Medial temporal lobe involvement in a dual-retrocue working memory task

Poster # GG17

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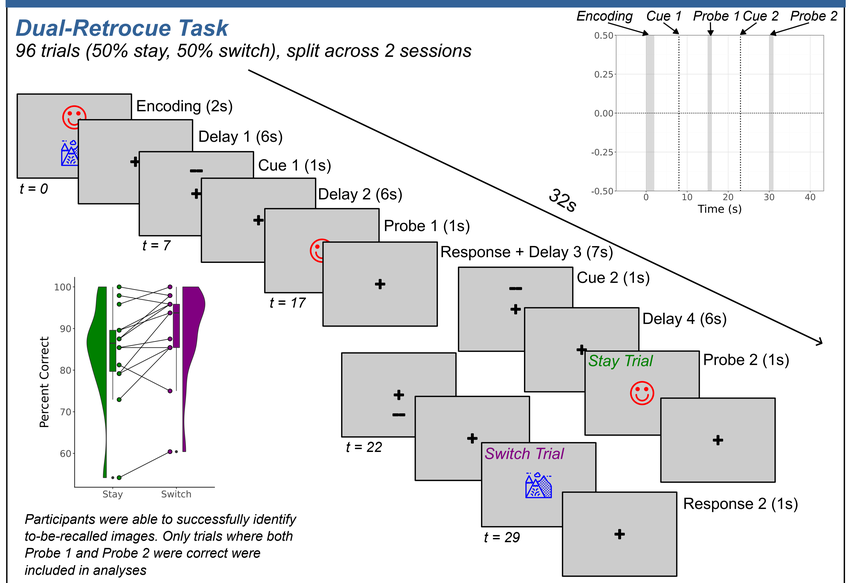
Introduction

- Work in both human and non-human primates has shown evidence that the maintenance of task-relevant information during working memory comes from persistent neural activity in the lateral prefrontal cortex[1]
- Recent work has shown that information may also be maintained in the face of interuptions to persistent activity, a phenomenon known as activity silent working memory (ASWM)[2]
  - While task-relevant information is maintained via recurrent activation in parietal and prefrontal regions, information that is not task-relevant (but may later become so) can be stored in an activated long-term memory state through sub-threshold patterns of reinforced synaptic weights
- In the present work, we use a dual-retrocue paradigm[3] to test the hypothesis that information stored in ASWM processes are brought into an active supra-threshold state when it becomes relevant by medial temporal lobe (MTL) structures

Methods

Dual-Retrocue Task

96 trials (50% stay, 50% switch), split across 2 sessions

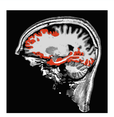


Participants were able to successfully identify to-be-recalled images. Only trials where both Probe 1 and Probe 2 were correct were included in analyses

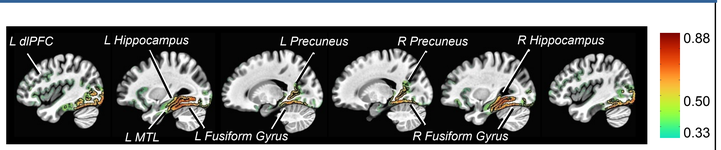
fMRI Data & Preprocessing

- Participants: N = 14 (7 F; mean age = 29.86 yrs; SD = 11.44 yrs)
- fMRI data collected on a 7T Siemens Terra scanner (3D EPI BOLD sequence; 1.3mm^3 voxels, TR=1s, TE=10ms); data denoised using NORDIC[4] and preprocessed using afni_proc.py[5], including aCompCor[6]
- Bilateral hippocampal ROIs (including hippocampal subfields) extracted from high-resolution T1w image using hippunfold[7] and manually split into anterior and posterior hippocampus segments using the uncal apex as an anatomical landmark; medial temporal lobe segmented into entorhinal cortex, perirhinal cortex and parahippocampal cortex ROIs using ASHS software[8] with the Magdeburg 7T atlas[9]
- All preprocessing and analysis code is publicly available at https://github.com/nimh-sfim/fastWM

