Neural correlates of context-based models of free recall

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1 Introduction

- Subjective experience is ever-changing

- Episodic memories include information about both **content** and **context**

- Previous studies have shown content reinstatement during recall[1,2]

- Models incorporating a representation of context that becomes associated with each studied item can explain the contiguity effect

- We tested[3] whether ECoG recordings in 64 neurosurgical patients showed patterns consistent with the context reinstatement hypothesis

2 Methods

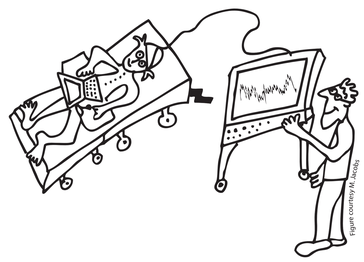

Figure 1. *Our setup.* Patients are implanted with subdural and depth electrodes by clinical teams. Experiments are administered on a bedside laptop computer.

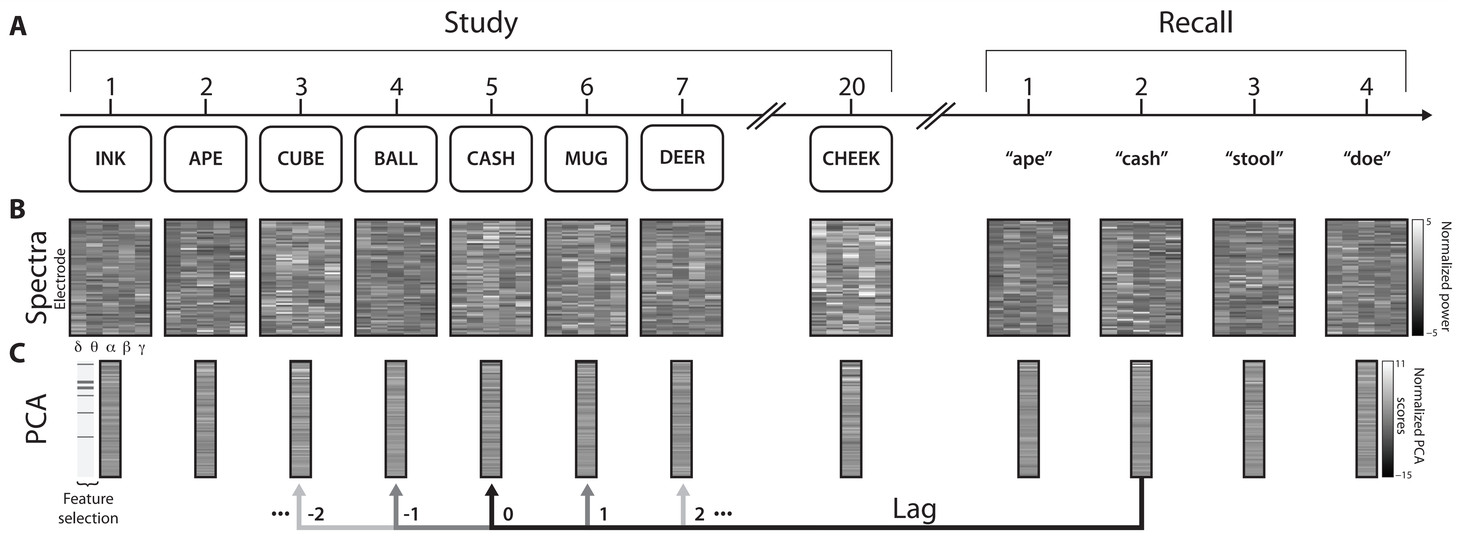

Figure 2. *Experiment and analysis.* **A.** The patient studies and freely recalls lists of 15 or 20 common nouns. **B.** For each electrode we compute mean power in 5 frequency bands during each study and recall event. **C.** We reduce the dimensionality using principal components analysis (PCA). We identify principal components which exhibit gradual change during study. Study and recall events are compared using Euclidean distance.

3 Results

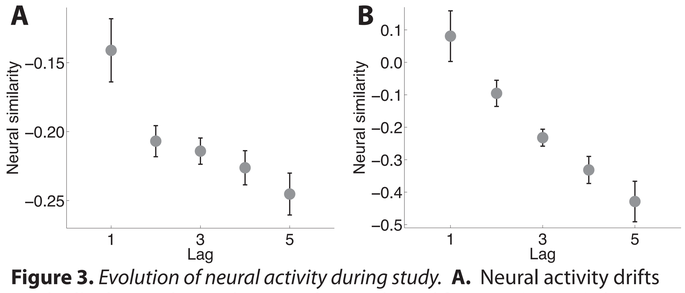

Figure 3. *Evolution of neural activity during study.* **A.** Neural activity drifts gradually during the study interval. **B.** Selected features (Fig. 2C) show an enhanced effect.

