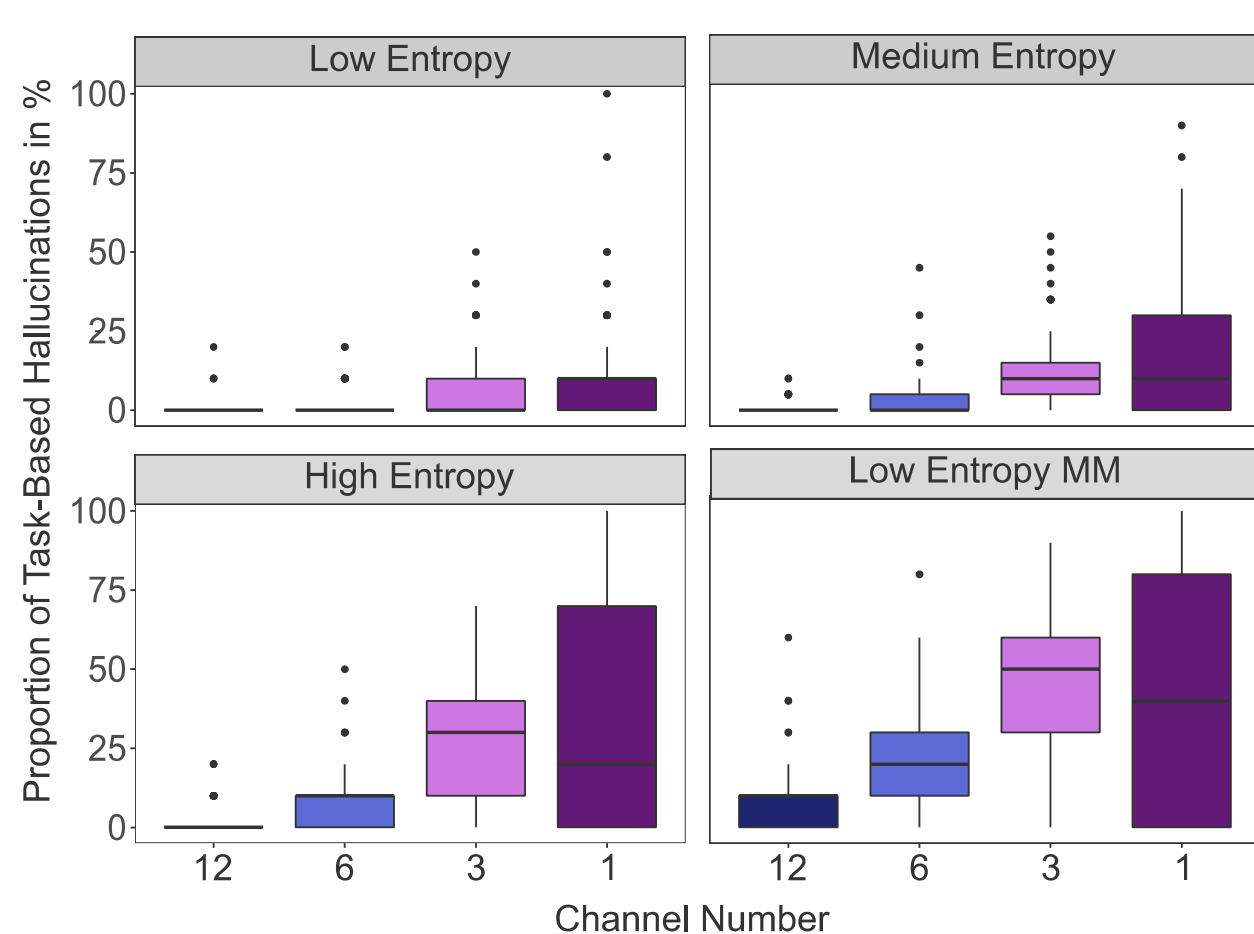
- Misperceptions increase with an increase of entropy and in the mismatch condition
- Misperceptions increase with ambiguity of sensory input (noise vocoding)
- Positive correlation between individuals with PLEs and number of misperception. This can be seen as a sign of overweighting of the prior in individuals PLE

Experimental Design

- N= 60; PLE-high group: n=30, PLE-low group: n=30
- Questionnaires: SPQ, AQ, CAPS, PDI, O-Life, WASI
- **Scanning parameters:**
- 3T Phillips Ingenia Elition X
- 32 channel headcoil
  - MPRAGE Sequence:
    TR: 9ms, TE:4ms, flip angle: 4°
  - Functional Scanning:
    Slice thickness: 3mm, Slice number: 44, continuous ascending sequence, TR: 1,61s, TA: 1,138.36, TE 30ms, flip angle: 65°

