The Degree of Bilateral Organization of the Motor Areas under Unimanual Motor Execution - a Correlation Analysis Approach Using Dynamic Monitoring of t-statistics

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Introduction

Higher motor areas, such as supplementary motor area (SMA) and pre-motor area (PMA), are involved in the regulation of spatially or temporary complex movement. These areas are bilaterally activated when complex movements are performed unimanually. Many movements in our dairy life consist of coordination of bimanual movement [1]. It was pointed out that activation of a general sensorimotor network is similar to the one observed during unilateral task performance [2], and there may be no specialized structure acting as coordination controller. Then, the neuronal basis of complex movements may depend on the same mechanism of bimanual movement even if the movements are performed unimanually. In this study, the extent of bilateral organization of the motor areas under unimanual movement was compared by using a sliding window analysis technique. Inter-hemisphere correlation of the brain activation in response to switching the side of motor execution was evaluated.

Material and Methods

Six subjects (4 males) who gave written informed consent participated in this study. The volunteers performed a finger movement task using a pair of turnkey system in response to the number displayed on an LCD panel. The session consisted of four conditions and three task and rest blocks were included in each condition (Fig.1). Simple movements of the index finger on the right (SR) or left (SL) were performed in response to the prompting number '2' in the first two conditions. In the third (CR) and fourth (CL) condition, the volunteer hit the key using the finger according to the number (1 ~ 5) randomly shown.

Functional data were obtained using a T2* weighted gradient recalled echo EPI sequence (TR = 3000 ms, TE = 30 ms, 30 axial slices, 4 mm thick, FOV = 22 cm) on a 3T MRI scanner (GE Signa VH/i3.0T). The image data were realigned and normalized into an MNI template by using SPM2 (UCL, London). The center coordinates of the ROIs for each motor area were determined by the reference activation maps. The time course of the t-value was extracted for each ROI (5x5x5 pixels) using a Matlab module employing the algorithm of sliding window analysis based on a general linear model (window width = 50 pts) [3, 4]. The correlation coefficient of the two dynamic curves on each side was obtained.

Results

Fig.1 shows the average time series of the t-statistics from the 6 subjects at the activation peak of the primary motor area (M1), SMA, PMA and superior parietal lobule (SPL). The extent of bilateral organization was categorized into four groups. **1)** The correlation between the dynamic curve on the right and that on the left side was highest in the SMA (MNI coordinate R[-2 -8 54]/L[8 -2 52], correlation coefficient = 0.98). **2)** In the PMA (R[-28 -10 64]/L[30 -10 62], 0.93) and Thalamus (R[-10 -22 4]/L[16 -22 8], 0.85), the correlation was also high, although the maximal peak in the time domain was weighted on the contralateral side of the complex motor execution. **3)** In the M1 (R[-34 -26 62]/L[34 -24 62], 0.24) and Cerebellum (R[22 -60 -20]/L[-16 -64 -20], 0.38), the activation on the contralateral side mostly increased during the complex motor execution, and the inter-hemisphere correlation was low. **4)** In the SPL (R[-28 -60 58]/L[30-62 62], 0.90), the response pattern indicated the dominance of the activity on the left side under complex movements (CR and CL).

Discussion

The conventional contrast method between task conditions reflects only the averaged difference of activation without any information of the transient change under each task condition. By using the dynamic analysis of the t-statistics, it was demonstrated that the degree of inter-hemisphere correlation of the activation was different among the motor areas. The high inter-hemisphere correlation of the dynamics in the SMA and PMA under unimanual motor execution may support that there is no distinction between the neuronal basis of unimanual complex movements and that of the bimanual movements. On the other hand, the dominance of the left SPL may reflect its conceptual role for coordination of complex movement.

It was suggested that inter-hemisphere comparison using dynamic analysis of the t-statistics might be useful to investigate the neuronal basis and dynamic entity of the bimanual functional network.

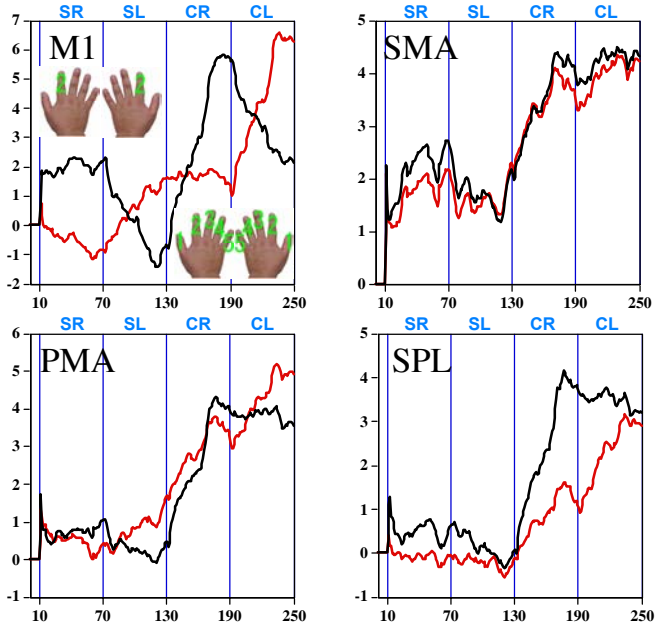

Fig.1

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