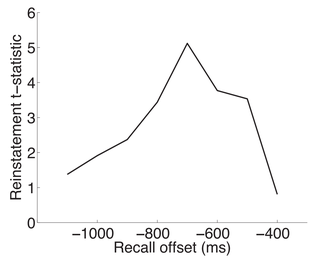

Figure 4. *Determining the start of the recall interval.* The degree of context reinstatement is plotted as a function of start time of the recall interval.

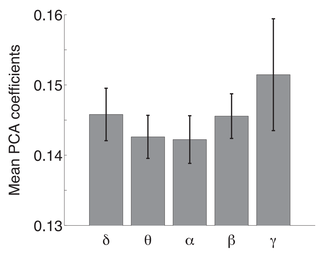

Figure 6. *Frequency specificity of the context representation.* Mean PCA coefficients (across all subjects) are plotted as a function of frequency band.

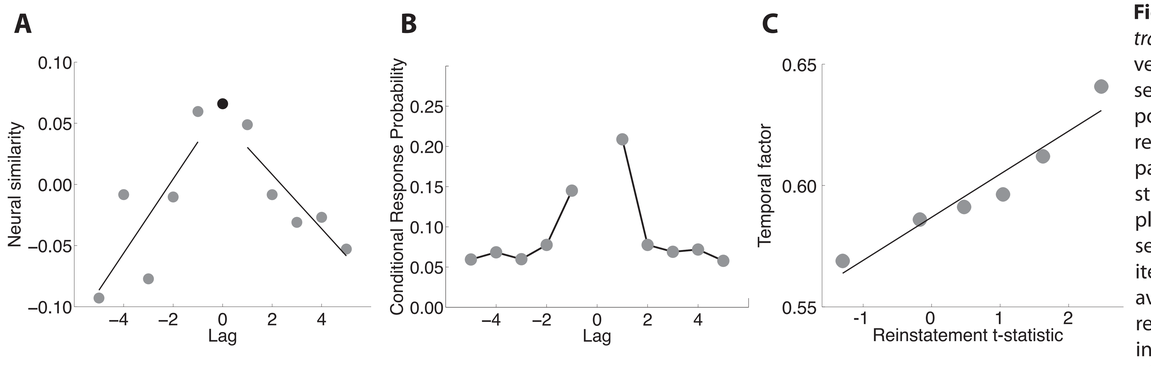

Figure 5. *A neural signature of mental time travel.* **A.** Neural similarity between the feature vector corresponding to recall of a word from serial position i and study of a word from serial position *i*+lag (black dot denotes study and recall of the same word, i.e., lag = 0). **B.** Participants tend to successively recall neighboring study items (the contiguity effect). Here, we plot the probability of recalling an item from serial position *i*+lag immediately following an item from serial position *i*, conditional on the availability of an item in that list position for recall. **C.** The magnitude of neural context reinstatement (A) is correlated with the tendancy of subjects to cluster their recalls in time (B).

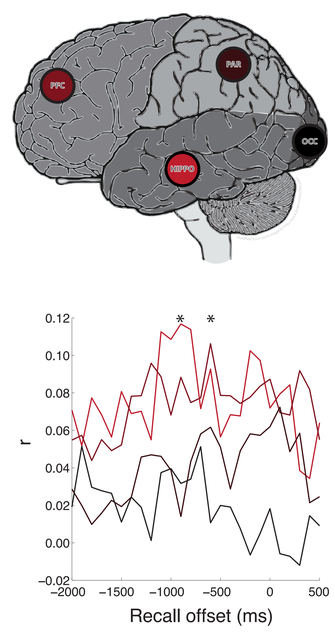

Figure 7. *Regional specificity of the context representation.* The degree of context reinstatement is plotted as a function of start time of the recall interval, for several brain regions.

4 Conclusions

- We identified a gradually changing component of neural activity that evolved on the same time scale as item presentations during a free recall experiment

- The patterns of neural activity recorded during study of a given word were reinstated during recall, and showed graded similarity to neighboring list items

- These findings provide the first neural evidence for temporal context reinstatement in humans

5 Bibliography

1. S.M. Polyn, V.S. Natu, J.D. Cohen, K.A. Norman, *Science* **310**, 1963 (2005).
2. H. Gelbard-Sagiv, R. Mukamel, M. Harel, R. Malach, I. Fried, *Science* **3**, 96 (2008).
3. S.M. Polyn, M.J. Kahana, *Trends in Cognitive Science* **12**, 24 (2008).

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