

Neural dynamics of memory encoding and retrieval

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Background

Electrophysiological correlates of episodic memory

- ▶ Prior iEEG and scalp EEG studies show:
 - ▶ Increased high frequency activity (HFA) during encoding, along with decrease in lower frequencies, predicts subsequent recall
Burke et al., 2014; Sederberg et al., 2003
 - ▶ Neural signature of successful encoding changes with serial positions of the item list
Sederberg et al., 2006
 - ▶ Increased HFA supports contextual encoding and retrieval
Long & Kahana, 2015; Long et al., 2017; Sederberg et al., 2007

Neural decoding of subsequent memory effect (SME)

- ▶ Multivariate classifiers combining iEEG spectral features predict encoding and retrieval success
Kragel et al., 2017

Can we accomplish similar classification using scalp EEG data?
What features predict encoding and retrieval success?
How does a classifier trained on a given behavioral contrast behave during other task periods?

Methods

Penn Electrophysiology of Encoding and Retrieval Study (PEERS)

- ▶ 24-session delayed free recall

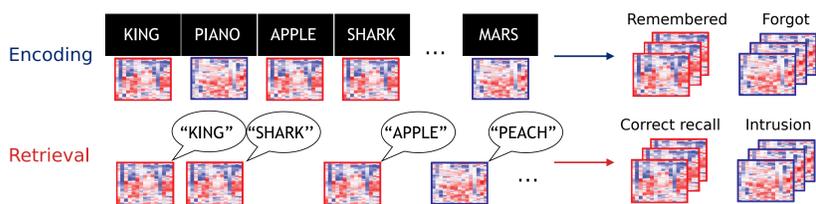


Subject inclusion

- ▶ Encoding (N=88): 15% < recall rate < 85%
- ▶ Retrieval (N=64): Intrusion rate > 5%

Spectral power of average-referenced voltage time-series

- ▶ Multitaper method
- ▶ 30 frequencies between 2-128Hz
- ▶ Normalized across all events within each session



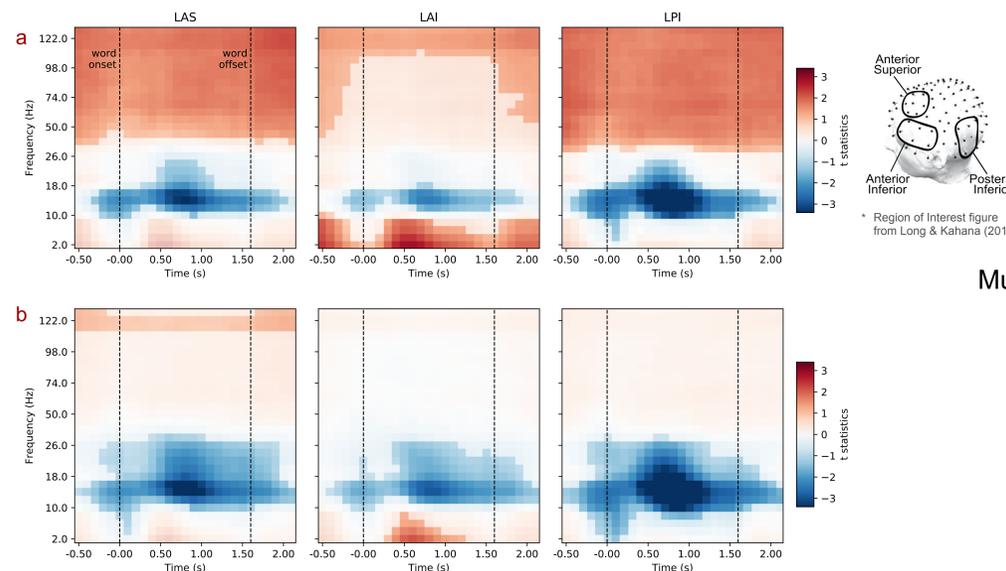
L2-penalized logistic regression

- ▶ Features: averaged power over epochs at Frequency x Electrode
 - ▶ Encoding epoch: [200ms, 1600ms] post word onset
 - ▶ Retrieval epoch: [-650ms, -150ms] pre-vocalization
- ▶ Leave-one-session-out cross-validation
- ▶ Encoding classifier: subsequently remembered vs. forgot
- ▶ Retrieval classifier: correct recall vs. intrusion

Biomarkers of Encoding

Univariate neural signature of successful memory encoding:

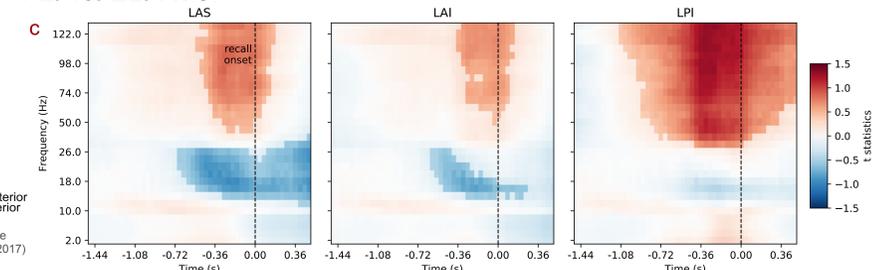
- ▶ SME in all encoding items (a) : **HFA ↑, Alpha ↓, List-level predictability**
- ▶ SME in non-primacy encoding items (b) : **HFA n.s., Alpha/Beta ↓**



