Oscillatory neural correlates of semantic organization in free recall

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Introduction

Memory of a list of words can be improved by forming links betwen items that appear near in time to one another (Sederberg et al. 2010) or by organizing recall in terms of existing semantic relations between the words (Cohen 1963). These influences are exhibited in free recall in the form of temporal clustering (successive recall of items presented adjacent to one another) and semantic clustering (grouping of semantically related items during recall).

Morton et al. (2013) found that patterns of oscillatory EEG activity reflect stimulus category and predict clustering by category during recall. They proposed that sustained category-specific oscillatory activity at encoding reflects construction of a cue that is used during recall to guide memory search, resulting in category clustering.

We examined whether a distracting task between studied items can disrupt the construction of a semantic retrieval cue. Based on previous results (Howard & Kahana 1999), we predicted that temporal clustering would not be affected by the addition of inter-item distraction. In contrast, we predicted that the addition of an interitem distraction task would disrupt formation of a category-specific retrieval cue, resulting in decreased category clustering.

Paradigm

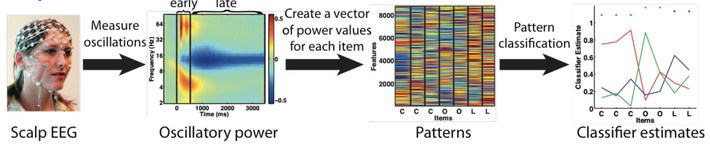
Immediate free recall (IFR): 24 items from 3 categories (celebrities, landmarks, and objects) presented, immediately followed by free recall.

Continual distraction free recall (CDFR): math task distraction added before and after each presented item, followed by free recall.

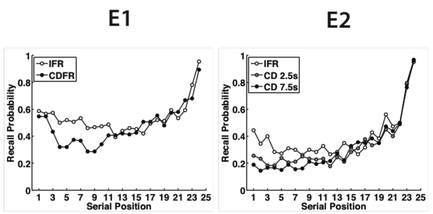
Experiment 1: Picture presented with name above it, for 3.5 s. Distraction task had two terms per problem, for 8.5 s, before and after each item.

Experiment 2: Picture presented during auditory presentation of name, for 2 s. Two distraction conditions, 2.5 s and 7.5 s. More difficult distraction task with 3 terms.

Scalp EEG Methods

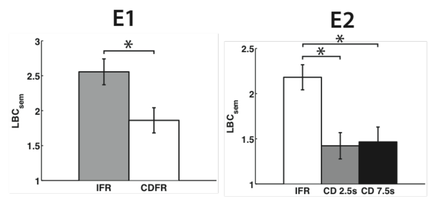


We recorded scalp EEG using a 128 electrode cap. Independent components analysis (E1) or regression (E2) used to remove eye artifacts. Wavelets were used to measure oscillatory power. Using pattern classification, we decoded category-specific oscillatory activity, and examined whether this activity predicted subsequent recall performance.



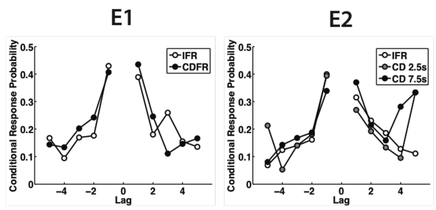
Increasing distraction causes decreases in recall performance.

Distraction mainly affects items in the first half of the list.



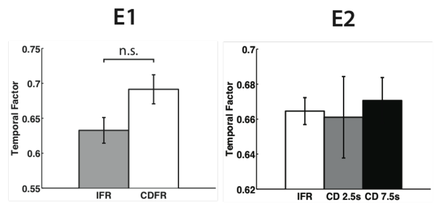
Distraction leads to decreases in category clustering.

An increase in distraction length from 2.5 s to 7.5 s does not cause a further decrease in category clustering.



