

Multiple Subject Effective Connectivity Analysis of Voluntary Movement

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Introduction

In human brain mapping, structural equation modeling (SEM) has been proposed to evaluate effective connectivity in a predefined anatomical network [1, 2].

Our previous work focusing on repetitive finger movement at three frequencies (0.3 Hz, 1 Hz and 3Hz) revealed that areas including cerebellum, primary motor area, supplementary motor area and putamen were involved during the task. Here we apply SEM to an anatomical model incorporating these areas to investigate changes in effective connectivity during left and right finger movement at three different frequencies. The quantitative estimations of the causal interaction among regions across 3 frequencies in 12 subjects show a differences in effective connectivity among conditions.

Method

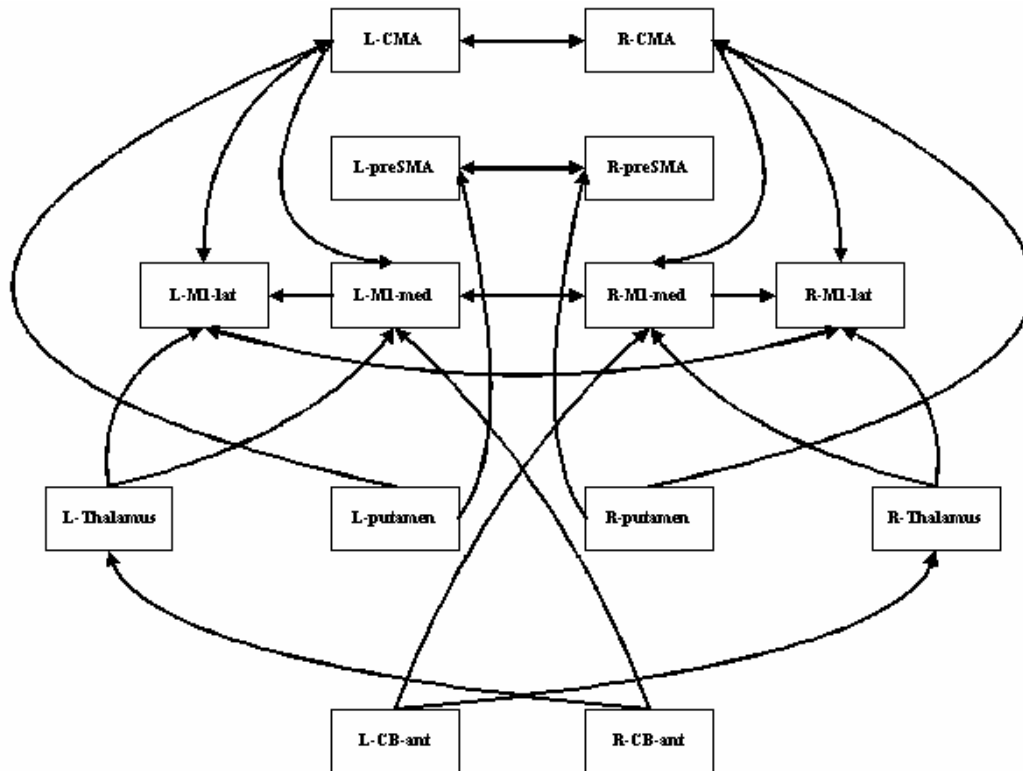
Subjects in this experiment performed visually-paced left and right finger movements at three frequencies (0.3 Hz, 1 Hz and 3Hz) during fMRI data acquisition. The details of the experimental design and data analysis were previously described in [3, 4].

An anatomical model including bilateral medial and lateral primary motor area (MI), supplementary motor area (SMA), cingulate motor area (CMA), putamen, thalamus and anterior cerebellum were used in this SEM. Connections among these areas are shown in Fig. 1. The covariance matrix among areas was computed after applying an isotropic smoothing kernel of 6mm.

A stacked-model approach was used to compare two conditions. Omnibus tests and tests for regional differences in effective connections were performed [1,2].

All calculations were done with LISREL (Scientific Software International, Inc.) using

maximum likelihood estimation.



RESULTS AND CONCLUSIONS

Pair-wise comparisons and corresponding p-values for each hand between two movement frequencies are listed in table 1. Using 0.05 as the threshold of statistical significance, the model shows statistical difference between two conditions. For analyses with specific areas, cerebellum is more involved in both hands high rate tapping (1 Hz and 3 Hz). This is consistent with the involvement of cerebellum during speeded repetitive tasks. The putamen is involved in all conditions except at left-hand 0.3 Hz tapping. The thalamus is more active during left hand activity, which implies the modulation of handedness on thalamus and the dissociation of thalamus for dexterity.

p-value	Left (0.3 Hz-1 Hz)	Left (1 Hz-3 Hz)	Left (0.3 Hz-3 Hz)	Right (0.3 Hz-1 Hz)	Right (1 Hz-3 Hz)	Right (0.3 Hz-3 Hz)
Omnibus	0.18757	0.00000	0.00000	0.00102	0.00027	0.00000
Cerebellum	0.55448	0.00000	0.08520	0.91728	0.59702	0.67895
Putamen	0.75047	0.01788	0.00956	0.00095	0.00896	0.00000
Thalamus	0.06108	0.01126	0.00871	0.20565	0.12339	0.08624

Table 1. P-values from the chi-square difference test in SEM.

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