

Electrophysiological evidence that the fine-grained temporal structure of subjective experience impacts the formation and retrieval of Episodic memories

Joanne L. Park*¹, David I. Donaldson¹ and Kevin Allan²

University of Stirling¹, University of Aberdeen²



Introduction



Episodic memory is essentially associative, producing memory traces from multiple elements of an event that must be bound together in space and time. To enable recollection of the contextual details of a specific episode, these multiple elements must be bound together as they occur in real-time.

Synaptic plasticity mechanisms, that allow the hippocampus to bind together multiple elements of an event, are exquisitely sensitive to the relative timing of their inputs, on a very fine-grained sub-second temporal scale.

Current evidence suggests that:

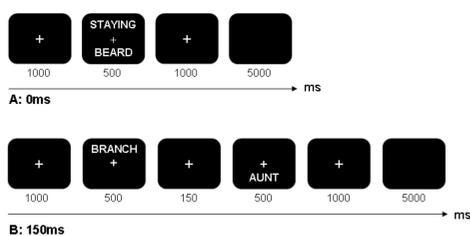
- Memories are encoded in real-time, with synaptic plasticity triggered at a rate in the order of <100ms (Jensen & Lisman, 2005).
- Plasticity is not induced if the temporal distance between pre-synaptic and post-synaptic spikes is too large (Abbott & Nelson, 2000).

Research question: Does the fine-grained temporal structure of subjective experience have an impact on the formation and retrieval of episodic memories?

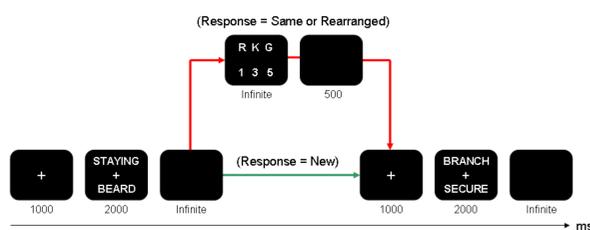
Methods

Participants: (N=18) Right-handed, native English speakers, between 18-35

Study procedure: Participants were shown a series of unrelated word pairs and were required to generate a short sentence containing both words on every trial. A: On 0ms trials both words were presented simultaneously. B: On 150ms gap trials the presentation of the words was separated by a 150ms fixation cross.

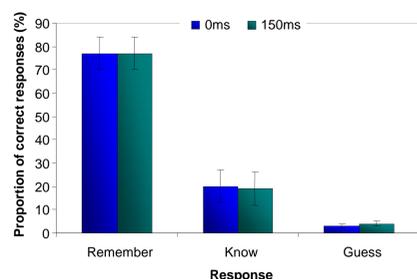
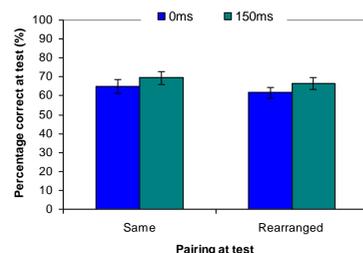


Test procedure: EEG was recorded at test whilst participants judged whether word pairs were a) presented in the same pairing as in the earlier study list, b) had been rearranged, or c) were completely new. For pairs that were judged to be same or rearranged, participants were prompted to make a remember/know judgement.



Results

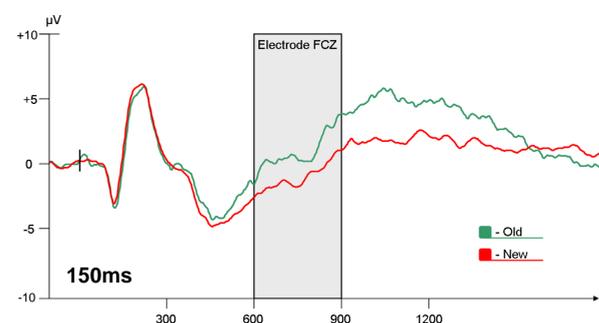
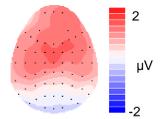
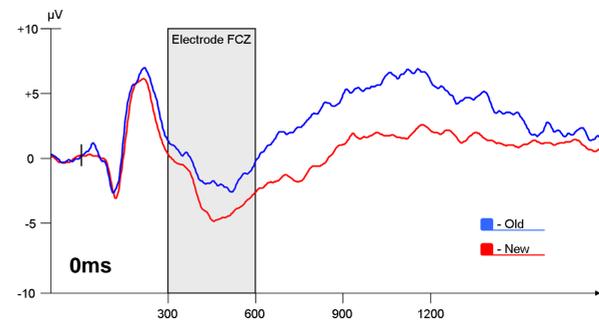
Recognition Performance: Analysis revealed that recognition performance was significantly higher for word pairs studied in the 150ms gap condition compared to pairs studied in the 0ms condition, across pairings at test.



