# Study-phase mechanisms of memory organization in free recall

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## Introduction

- Semantic clustering is the tendency to consecutively recall words that share meaning Bousfield, 1953
- Items become bound to context during study Polyn et al., 2009
- Semantically associated stimuli may act as "reminders" during encoding Greene, 1989; Hintzman, 2011
- Neural signals present during memory formation predict subsequent organization Long & Kahana, 2017

## Question

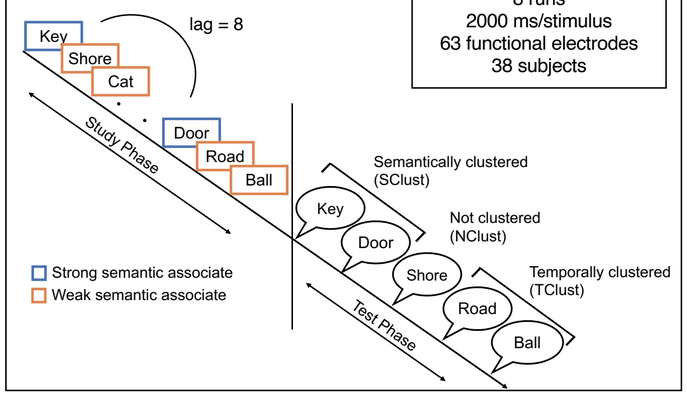
- To what extent do prior study items impact neural encoding mechanisms of subsequent items?

## Hypotheses

- Hypothesis 1: differential processing of associated study items
- Hypothesis 2: associated study items processed via shared mechanism, e.g. item-context binding

## Free recall task

2 phases/run
8 runs
2000 ms/stimulus
63 functional electrodes
38 subjects




## References

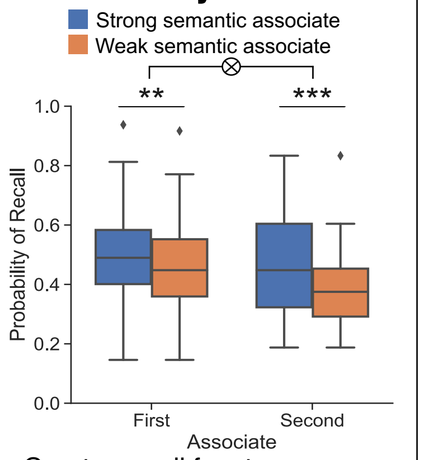
Bousfield, W.A. (1953). The occurrence of clustering in the recall of randomly arranged associates. *Journal of General Psychology, 49,* 229-240.

Hintzman, D.L. (2011). Research Strategy of Memory: Fads, Fallacies and the Search for the "Coordinates of Truth." *Perspect Psychol Sci, 6*(3), 253-271.
Greene, R.L. (1989). Spacing effects in memory: Evidence for a two-process account. *JEP: LMC, 15*(3), 371-377.

Long, N.M. & Kahana, M.J. (2017). Modulation of task demands suggests that semantic processing interferes with the formation of episodic associations. *JEP: LMC, 43*(2), 167-176.

Polyn, S.M., Norman, K.A. & Kahana, M.J. (2009) A context maintenance and retrieval model of organizational processes in free recall. *Psychological Review, 116*(1), 129-156.

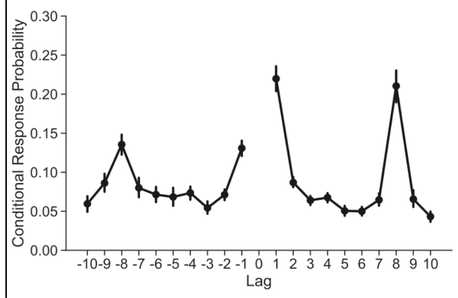
## Probability of recall




Greater recall for strong semantic associates, especially for second associates

*** $p < 0.001$, ** $p < 0.01$

## Contiguity effects

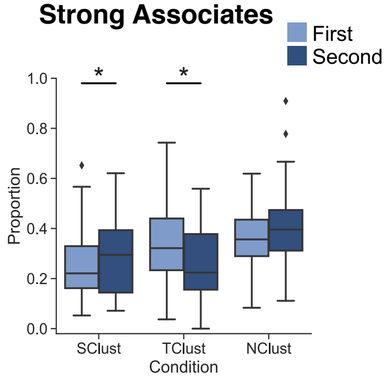



Elevated CRP at +/- 8 lag reflects semantic organization

Participants organize their recalls, consecutively recalling study neighbors and semantic associates

