Context-cued Predictions of Task Demands Facilitate Perceptual Decisions in Virtual Environments

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Background

Task-set defines task-relevant and -irrelevant features, and guides cognitive control to adjust neural information processing in order to achieve adaptive behavior.

We live in a highly auto-correlated world, with predictable task demands that can be used to facilitate task performance. Previous studies demonstrate that (1) humans adjust behavior using temporal prediction of task demand[1, 2], and (2) dorsal striatum is involved in predicting task demand using temporal information[2, 3] (e.g., previous experienced tasks).

However, it is unknown (1) **whether task demand can be learned and predicted from associative memory** and (2) **whether and how the hippocampus contributes to learning and predicting task demand**.

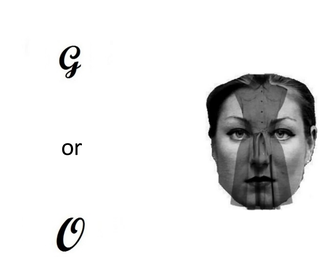
To answer these questions, we embedded a **cued perceptual decision making task** in **spatial contexts presented in an immersive environment.** Data were analyzed using **reinforcement learning** and **multivariate pattern analysis.**

Hypotheses:

(1) **Context-task demand associations can be learned to guide behavior.**

(2) **Hippocampal representations of spatial contexts are modulated by its associated task demand.**

Methods (N=34)



Perceptual categorization based on task pre-cue.

75% face task/25% object task

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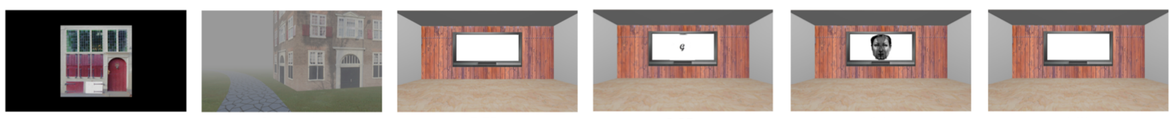
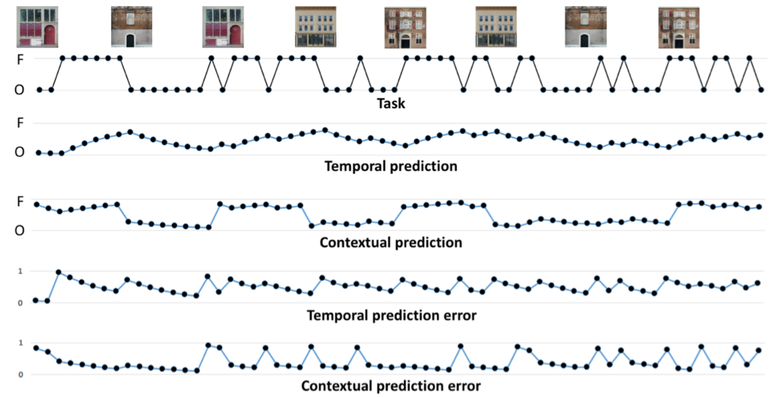
Context-task demand associations created by different proportions of Face task vs. Object task performed within one of four virtual contexts.



At the beginning of each block, participants were cued to navigate to a context/building in a 3D environment. After entering the context, participants categorized either the face or the object of a compound stimulus based on a task pre-cue The proportion of face vs. object tasks created different contextual task demand based on the manipulations above.

Results

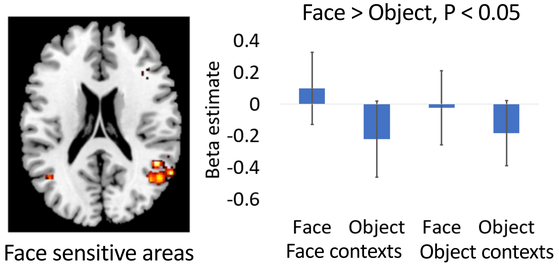
Behavior was modulated by both temporal and contextual predictions of task demand



Larger prediction errors were associated with slower responses.

Face/Object task modulated responses in visual areas

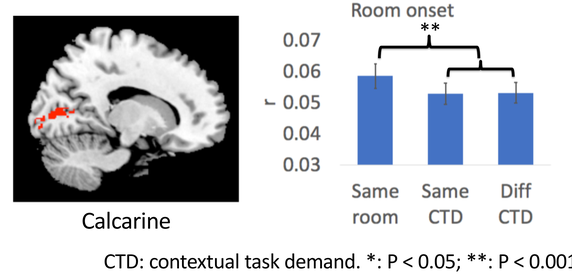
Object sensitive areas



Face sensitive areas

Context modulated activity patterns in hippocampus

Hippocampus



Calcarine

CTD: contextual task demand. *: P < 0.05; **: P < 0.001

Summary and Future Directions

1. Humans used spatial contexts to predict task demand and adjust their behavior accordingly.
2. Hippocampal representations of the spatial contexts were modulated by associated task demand: hippocampus separated representations more for rooms sharing the same associated task demand.
3. Future analyses will focus on (1) reinstatement of task demand, (2) encoding of contextual task demand, and (3) hippocampal modulation on the reinstatement and encoding of context-task demand association.

References 1. Waskom et al., 2017; 2. Jiang et al., 2018; 3. Jiang et al., 2015.

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