STIMULUS PREDICTION IN THE HIPPOCAMPUS RESULTING FROM RAPID STATISTICAL LEARNING

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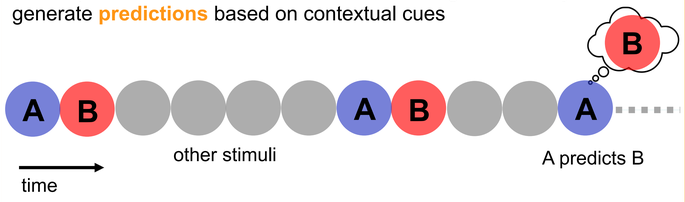
Introduction

Extracting regularities from our environment (i.e., **statistical learning**) is a fundamental learning mechanism that shapes our memory representations and guides behavior

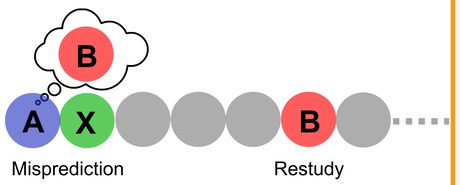
One important consequence of statistical learning is the ability to generate **predictions** based on contextual cues



What if a prediction turns out to be wrong?

Non-monotonic plasticity hypothesis posits that when A is strongly activated (in perception) and B is moderately activated (from prediction), neural connections between A and B are weakened (Norman et al., 2006, 2007)

If B is later restudied in a different context, this activates new features not previously shared with A



The result is that A and B representations are less overlapping than they were pre-learning or **neural differentiation** (Kim et al., 2017)

This mechanism depends on establishing a predictive A-B relationship, and prior work has shown that this can occur in the **hippocampus** (Kok & Turk-Browne, 2018; Sherman & Turk-Browne, *SfN* 2018)

Based on this prior work, we sought converging evidence that *predicted* representations become more decodable in the hippocampus as a function of rapid statistical learning

Using item-specific, multivoxel patterns acquired using high-resolution fMRI during three exposures to predictive A-B scene pairs, we aimed to:

1. Validate our approach by tracking item-level representations due to perception in scene-selective parahippocampal place area (PPA). **Both A and B scenes should be decodable in PPA during all learning exposures.**
2. Track item-level representations in the hippocampus over the course of three learning exposures. **The predicted representation (evidence of B) should strengthen in the hippocampus after repeated exposure to temporal regularities.**

Methods

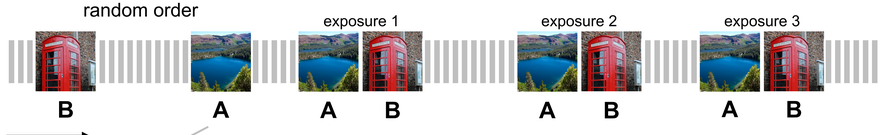
Incidental encoding task: Is each scene indoor or outdoor?

Pre-Learning

Each scene shown 1x in a random order

Statistical Learning

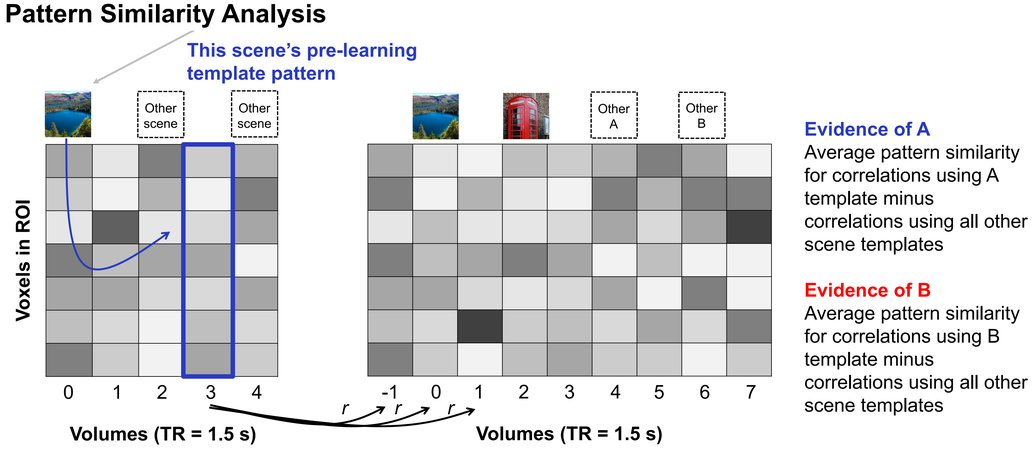
A and B scene pairs shown together 3x; B always follows A



Stimulus duration = 1000 ms
Inter-stimulus interval = 2000 ms

96 AB scene pairs/participant
N = 47 participants

Pattern Similarity Analysis



Evidence of A
Average pattern similarity for correlations using A template minus correlations using all other scene templates