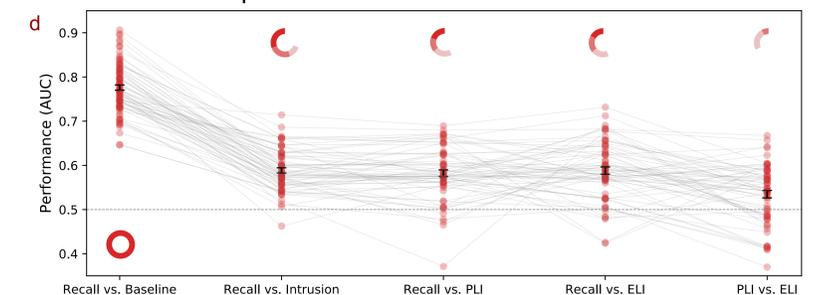
Biomarkers of Retrieval

Univariate neural signature of contextual memory retrieval:

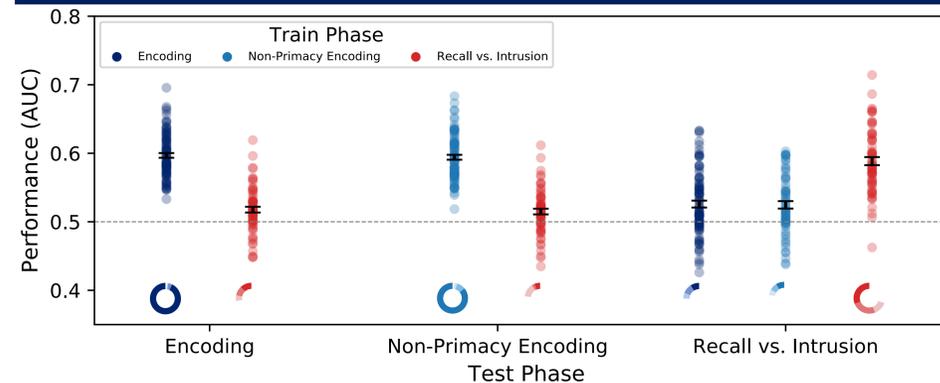
- ▶ Recall vs. Intrusion (c), PLI, ELI : **HFA ↑, Alpha/Beta ↓**
- ▶ PLI vs. ELI : **n.s.**



Multivariate classifier performance for different retrieval event contrasts (d):



Model Performances

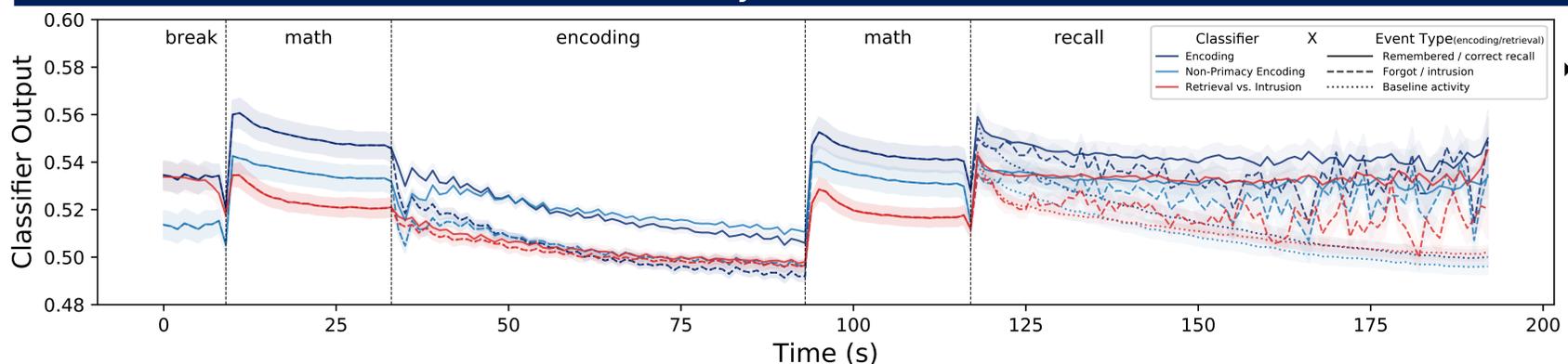


- ▶ **Encoding and retrieval classifiers reliably predict same-task behavioral contrast in hold-out sessions**
- ▶ Non-primacy encoding classifier rivals with full-encoding classifier, even in the absence of significant univariate HFA effect
- ▶ Successful encoding and successful retrieval share common features

Notation

 Proportion of significant classifiers
 = $p < 0.001$
 = $p < 0.01$
 = $p < 0.05$
 n.s. = non significant
 LAS = Left anterior superior
 LAI = Left anterior inferior
 LPI = Left posterior inferior
 PLI = Prior-list intrusion
 ELI = Extra-list intrusion
 Error bar/shaded region = \pm SEM

Feature Dynamics in all Task Periods



▶ **Predictive features present decay within task periods but resurges during task switch**

Discussion

- ▶ With multi-session data, we can reliably decode both encoding and retrieval success using scalp EEG
- ▶ Encoding classifiers generalize to predict retrieval success to some degree, and vice-versa
- ▶ Components of both encoding and retrieval classifiers decay over the course of each task period, suggesting some type of neural fatigue

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