Interaction Among Brain Areas During Memory Retrieval

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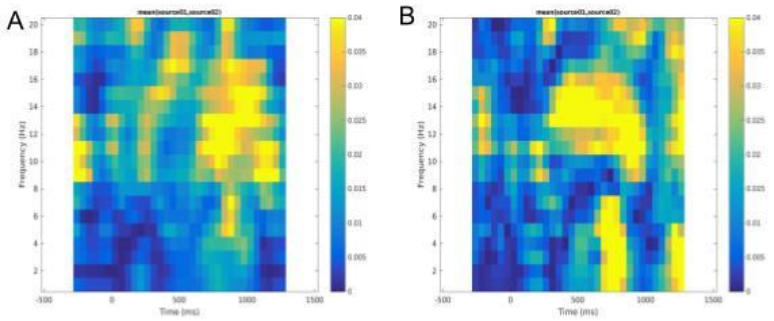
This summer I worked to further research in locating the direction information flows during memory retrieval. The brain is constantly active, and to communicate between different regions, neurons fire together and create rhythmic activity called “oscillations”. Oscillations are delineated into bands of frequencies, and our study focuses on theta oscillations (4-8 Hz) because they have been found to be involved in memory.

The data used in this project originates from a study conducted by Professor Erika Nyhus, using electroencephalogram (EEG) recordings to measure scalp voltage during a memory task. In the task, participants practiced a list of words and then were tested by being presented with a mixture of the practiced words along with new words. Participants were asked to respond if the word presented was one they had practiced (memory retrieval), or not previously seen. Results found that theta activity in the frontal and parietal regions, and found theta was consistently higher when subjects were presented with practiced words, supporting its involvement in memory retrieval.

This project has been an ongoing attempt to create Matlab code to determine directionality of the theta oscillations by using this memory study. While it has been shown before that there is interaction between the medial temporal lobe and the prefrontal cortex at theta frequency during retrieval, the present analysis uses a statistical analysis to calculate the direction of information flow. This analysis, called Granger Causality, tests the degree to which the activity of one source can predict another source. If there is a high degree of influence, it indicates a causal relationship. These code first cleans the data of unnecessary noise and locates the theta oscillations before computing Granger Causality.

This summer, I worked to prepare the analysis to run across all 32 subjects of the original study by using Matlab code written by students that have previously worked on this project. This involved going through the code and making adjustments to them so that they are compatible with the updated versions of Matlab and the toolbox used to analyze the EEG data, and then running the analysis across all subjects. Preliminary data suggests theta oscillations flow in the posterior to anterior direction, consistent with a study using intracranial EEG implanted in the head (Anderson, 2010). In the future, this code can be used in other studies to compute Granger Causality and can be used to explore the interactions between brain areas using oscillations besides the theta band.



Plot showing the strength of Granger Causality moving from (A) the prefrontal cortex to the medial temporal lobe, and (B) the opposite direction, medial temporal lobe to prefrontal cortex

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Anderson, K. L., Rajagovindan, R., Ghacibeh, G. A., Meador, K. J., & Ding, M. (2010). Theta oscillations mediate interaction between prefrontal cortex and medial temporal lobe in human memory. *Cerebral Cortex, 20*(7), 1604-1612.