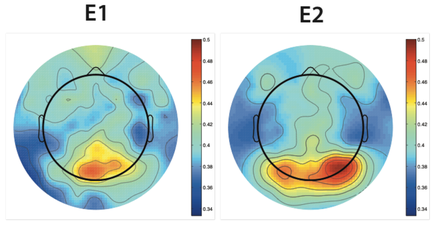
Participants demonstrate temporal organization, even when items are separated by distraction.

To control for category organization, only within-category transitions are included.



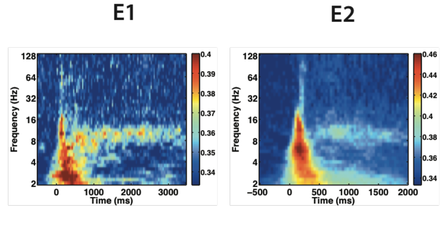
Distraction had no effect on temporal clustering.

In E1, there is a trend toward an *increase* in temporal clustering with increasing distraction.



Oscillatory activity consistent with N170 topography distinguishes between categories.

Performance in separate pattern classification analyses for each electrode. Deep blue indicates chance performance (1/3). We also observe a significant category-specific N170 in electrodes T5 and T6, with a right lateralization. The N170 is thought to be generated by fusiform gyrus.



Oscillatory activity at a range of frequencies distinguishes between categories.

Performance in separate classification analyses for each time and frequency bin. Deep blue indicates chance performance (1/3). A similar pattern of discriminability is observed in E2, where low-level stimulus features (color, contrast, mean luminance) are controlled.

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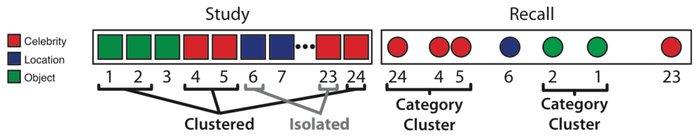
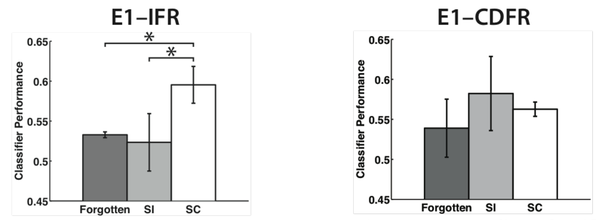




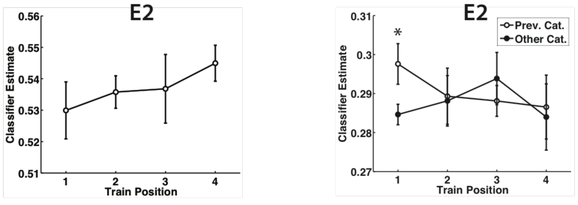
During IFR encoding, classifier performance predicts subseqent category clustering.

This suggests that category-specific representations active during encoding influence subsequent memory search. SI: subsequently isolated. SC: subsequently clustered.

During CDFR encoding, classifier performance does not predict recall organization.

This may reflect a decreased use of category-specific cues during recall.

A similar trend is observed in E2, but it is currently unclear whether the effect is modulated by distraction. Because of the smaller number of recalls in E2, more data are required.



Classifier evidence for the current category increases as multiple items from a category are presented.

p=0.025, one-tailed test. Data are collapsed over conditions. This is consistent with integration of category-specific information into a temporal context cue.

Classifier evidence for the previously presented category decreases as items from a new category are presented.

p=0.035, one-tailed test. The third, not current or previous category, does not change sigificantly.

We did not observe these effects in E1, possibly due to a lack of statistical power (E2 has nearly twice as many item presentation epochs per subject).

Conclusions

As predicted, inter-item distraction attenuated semantic organization without affecting temporal organization. Using pattern analysis of oscillatory EEG data, we found evidence that, when there is no distraction, category-specific activity during encoding predicts the degree of category organization during recall. In the presence of distraction, category-specific activity during encoding does not predict category organization; this may reflect a decreased use of category cues during recall. We also found evidence that activity during encoding reflects the recent history of presented stimuli, consistent with retrieved-context models of memory. More data will be required to determine whether this integrative activity is affected by distraction.