Exploring Working Memory Networks using Hidden Markov Models

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The human brain is a complex system that exhibits dynamic patterns of activity in response to external stimuli. Magnetoencephalography (MEG) is a noninvasive neuroimaging technique that has high spatial and temporal resolution to provide insight into these brain dynamics. However traditional MEG data analysis methods may not be able to identify rapid changes in functional networks. The classification of dynamic networks in a brain performing a task requires more complex modeling tools. In this study, we examine the use of hidden markov models (HMMs) to identify the presence of these networks in a working memory task. HMMs are probabilistic models that can capture the temporal dependencies and transitions between latent states that represent different network configurations. We hypothesized that HMMs would reveal distinct encoding and recall networks that involve the frontoparietal network, which is known to play a key role in working memory and executive function. Forty-two participants from the NIMH Healthy Volunteer dataset, a collection of neuroimaging and phenotypic data will be used in the study. The Sternberg working memory paradigm, which has an encoding phase where participants memorize a 4 or 6 letter string and a recall phase where participants must determine if a given probe was present in the string, was used to elicit encoding and recall networks. MEG data was collected via a 275 channel CTF scanner. MNE python was used to project data to the brain with LCMV beamformers and parcellation time series were constructed using the Desikan-Killiany atlas. The OSL Dynamics toolbox was used to orthogonalize the time series and compute the HMMs. The model was trained on the continuous data which was then epoched separately around when the string and the probe were shown. The average state activation vs time for an average epoch was generated along with the state power mapped on the brain for each state. The encoding-epoched and recall-epoched modes both displayed visual components approximately 100 ms post-stimulus. Separate left-dominant frontal and parietal components were also isolated in the encoding and recall models. The frontoparietal network was more active during encoding than recall, especially for higher memory load conditions. This study demonstrates the utility of HMMs to identify encoding and recall networks in working memory datasets. Results from this study can be used to inform future analysis of task-based data to classify dynamic brain networks.