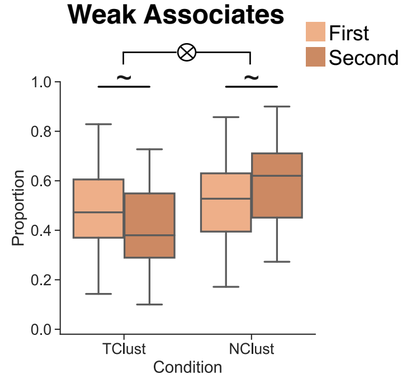
## Organization by associate

### Strong Associates




First associates are more likely to be temporally clustered whereas second associates are more likely to be semantically clustered

### Weak Associates




First associates are more likely temporally clustered whereas second associates are more likely not clustered

* $p < 0.05$, ~ $p < 0.1$

## Summary

- Second strong associates are the most likely to be recalled and semantically clustered
- The neural subsequent semantic clustering effect differs for first and second strong associates
- These results support Hypothesis 1 that encoding mechanisms are impacted by prior study items

## Acknowledgements

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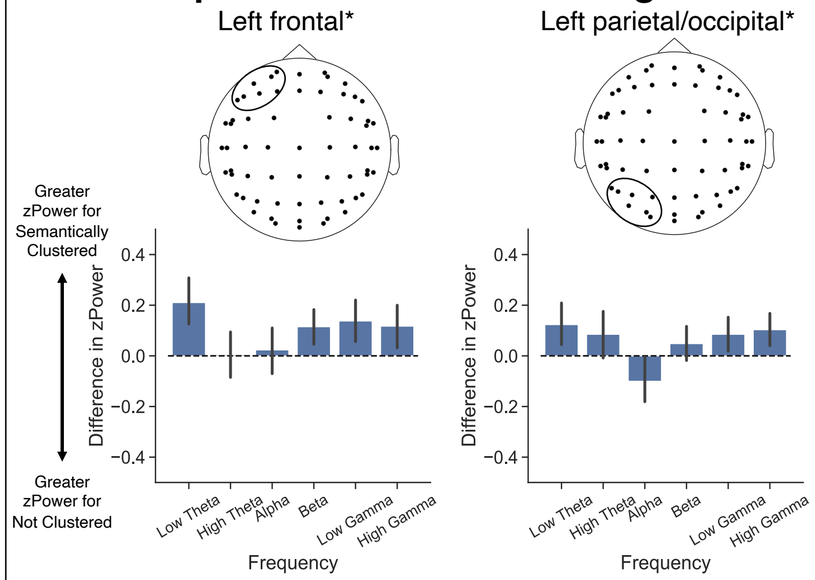
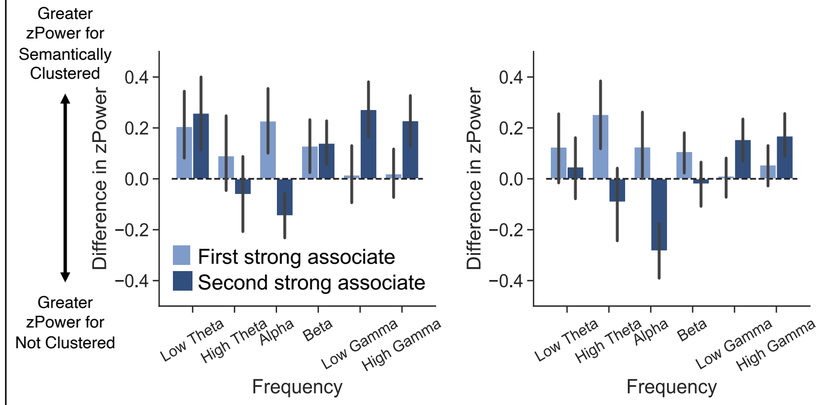
## Subsequent Semantic Clustering Effects




We find a neural subsequent semantic clustering effect (SCEs) whereby there is greater frontal and parietal zPower in low theta, beta, low and high gamma for semantically clustered items




The neural SCEs differs for first and second associates: for second associates the SCEs is characterized by increased high frequency activity and decreased low frequency activity

* based on Long & Kahana 2017

## Future directions and open questions

- Subsequent semantic clustering effects over time – does the SCEs differ early in the stimulus interval vs. later in the stimulus interval?
- Neural temporal clustering effects – are there differences in zPower for temporally clustered vs. not clustered items?

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