Searchlight Decoding on Independent Localizer Data



Example mask from one subject

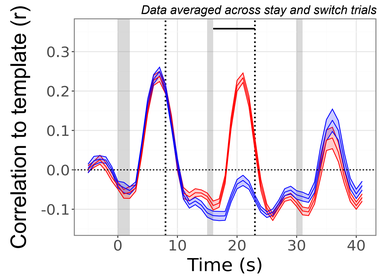


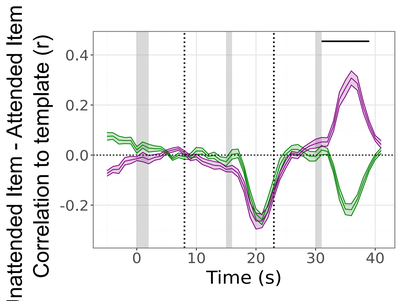
- Cross-validated logistic regression searchlight decoder (7mm radius sphere) was trained on data from an independent functional localizer (16-blocks of a 1-back task for faces, scenes and objects; 16 images per block presented for 400ms with 600ms ISI)
- Averaging within-subject decoding accuracy reveals robust decoding (outlined; accuracy > 50%, with chance = 33%) across posterior hippocampus, medial temporal lobe structures and visual cortex, but no robust decoding in dlPFC

Medial Temporal Lobe During Dual-Retrocue Trials

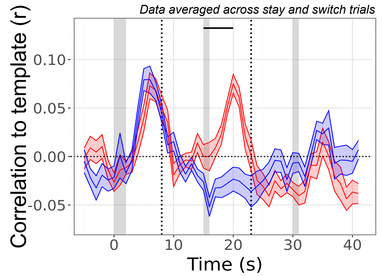
Lines reflect cluster corrected significance p < 0.05

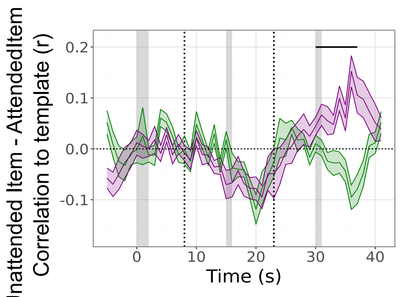
R Fusiform





R Perirhinal Cortex (35)

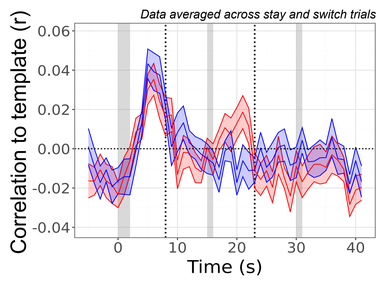


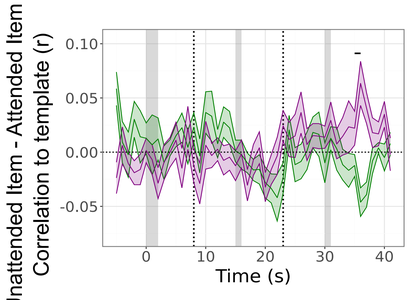


Attended Memory Item (AMI) | Unattended Memory Item (UMI) | Stay Trials | Switch Trials

- Correlating multi-voxel patterns at each time point to a category-specific template defined from independent localizer data reveals robust representation of to-be-remembered category in fusiform and perirhinal cortex, with representation of the **attended memory item (AMI)** after the first cue, and significantly more representation of the **unattended memory item (UMI)** after the second cue on **switch trials**
  - Perirhinal cortex shows onset of category-specific representation slightly before the fusiform cortex, potentially indicating it holds representations of to-be-remembered information in an activated long-term memory state before it becomes task-relevant

