Movement trajectory is a determinant of use-dependent motor cortical plasticity

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Introduction

Little attention has been paid to an effect of limb position on recovery of motor function during rehabilitation therapy. Within the M1, a direction-like neuron that is active in association with movement trajectory in extrinsic space is largely represented [1]. However, little is known about change in motor cortical representation induced by an exercise with movement trajectory. The purpose of our study was to investigate whether or not movement trajectory is a determinant of motor cortical plasticity.

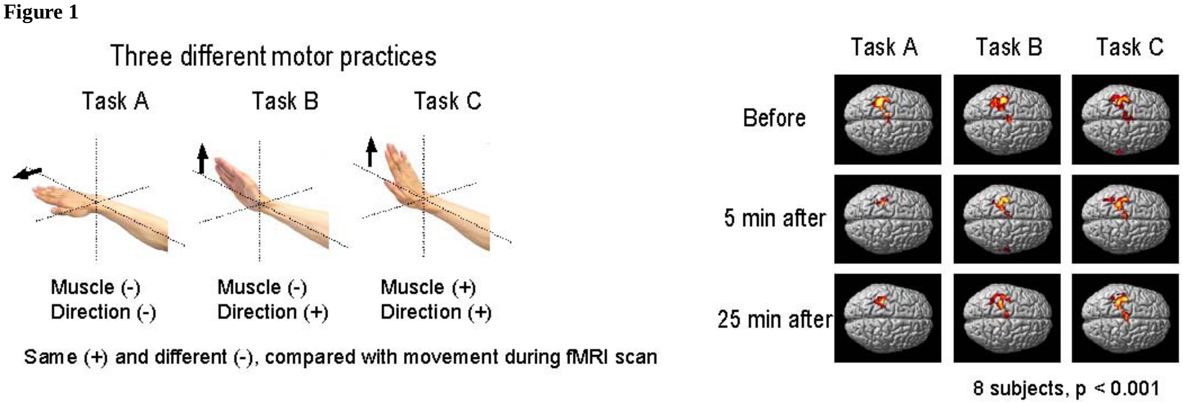
Methods

Eight healthy volunteers were investigated. Block-designed fMRI was conducted before, and at 5 min and 25 min after motor practice. For each scan (4 min 30 s), 30-s movement and 30-s rest periods were alternately performed beginning with the rest period (imaging parameters: TR=5000ms, TE=30ms, FA=90degree, FOV=22cm, slice thickness=3mm, gap=1mm, image matrix=64x64, 30 slices, 54 time points). To monitor subject's performance, electromyogram was recorded from the right forearm muscles. During each fMRI scan, the subjects performed the right wrist extension in a horizontal plane, guided by visual pacing at 1 Hz. Three different practice conditions (1 Hz rate, 10 min period) were employed (Figure 1, left): (1) Task A: radial deviation of the right wrist in a horizontal plane, (2) Task B: radial deviation of the right wrist in a vertical plane, and (3) Task C: extension of the right wrist in a horizontal plane in the same way as the movement during fMRI scan. Each condition was scanned on the different day for the same subject. Image analysis was performed on SPM99. After analyzing each subject data, multi-subject analysis was conducted with random effect model; the activation map for each task group was created ($p < 0.001$, uncorrected), and then each task group was contrasted ($p < 0.005$, uncorrected).

Results

Group data obtained by random effect analysis showed that activation in the M1 was greater for Task B and Task C than for Task A at both 5 min and 25 min after practice (Figure 1, right); the augmented activation was observed exclusively in the M1 including Brodmann's area 4 and 6. Although Task C showed an increased tendency of the M1 activation compared with Task B, no statistically significant difference was observed between the two tasks at both 5 min and 25 min after practice.

Figure 1



Discussion

Short time practice initially results in smaller activation (habituation/selection of optimal neural routine) in the M1, but later in larger activation (enhancement) [2, 3]. Compared with movement during fMRI scans, Task B involved the same movement direction but different forearm muscles. Movement in Task A was different from movement during fMRI scans in both movement direction and involved muscles. Although Task A and Task B were same in terms of movement direction relative to the wrist joint, the activation in the M1was larger for Task B than for Task A. Thus, movement trajectory/direction in extrinsic space is likely one of important determinants for motor cortical plasticity, probably because substantial populations of direction-like neurons are represented within the M1 [1]. Practice with movement direction in extrinsic space seems a useful approach to recover motor function in brain-damaged patients.

References

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