# Motor Plasticity: An Investigation using Functional MRI and Structural Equation Modeling

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## INTRODUCTION

Motor plasticity has been extensively studied in both normal subjects and patient populations. The majority of research has focused on changes in activation within specific brain regions. This approach has revealed learning-related changes in neural activation in a number of cortical and subcortical areas. An alternative approach focuses on changes in the interconnectivity between specific brain regions rather than changes in regional activation. Effective connectivity [1] is one of the most commonly used measures of inter-regional connectivity. Structural equation modeling (SEM) [4] is a widely-used system level modeling approach in the functional neuroimaging literature. So far, there is little data to address whether changes in regional activity are accompanied by changes in effective connectivity within the motor system as training progresses. We tested this as a hypothesis using SEM as a system model to analyze the effective connectivity in an fMRI data set collected over four weeks of practice of a simple motor learning task.

## METHODS

Ten healthy subjects were trained to perform explicit finger sequence movement as in [3]. Three sets of fMRI images were acquired every two weeks. Our SEM models were chiefly based on the network proposed in [5], but with some modifications. The modifications were as follows. I. The intermediate nodes in Ungerleider et al.'s network [5] were removed from our models for simplification. II. The area of posterior ventrolateral prefrontal cortex (pVLPFC) was included in our models for its function in working memory [2]. Therefore, our models encompassed primary motor area (M1), supplementary motor area (SMA), dorsal premotor cortex (PMd), posterior ventrolateral prefrontal cortex (pVLPFC), basal ganglia, and cerebellum. III. Compared to their reverse connections, the connections from M1 to PMd, from M1 to SMA and from PMd to SMA were less important. Therefore they were not specified in our models to release degree of freedom. IV. The connections between pVLPFC and other five areas and were specified based on previous studies. V. The bidirectional connections between M1 to the basal ganglia, between the basal ganglia and the cerebellum, the connection from PMd to the cerebellum were added to our models based on previous findings. Dependent on different connections among the selected regions, three models were tested (Figure 1).

## RESULTS

The observed motor activations include M1, primary somatosensory cortex (S1), SMA, PMd, pVLPFC, basal ganglia, and cerebellum. All the selected areas were found increasingly active from Phase 1 to Phase 2, but decreasingly active from Phase 2 to Phase 3. Most of these changes were significant. All models described in Figure 1 were tested using the data from the three sessions. Model 1 and Model 2 were rejected due to their poor goodness of fit statistics. Model 3 was able to fit the three phases of data. Random model search showed that Model 3 was the only model which could fit the three phases of data simultaneously. Figure 2 depicts the path coefficients (positive or negative, strength) of the Model 3 across the 3 sessions. The changes of path coefficients (across the three phases) were evaluated by using Fisher's z transformation. Significant changes occurred in the effective connectivity as motor training progressed.

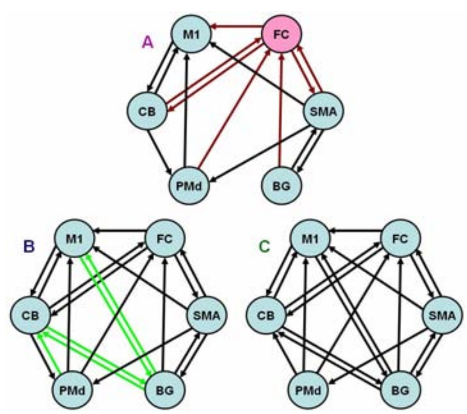


**Figure 1:** The three models to be tested. A: Model 1; B: Model 2; and C: Model 3. M1 = primary motor area, SMA = supplementary motor area, PMd = dorsal premotor cortex, FC = posterior ventrolateral prefrontal cortex, BG = basal ganglia, and CB = cerebellum.

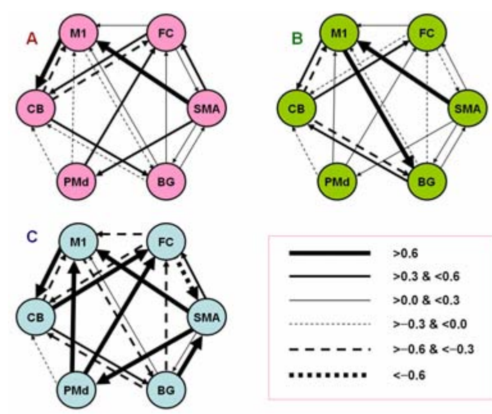


**Figure 2:** Path coefficients of the Model 3 across the 3 sessions. Different types of lines were used to provide rough information of path coefficients. PMd = dorsal premotor cortex, FC = posterior ventrolateral prefrontal cortex, BG = basal ganglia, and CB = cerebellum.

## CONCLUSION

We have used SEM and fMRI to identify changes in inter-regional connectivity during motor learning to elucidate the mechanisms of motor plasticity. Changes in the regional activity were also investigated. The results show that, during a four weeks' sequential finger movement training, there were changes in motor system across different phases of training. The changes happened both regionally and inter-regionally. All the selected areas were found increasingly active from Phase 1 to Phase 2, but decreasingly active from Phase 2 to Phase 3. There were changes in path coefficients across different phases, most of the changes were significant, implying that significant changes happened in effective connectivity as training progressed.

## REFERENCE

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