Remember/Know data: Analysis revealed that recognition for items presented in the same pairing at test was largely supported by recollection based responding and that the temporal manipulation at encoding did not differentially affect RKG responses.

Familiarity

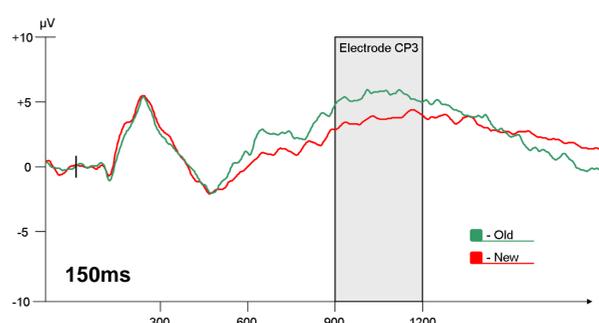
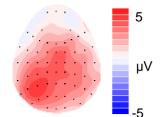
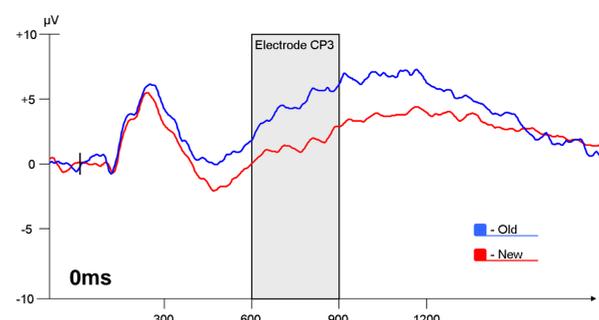
Familiarity (Mid-frontal effect): An early positive ERP component occurring between 300-500 ms post-stimulus maximal at mid-frontal electrodes has been linked with familiarity in recognition memory



Mid-frontal effect: Old/new differences were present at mid-frontal locations for the 0ms condition in the 300-600ms time window. But significant old/new differences for the 150ms gap condition were delayed until 600-900ms.

Recollection

Recollection (Left-parietal effect): A positive ERP component evident between 500-800 ms post stimulus maximal at left parietal electrodes has been linked to recollection based recognition.



Left-parietal effect: Old/new differences were present at left centro-parietal locations for the 0ms condition in the 600-900ms time window. Significant old/new differences for the 150ms gap condition were again delayed, and did not emerge until 900-1200ms.

Conclusions

- A:** The fine-grained temporal structure of subjective experience is retained within an episodic representation.
- B:** A temporal gap between episodic elements at encoding enhances accuracy but slows the onset of retrieval processing.

Summary

Episodic memory is essentially associative, producing memory traces from multiple elements that must be bound together in real-time, from the continuously changing stream of subjective experience. The key question addressed by this study was whether the fine-grained temporal structure of subjective experience has an impact on the formation and retrieval of episodic memories. The results indicated that memory was enhanced when episodic elements occurred separated by a brief temporal gap and this enhancement was accompanied by a corresponding delay in the onset of episodic retrieval processes.

References

- Jensen, O., & Lisman, J.E. (2005) Hippocampal sequence-encoding driven by a cortical multi-item working memory. *Trends in Neurosciences*, **28**(2), 67-72.
- Abbott, L.F., & Nelson, S.B. (2000). Synaptic plasticity: Taming the beast. *Nature Neuroscience*, **3**, 1178-1183.