FUNCTIONAL MRI MEASUREMENTS OF EFFECTIVE CONNECTIVITY DURING MOTOR TASKS

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Measuring effective connectivity, or the influences of brain regions on each other, can reveal important details about the functioning of the brain. It provides information beyond that gained from techniques like statistical parametric mapping that indicate only the location of neural activity. Structural equation modeling (SEM) is a multivariate statistical modeling framework that has been applied to analyze effective connectivity using functional magnetic resonance imaging (fMRI) data. I compared two methods of fitting structural equation models: maximum likelihood (ML) and two-stage least squares (TSLS). TSLS had an advantage over ML when models were mis-specified, because with TSLS, errors in one equation of the model did not result in incorrect connectivity estimates in other equations. This is important for brain imaging, because models are not likely to be specified perfectly.

I then applied SEM to measure effective connectivity between motor-related brain regions during the performance of finger movement tasks in right-handed subjects. In one fMRI experiment, subjects tapped their fingers at rates of 1 Hz and 0.25 Hz in response to visual cues. The influence of supplementary motor area (SMA) on sensorimotor cortex (SMC) during finger movement was higher at the faster rate, but the connectivity between intermediate cerebellum and SMC did not depend on rate; also the influence of SMC on cerebellum was more important than the reciprocal influence.

In a second study, subjects moved the fingers of each hand at 1 Hz in response to periodic auditory cues. The influence of left SMA on left SMC increased during right hand movement, and the influence of left SMA on right SMC increased during left hand movement. However, there was no significant hand-dependent change in the influences of the right SMA. This asymmetry in connectivity implies that left SMA plays a dominant role in unilateral movements of either hand in right-handers.

In both experiments, the information provided by structural equation modeling gave important insights into the changing functional relationships of the brain's motor regions. This research takes a step toward a fuller understanding of the network communication that underlies much of the brain's function.