The effect of repetition-related neural pattern similarity on subsequent episodic memory retrieval

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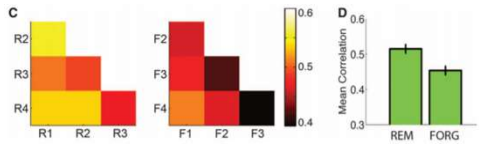
Background

In episodic memory research, two competing hypotheses are often referenced when considering the conditions that lead to the formation of lasting memories. Whereas it is sometimes argued that thinking about an event in multiple, distinct ways (i.e., *encoding variability*) leads to memory improvement, the repeated and similar retrieval (i.e., *reactivation*) of an event can also enhance memory durability.

We examine the possible mechanisms of reactivation versus variability here by using high-resolution functional magnetic resonance imaging (fMRI) to track neural similarity during memory encoding. Multivariate patterns of fMRI activity across multiple encoding instances, particularly focusing on regions of the medial temporal lobe and hippocampus, are used to relate similarity to performance on a subsequent test of memory retrieval.

Prior work

- One early study [1] supporting the encoding variability hypothesis tested whether the meaningfulness of a stimuli was associated with the number of variations of encoding responses, and thereby led to lasting memory formation. In a second experimental phase, different groups of subjects were presented either with a new set of word-digit pairs or with the same set they previously encountered. In a final encoding phase, the original list was presented again. On a subsequent memory test in which all the words had to be recalled, meaningfulness was inversely related to performance, supporting the encoding variability hypothesis.
- Xue and colleagues[2] performed a series of three experiments in neural pattern similarity during face encoding that was related with subsequent memory retrieval. The findings from all three experiments suggested that increased pattern similarity was associated with improved recognition performance, contrary to the variability hypothesis and consistent with the reactivation hypothesis.



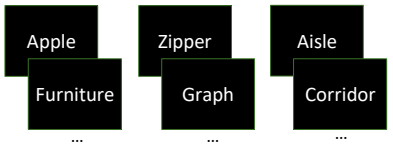
Xue, et al, (2010)

The purpose of the current study was to replicate and extend the findings of Xue et al. (2010). We used an analogous experimental procedure with multiple encoding instances and then tested how pattern similarity was related to later retrieval performance.

Behavioral design & results

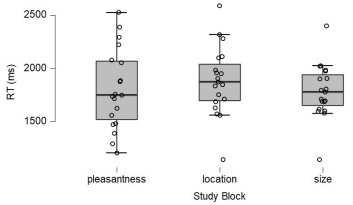
Encoding phases

Subjects (N=17) participated in an encoding phase which took place in the fMRI scanner and consisted of 3 blocks of 40 critical words (repeated in each block).



- 4-9 letter words
- 1-50 per million written frequency
- At least 500 of scale of familiarity, concreteness, and imageability

- Each encoding block required a different type of judgment: pleasantness (very pleasant to very unpleasant), location (likely found inside to likely outside), and size (much larger to much smaller than a typical shoebox).

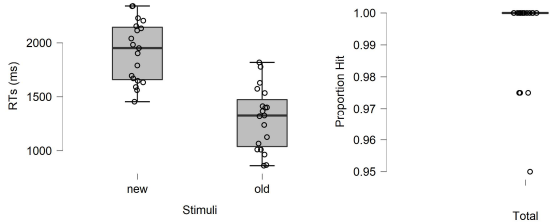


➢ There was no significant difference between blocks RTs F(2,36) = 2.20, p = .13, η^2 = .11

Testing phase

Following the encoding phase, subjects were shown a mix of previously encoded words and new words.

- Subjects had to distinguish whether each word was from the encoding phase (old) vs. new.
- If a word was judged as old, subjects reported whether they *remembered* details about seeing it, or that it was merely *familiar*.

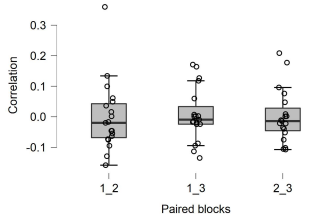


➢ A paired samples t-test indicated that the correct RTs to old items (M = 1301, SD = 291) were faster than those to new items (M = 1919, SD = 282), t(18) = 9.58, p < .001, Cohen's d = 2.20

➢ The proportions of correctly labeled old stimuli (hits) was high (M=0.99; SD=.01), against a low false alarm rate (M=.10; SD = .13), resulting in an average corrected recognition (Pr) score of 0.89 (vs. 0: t(18) = 28.95, p < .001, d = 6.64.

fMRI results

Neural pattern comparison during memory encoding



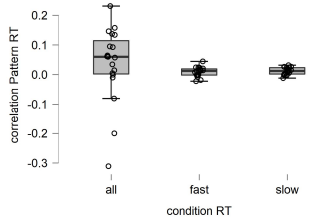
➢ For the encoding phase, the patterns of neural activity across the entire scanned volume exhibited near-zero correlations for each of the pair-wise comparisons.

➢ A one-way ANOVA showed no significant differences in correlations, F(2,36) = .058, p = .94, η^2 = .003.

Correlating pattern similarity with retrieval performance

➢ Each item's pattern similarity at encoding was next correlated with its retrieval phase RT, resulting in a positive (M = .036, SD = .127) but non-significant correlation (vs. 0: t(18) = 1.25, p = .23, d = .29).

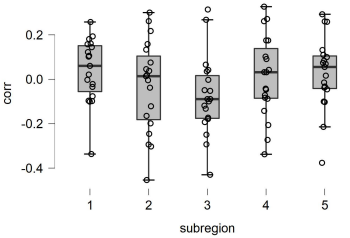
➢ The RTs were also median-spilt into fast and slow groups, again revealing no group difference, t(18) = .75, p = .46, i = .17.



Similarity and retrieval performance in MTL subregions

➢ We also computed the correlations between pattern similarity and RT within different subregions of the medial temporal lobe (MTL; bilateral)[3]:

1. hippocampus head
2. hippocampus body
3. hippocampus tail
4. parahippocampal cortex
5. perirhinal cortex



Summary & conclusions

- Although these results are preliminary, the positive correlation between correct RTs during the retrieval phase and neural pattern similarity during encoding is consistent with the encoding variability hypothesis.
- We're currently exploring whether these brain-behavior correlations across encoding and retrieval could be informative about how MTL and hippocampal subregions might differentially support the durability and generalizability of long-term memories.

References

[1] Martin, E. (1968). Stimulus meaningfulness and paired-associate transfer: An encoding variability hypothesis. *Psychological Review, 75(5)*, 421–441.

[2] Xue, G., Dong, Q., Chen, C., Lu, Z., Mumford, J. A., & Poldrack, R. A. (2010). Greater Neural Pattern Similarity Across Repetitions Is Associated with Better Memory. *Science, 330(6000)*, 97–101.

[3] Ritchey, M., Montchal, M. E., Yonelinas, A. P., & Ranganath, C. (2015). Delay-dependent contributions of medial temporal lobe regions to episodic memory retrieval. *eLife, 4*.