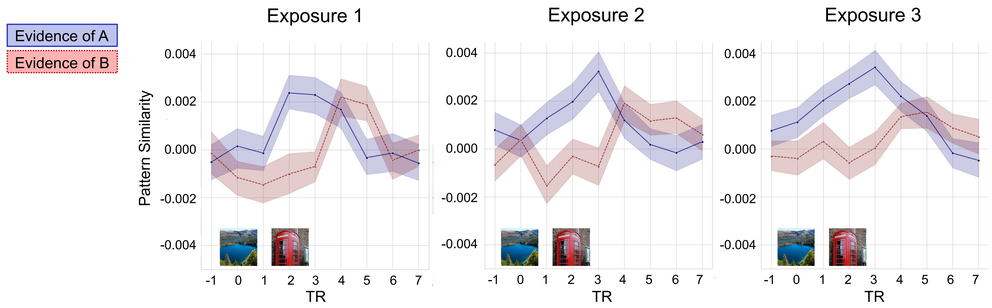
Evidence of B
Average pattern similarity for correlations using B template minus correlations using all other scene templates

Templates are shifted by 3 TRs (4.5 sec) to account for hemodynamic lag

We get a template pattern for every individual scene

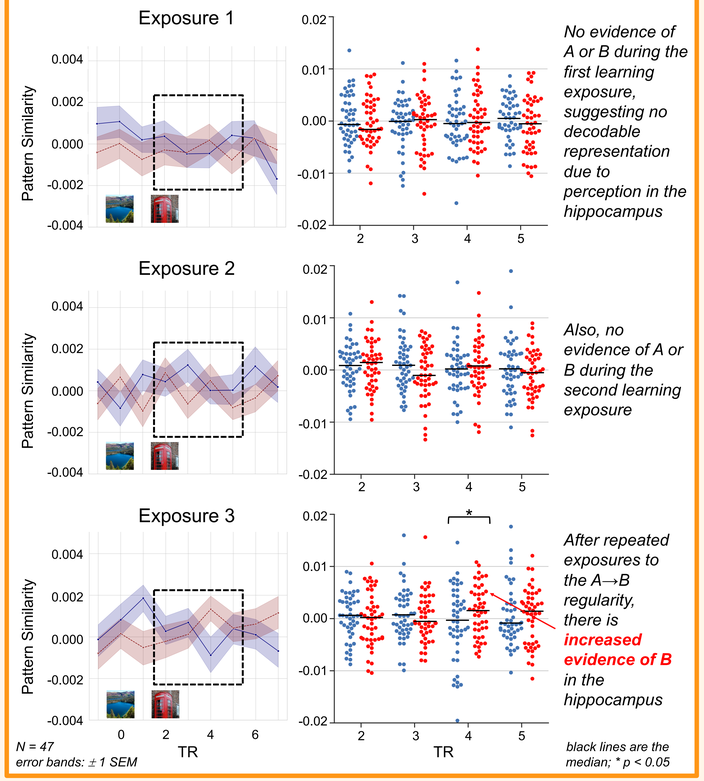
For each AB exposure trial:
- Volume 0 = A onset
- Correlate scene A's template with each volume's pattern
- Correlate scene B's template with each volume's pattern
- Correlate all other scenes' templates with each volume's pattern

Perception in PPA



N = 46, one subject excluded for poor scene localizer performance; error bands are ± 1 SEM

Prediction in hippocampus



No evidence of A or B during the first learning exposure, suggesting no decodable representation due to perception in the hippocampus

Also, no evidence of A or B during the second learning exposure

After repeated exposures to the A→B regularity, there is ***increased evidence of B*** *in the hippocampus*

N = 47
error bands: ± 1 SEM

*black lines are the median; * p < 0.05*

Conclusions and Future Directions

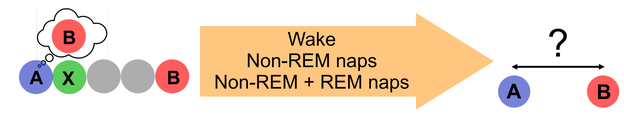
PPA: Perception of A and B scenes can be decoded using item-specific, multivoxel pattern similarity analysis

Hippocampus: Increased evidence of B on the third, but not first or second, learning exposure. **This could reflect the hippocampus generating a *prediction* of B in response to A after only two learning exposures (i.e., rapid statistical learning).**

These findings are important for validating the task we are using to test our hypotheses about prediction, neural differentiation and sleep:

What role does REM sleep play in differentiation?

The ultimate goal of this project is to: (1) relate the strength of B activation during misprediction events to the overall amount of neural differentiation; and (2) test if a period of REM sleep drives these representational changes, thereby reducing interference/competition



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