Tracking Episodic and Semantic Retrieval with fMRI Pattern Classification

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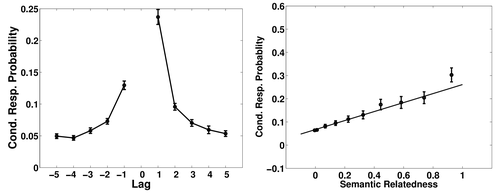
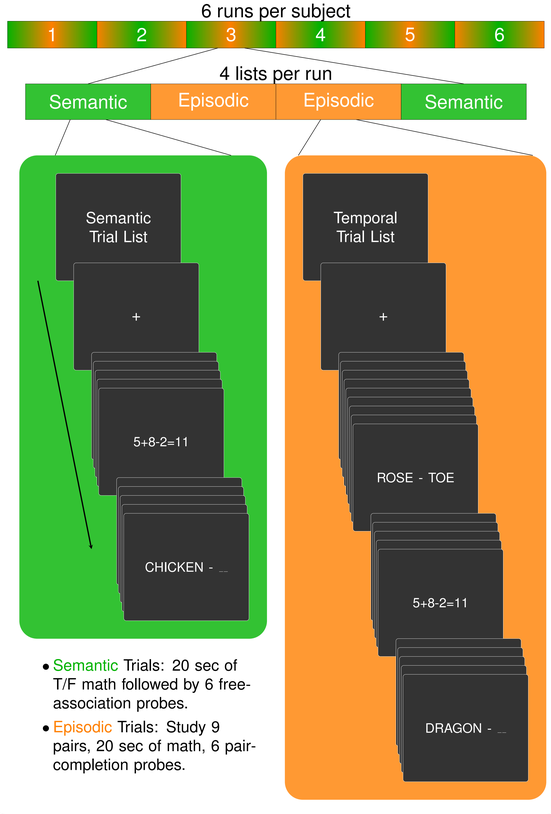
Introduction

- We are interested in the dynamics of memory encoding and retrieval.
- Free recall studies demonstrate that both temporal (Kahana, 1996) and semantic (Howard & Kahana, 2002) cues drive memory retrieval.
- Here we tested whether pattern classification techniques can predict retrieval state in probed recall.



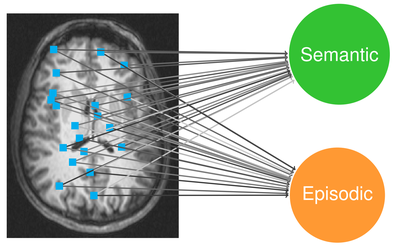
- Lag-Conditional Response Probability (left) and Semantic-Conditional Response Probability (right) calculated across 9 delayed free-recall studies.

Probed Recall Task



- Semantic Trials: 20 sec of T/F math followed by 6 free-association probes.
- Episodic Trials: Study 9 pairs, 20 sec of math, 6 pair-completion probes.

Multi-Variate Pattern Classification



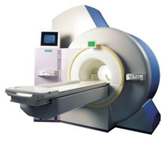
- Convolved time-periods of interest with HRF and picked TRs with peak activation.
- Z-scored each run separately.
- For each cross-validation iteration:
  - Selected the top 1000 voxels with a GLM to reveal the voxels that best discriminate between semantic and episodic retrieval states.
  - Trained back-propagating neural-network classifier with sigmoidal activation function on TRs representing the 1000ms following the probe onset.
  - Tested the classifier on all TRs from the testing run.

Behavioral Performance

	% Rec./Cor.	R.T. (ms)	Sem. Similarity
Semantic Ret.	0.993 ± 0.004	2440 ± 143	0.553 ± 0.035
Episodic Ret.	0.899 ± 0.043	1817 ± 67	0.017 ± 0.001

- Semantic similarity based on word association spaces database (Nelson et al., 2004; Steyvers et al., 2004).

fMRI Methods



- Scanning was performed with a 3-Tesla Siemens Allegra fMRI scanner.
- Participants' anatomical data were acquired with an MPRAGE pulse sequence (176 sagittal slices) before functional scanning.
- Functional images were acquired using a T2-weighted echo-planar pulse sequence. TR was 2000 ms; TE was 30 ms.
- Functional data were motion-corrected, despiked, detrended, and then smoothed with a 4mm Gaussian kernel with AFNI (http://afni.nimh.nih.gov/).
- All of the multi-variate analyses described were implemented using the Princeton Multi-Voxel Pattern Analysis (MVPA) toolbox in Matlab, which is available online at http://www.csbmb.princeton.edu/mvpa.