R Hippocampus



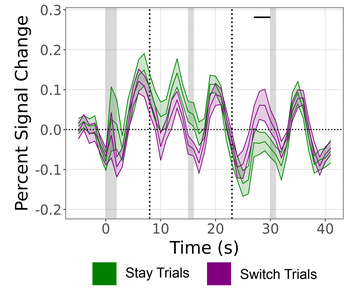


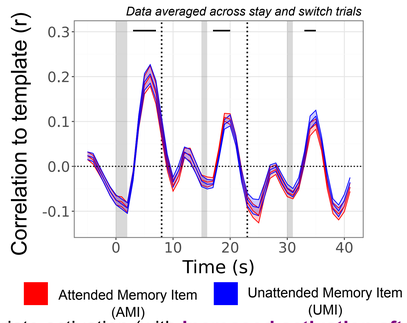
Attended Memory Item (AMI) | Unattended Memory Item (UMI) | Stay Trials | Switch Trials

- Hippocampus shows similar patterns to fusiform and perirhinal cortex, but representation of category-specific representation is restricted to the encoding and retrieval periods, suggesting it may be involved in memory-guided decision-making processes after the to-be-remembered item is retrieved from an activated long-term memory state
  - Similar pattern of results found in anterior and poterior hippocampus, in addition to a combined CA1/CA2 hippocampal subfield ROI

L dlPFC During Dual-Retrocue Trials

Lines reflect cluster corrected significance p < 0.05

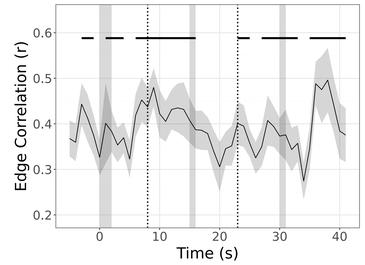




- Although L dlPFC shows trial-locked univariate activation (with **increased activation after the second cue on switch trials**) and correlation to templates when images are presented, there is no effect of image category
  - Face and scene templates from localizer data show an average correlation of ***r = 0.57,*** suggesting that visual image category may not be distinguishable in L dlPFC

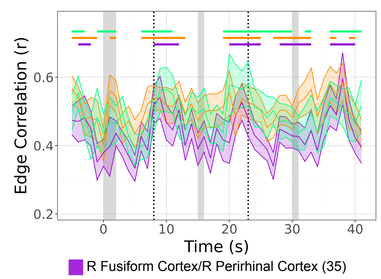
Edge Time Series

R Fusiform x L dlPFC



Lines reflect statistical significance vs phase randomized null; p < 0.01 (uncorrected) for fusiform, p < 0.05, corrected for multiple comparisons for fusiform/MTL/hippocampus

Fusiform, MTL and Hippocampus



R Fusiform Cortex/R Perirhinal Cortex (35)
R Fusiform Cortex/R Hippocampus
R Hippocampus/R Perirhinal Cortex (35)

- An edge time series approach[10] reveals connectivity during delay periods after both cues, potentially reflecting active maintenance of to-be-remembered items in fusiform cortex
- R fusiform, R hippocampus and R perirhinal cortex also show significant connectivity across the task, notably during the delay periods and retrieval of information
  - Hippocampus connectivity with fusiform and perirhinal cortex increases before connectivity of fusiform and perirhinal cortex itself, consistent with a possible role in mediating the transfer of information from being actively maintained in fusiform cortex to passive maintenance in perirhinal cortex

Conclusions and Future Directions

- Medial temporal lobe structures such as the perirhinal cortex may hold to-be-recalled information in an activated long-term memory state before it becomes task-relevant
  - The hippocampus may mediate information transfer back to fusiform cortex once it becomes task-relevant and must be actively maintained for use in the task
- L dlPFC shows an increase in trial-locked univariate activation after the second cue on switch trials but no effect of image category, and decoding there was not robust, suggesting it supports task-general processes such as cue updating and coordinating maintenance of information, rather than directly representing item-specific content
- Future work includes better indexing category-agnostic processes, and relating hippocampal activation and decoding performance to a post-scan memory test

References 1. Fuster et al. (1971) *Science* 2. Stokes, MG. (2015) *Trends in Cognitive Science* 3. Rose et al. (2016) *Science*.
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