A comparison of computational methods to calculate effective connectivity from functional magnetic resonance imaging time series data

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Many different computational methods have emerged with which to calculate effective connectivity from fMRI data. There has been very little work done to directly compare these methods. A comparison of three of the more commonly used methods, structural equation modeling, autoregressive analysis, and Granger causality, using both simulated and real fMRI time series data has been conducted.

The simulated data results suggest that both structural equation modeling and autoregressive analysis are acceptable choices to use with fMRI data, however all three methods were able to measure changes in path weights. Structural equation modeling demonstrated a larger dynamic range when presented with modeled path weights of varying magnitudes, indicating that it would be sensitive to small changes in path weights. Both structural equation modeling and autoregressive analysis outperformed Granger causality in both regards; the Granger causality results indicate that the sampling rate of the average fMRI experiment is still too small for this method to yield relevant information about underlying neural system dynamics.

The results from the real fMRI data echo that which was observed with the simulated data. As structural equation modeling requires the creation of an a priori causal structure, in cases where such information does not exist, autoregressive analysis may be a good alternative.

The three computational methods were applied to finger tapping data measured in neurologically normal and hemiparkinsonian subjects. It has been documented that patients with Parkinson's disease have an altered perception of effort, which may account for one of the hallmark symptoms of the disease, bradykinesia. Subjects performed bimanual index finger tapping with and without the application of increased effort. FMRI results suggest that the parkinsonian subjects relied more on cerebellar-premotor circuits when performing the tapping task without increased effort and basal ganglia-cortical circuits when performing the tasks with increased effort. These results are echoed by the connectivity analyses.