Analysis of Directed Information Flow During Episodic Memory Retrieval at Theta Frequency

Patrick Bloniasz and Kate Walsh, Class of 2022

Episodic memory retrieval is a process by which humans use an extensive network of brain regions to recall details of situational memories. Little is known, however, about the effective connectivity in the brain during this episodic memory retrieval. Previous research conducted by Professor Erika Nyhus has shown the importance of theta oscillations, or brain activity occurring at 4-8 Hz, during episodic memory retrieval. Specifically, they investigated how these oscillations modulate interactions between the frontal cortex, parietal cortex, and hippocampus (frontal-parietal-hippocampal network) during these cognitive processes of memory (Nyhus & Curran, 2010). Based on previous work (Nyhus & Curran, 2010; Anderson et al., 2010), we expect that at theta frequency, there is directed information flow from the left inferior parietal cortex to the right dorsolateral prefrontal cortex.

To test this hypothesis, we applied Granger causality analysis to measure the directional flow of information in previously recorded electroencephalography (EEG) data during a source memory retrieval task. Granger causality analysis, essentially, assumes that if a linear model created using data from factors *X* and *Y* is better at predicting the future of *Y* than data from *Y* alone, there is directional flow of information from *X* to Y. We began by using a three-step procedure for artifact rejection to ensure that only relevant data was included in analysis. This process involved artifact subspace reconstruction (ASR) to remove unfilterable artifacts, hand-rejection of residual artifactual data, and independent component analysis (ICA) to remove eye-blinks and the remaining line noise. Using the EEGLAB toolbox groupSIFT (Source Information Flow Toolbox), we were able to perform across-subject Granger causality analysis on the EEG data. At theta frequency (frequency band 3-6 Hz), we see directed information flow in similar brain regions as those previously implicated in our fMRI data, including connections between parietal regions and the frontal lobe (e.g., Figure 1).

As this project continues into the school year, we will continue to investigate “best practice” parameters for analysis of this data, as the groupSIFT toolbox we are using is still in beta. Once our parameters for preprocessing and groupSIFT analysis are finalized, we plan to apply our developed scripts to previously recorded EEG data during an item retrieval task and a within-experiment source and item memory retrieval task. These analyses will develop our understanding of directed information flow during episodic memory retrieval, and will contribute to working theories of the role of theta oscillations across the networks involved in these pre- and post-retrieval control processes.

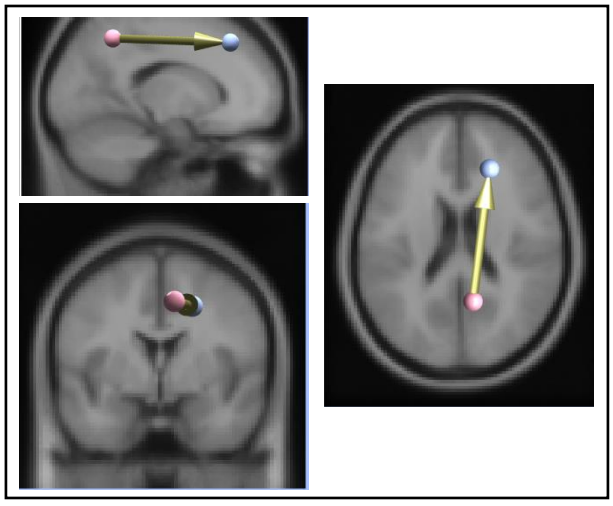

Figure 1. Significant directed information flow at theta frequency from right precuneus to right superior frontal lobe (summed $t = -224$, $p < 0.05$).

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