Cross-frequency Coupling in the Human Hippocampus During Item Retrieval in Episodic Memory

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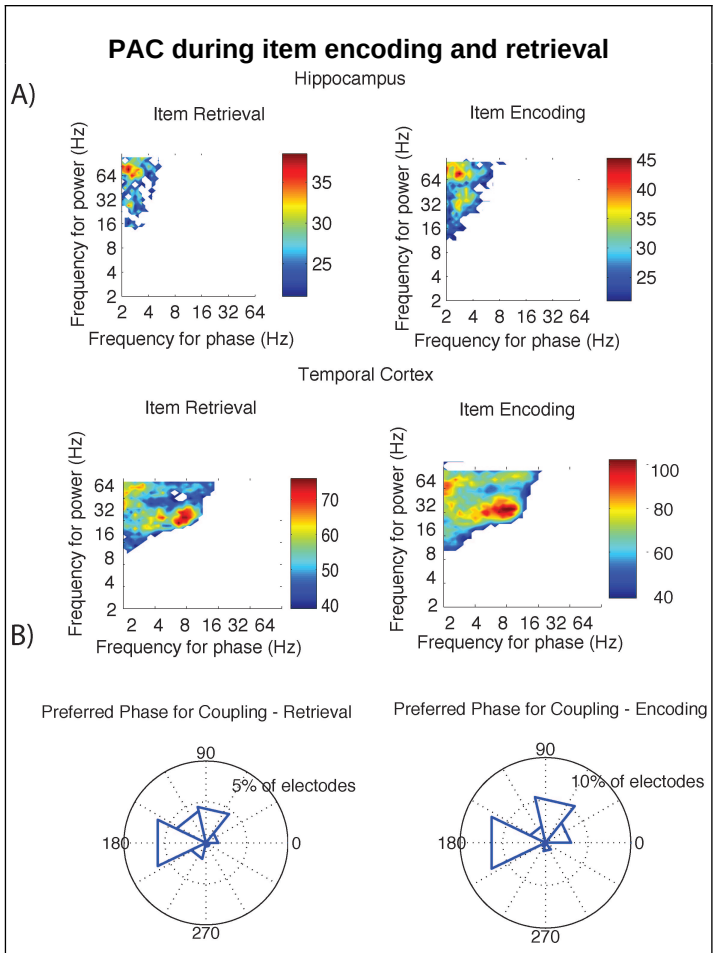
Introduction

Episodic memory, memory for specific items or events within a temporal context, is an important form of memory that is implicated in the memory dysfunction associated aging and with disease. Cross-frequency coupling (CFC) has been observed in the rodent hippocampus during learning of episodic memory items. In CFC, the phase of a slower oscillation modulates the amplitude of high frequency (i.e. gamma band) oscillations. Increases in CFC are associated with item retention and retrieval. Further, extensive theoretical modeling supports the role of phase coding in memory retrieval. Different theta phase preference of CFC may signal whether a memory item is being actively encoded or is being retrieved, thereby sorting the contextual information necessary for appropriate episodic associations.

Methods

We analyzed 278 electrodes located in the hippocampi of 46 epilepsy patients. The patients performed the Free Recall task, a standard test of episodic memory. We recorded iEEG signal during both item encoding and retrieval, using a phase-bin ANOVA and circular regression to identify electrodes exhibiting CFC and the preferred phase of coupling.



A) PAC by frequency during encoding and retrieval. Pattern occurs at slow theta frequencies in the hippocampus. B)Preferred phase for PAC during encoding and retrieval. Distribution of phase values is not significantly different.

Results

CFC occurs during both encoding and item retrieval. The magnitude of CFC is greater during successful encoding compared to unsuccessful encoding ($p<0.001$, ttest), but is not significantly different between encoding and retrieval. The distribution of phase values for CFC during encoding and retrieval was not significantly different ($p = 0.52$, Fisher circular means test). In both instances, a biphasic distribution of phase values (180 and ~75 degrees) was identified.

Conclusions

CFC supports both item encoding and retrieval during episodic memory. In our analysis, we found no evidence of differential phase coding to distinguish encoding and retrieval for individual items. Differential phase coding may not be observable with macro-scale electrode recordings, or it may not be a feature of human memory.