Changes in neural activity across repeated retrievals of autobiographical memories

Lauri Gurguryan, Mathilde Rioux, & Signy Sheldon
Department of Psychology, McGill University

Background

- Recollecting autobiographical memories requires constructive episodic processes to bring together various event details to create mental representations of past experiences [1].
- Evidence suggests that the constructive demands of a retrieval task may change as a function of repeated retrievals[2] and thus alter the neural support for remembering.
- Given the critical role of the hippocampus in episodic memory construction[3], the effect of repeated retrievals should be especially apparent in this region as well as extend to other regions implicated in autobiographical memory.
- **Objective**: to examine the effect of repeated autobiographical memory retrieval in the brain.

Experimental design

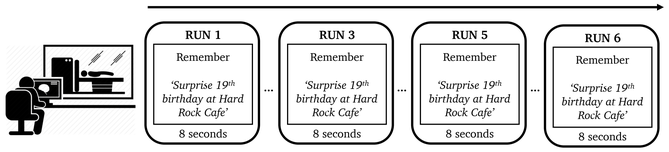
N= 24 healthy young adults (17 F; mean age=21 yrs)

1. Pre-scan autobiographical memory questionnaire

	Event Title	Date	Vividness	Emotion	Importance	Rehearsal
E.g.,	*Surprise 19th birthday party at Hard Rock Cafe*	*February 2010*	*4*	*4*	*5*	*3*
1						
...						
12						

- For each participant, 6 recent and 6 remote autobiographical memories that were rated equally in terms of vividness, emotionality, importance, and lifetime rehearsal were selected to be used as personalized cues during the in-scanner task.

2. fMRI scan session



- While undergoing an fMRI scan, participants recollected 12 pre-selected autobiographical memories. Each memory was recalled 4 times (T1, T2, T3, T4) in a randomized order across 6 functional runs.

Results

Characterizing changes in hippocampal activity patterns as a function of repetition

fMRI analyses:

- Data were preprocessed using SPM 12; realignment, unwarping, slice-time correction, and spatial normalization to MNI space were applied to the images.
- Beta weights were extracted from the 4 hippocampal ROIs using REX[4].

Hippocampal ROI creation:

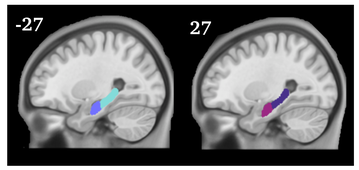


Figure 1. *Group average hippocampal ROIs.*

- Subject-specific hippocampi were manually segmented into anterior and posterior ROIs based on the OAP protocol[5]
- Segments were normalized and averaged to define our 4 ROIs of interest: left anterior, left posterior, right anterior, and right posterior hippocampus.

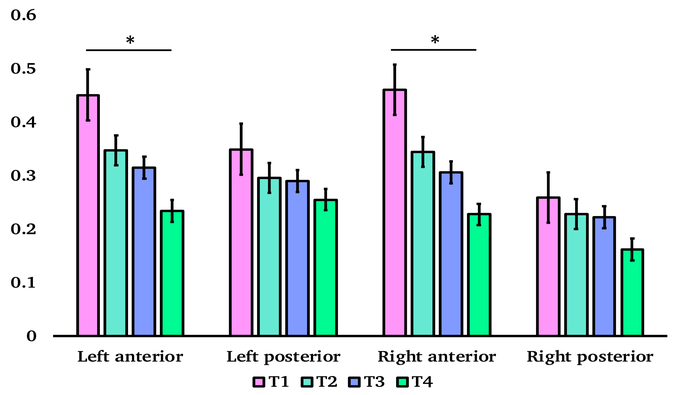


Figure 2. *Average beta weights as a function of repetition, collapse across memory age. Error bars represent standard error and significant results are denoted by an asterisk (p<.05).*

- There was a significant main effect of repetition in the left anterior ($F(3,69)=3.64$, $p<.05$, $\eta^2p=.14$) and right anterior ($F(3,69)=2.83$, $p<.05$, $\eta^2p= .11$) hippocampi only.
- There was a significant decrease in activity from T1 to T4 (left anterior: $t(69)=3.26$, $p<.05$; right anterior: $t(69)=2.91$, $p<.05$).

Dissociating patterns of whole-brain activity as a function of repetition

fMRI analyses:

- Data were additionally spatially smoothed with an 8-mm FWHM kernel.
- A mean-centered task Partial Least Squares (PLS)[6] analysis, a multivariate data-driven analytic approach, assessed the relationship between neural activity and our experimental manipulation of interest (repeated retrievals).
  - Latent Variables (LVs) reflecting neural patterns common and distinct to the experimental manipulation were established with permutation tests.
  - Brain scores reflecting the degree that a manipulation is associated with a neural pattern were computed.
  - Results are presented at $p<.005$ (bootstrap ratio score +/- 2.8) and cluster size >10 voxels.

LV 1. Distinct neural activity as a function of initial vs. late retrieval ($p<.005$; explains 60.14% of the crossblock covariance)

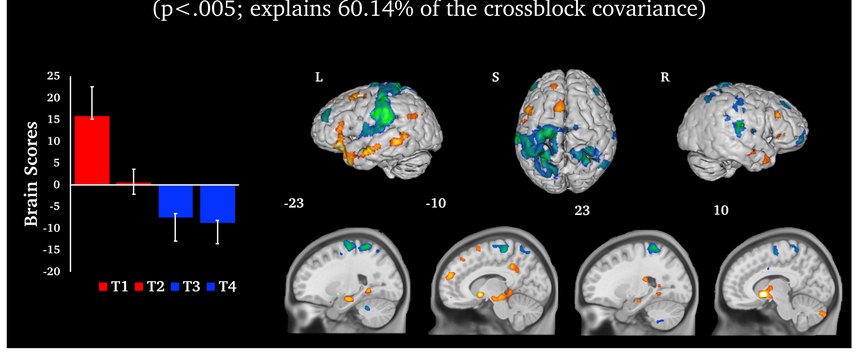


Figure 3. *Left: group average brain scores are shown with 95% confidence intervals. Right: neural activity patterns; positive brain scores (warm colours) reflect activity associated with first retrieval and negative brain scores (cool colours) reflect activity associated with later retrievals.*

- This analysis revealed only one significant LV that dissociated neural activity as a function of repeated retrieval.
- Initial retrieval is more robustly associated with activity within canonical autobiographical memory regions, including lateral and medial temporal lobe regions (e.g., bilateral parahippocampi and anterior hippocampi).
- Late retrieval is associated with distributed activity within parietal cortices (e.g., bilateral parietal lobules and precuneus).

References

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[2] Svoboda, E., & Levine, B. (2009). The effects of rehearsal on the functional neuroanatomy of episodic autobiographical and semantic remembering: a functional magnetic resonance imaging study. *Journal of Neuroscience*, *29*(10), 3073-3082.
[3] Zeidman, P., & Maguire, E. A. (2016). Anterior hippocampus: the anatomy of perception, imagination and episodic memory. *Nature Reviews Neuroscience*, *17*(3), 173-182.
[4] REX toolbox: http://web.mit.edu/swg/software.htm.
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lauri.gurguryan@mail.mcgill.ca / signy.sheldon@mcgill.ca

Significance

- The anterior hippocampus plays a critical role in initially constructing an autobiographical memory representation that can be reactivated during subsequent retrievals.
- The reduction in constructive episodic processing demands that occurs across repeated retrievals also alters neural activity in distributed regions that support autobiographical memory.