Acknowledgments

- This poster was created in LaTeX 2$_\varepsilon$ with the posterboxen style and TikZ.
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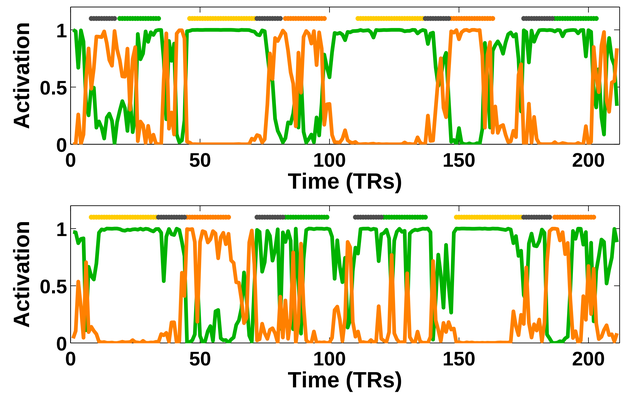
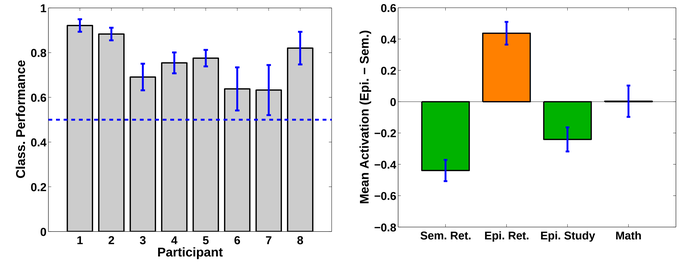
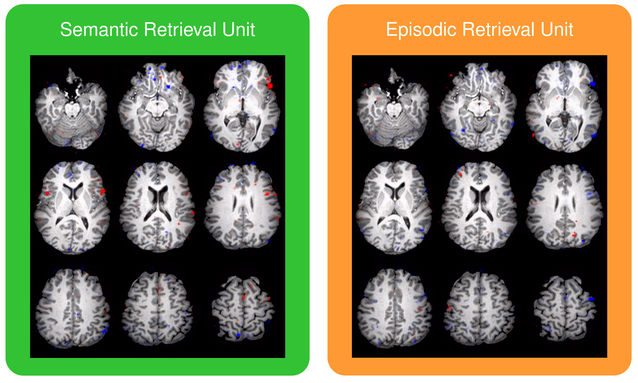
Classification Results





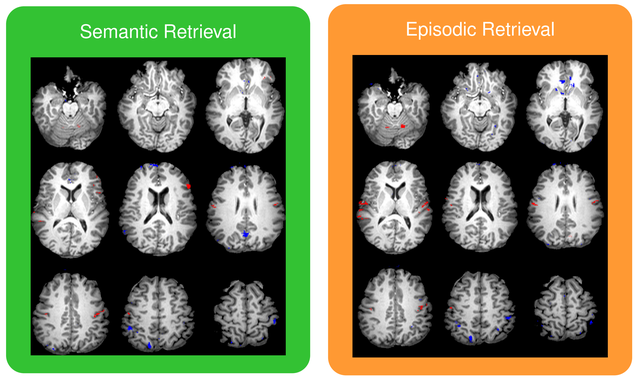
- *Left*: Activation across all TRs for individual cross-validation runs from two participants.
- *Middle*: Overall classification performance for each participant.
- *Right*: Mean classifier activation across participants for four time-periods of interest.

Classifier Importance Maps



- Mean voxel activations based on reversing the neural network weights from the Semantic and Episodic units.

GLM Results



- Results from a GLM combined across all 8 participants via a t-test, thresholded at $p < .001$.
- Left Inferior Frontal Gyrus for semantic retrieval (Thompson-Schill et al., 1997).
- Superior Temporal (predominantly right) found in episodic retrieval. (Heckers et al., 1998).
- Prefrontal and Anterior Cingulate for maintenance of episodic memory retrieval (Lepage et al., 2000).

References

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Conclusions

- We achieved above-chance classification of Semantic versus Episodic retrieval state for all participants.
- Participants enter into a semantic retrieval state during episodic encoding.
- Voxels which were heavily weighted by the classifier and found significant with the GLM are in line with previous literature.
- In future work we plan to apply pattern classifiers to free recall in an attempt to predict semantically similar versus temporally similar responses.