Hypothesis
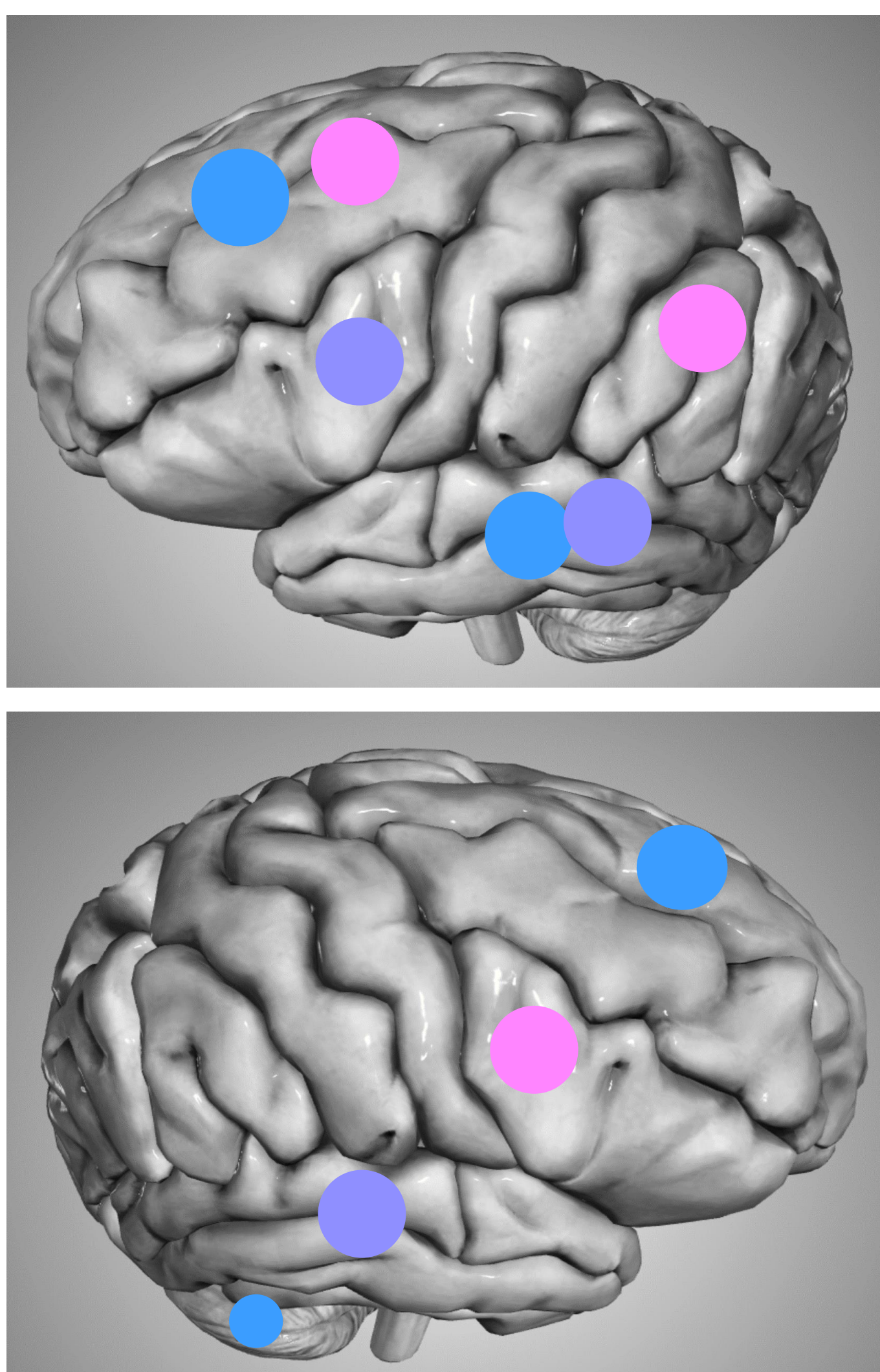
Prediction	Contrast low entropy > high entropy	Stronger predictions in group
Prediction **Low entropy** *The ship disappeared into the thick …. fog* **High entropy** *The new laptop was on top of a ….. box*	Contrast low entropy > high entropy Activation: - Left ventral premotor cortex, left MFG, left SMA, left IPL, right IFG	Stronger predictions in group with PLEs lead to increased brain activation in group with PLEs in comparison of same entropy levels
Prediction error **Low entropy, match (correct)** *The ship disappeared into the thick … fog* **Low entropy, mismatch (correct)** *The ship disappeared into the thick … cream*	Contrast: low entropy mismatch > low entropy match Activation: - Bilateral STG, left posterior STS, left IFG	Weaker prediction errors in group with PLEs lead to less brain deactivation in the proposed brain regions
Task induced Hallucination **Correct word** *The ship disappeared into the thick … cream* → answer: "cream" **"Wrong" Word** *The ship disappeared into the thick … cream* → answer: "fog"	Contrast wrong > correct Activation: - bilateral SFG, left MFG, left STG, left MTG, right cerebellum, right cingulate cortex	Altered pathways in group with PLEs lead to activation of (different) association cortices

References

Barkus E, Stirling J, Hopkins R, Mckie S, Lewis S. Cognitive and neural processes in non-clinical auditory hallucinations. *Br J Psychiatry.* 2007;191(S51):s76-s81.

Blank H, Davis MH. Prediction errors but not sharpened signals simulate multivoxel fMRI patterns during speech perception. *PLoS Biol.* 2016;14(11):e1002577.

Rothermich K, Kotz SA. Predictions in speech comprehension: fMRI evidence on the meter–semantic interface. NeuroImage. 2013;70:89-100.

Sohoglu E, Peelle JE, Carlyon RP, Davis MH. Predictive top-down integration of prior knowledge during speech perception. *J Neurosci.* 2012;32(25):8443-8453.

Willems RM, Frank SL, Nijhof AD, Hagoort P, Van den Bosch A. Prediction during natural language comprehension. *Cereb Cortex.* 2016;26(6):2506-2516.