Plastic change of motor cortex induced by transcutaneous electric nerve stimulation


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Synopsis
To investigate if motor cortical representation shows plastic change after short-term somatosensory stimulation, the brain activation during the right thumb movement was compared before and after transcutaneous electric nerve stimulation (TENS) by using fMRI. The activation in the primary motor area (M1) decreased after the intervention with TENS. This reduction lasted for 30 min. The fact that the same motor outputs were achieved by the activation of smaller volume in the M1 suggested that the M1 works more efficiently after peripheral somatosensory stimulation. Short-term somatosensory stimulation may be useful to rehabilitate motor-disabled patients after brain damages.

Introduction
Because motor cortex has a tight anatomical connection with somatosensory cortex, it is postulated that modification of the somatosensory system may alter the motor cortical excitability via this linkage. If this assumption is true, stimulation of peripheral sensory nerves may help to restore motor function of the patients after the damage of central nervous system. To investigate if motor cortical maps plastically change by short-term somatosensory stimulation.

Methods

Subjects: Eleven right-handed healthy volunteers (three females, eight males), who gave written informed consent.

Tasks: TENS was provided at the thenar area of the right hand with sub-motor threshold for 15 min. The subjects performed repetitive right thumb opposition at the rate of 2 Hz. Brain activation was investigated before and after TENS (TENS task): (1) before TENS, (2) 0 min after TENS, (3) 15 min after TENS and (4) 30 min after TENS. To consider the possibility that use-dependent adaptation could occur in the motor areas, the same set of fMRI sessions without TENS was recorded as a control experiment (No-TENS task).

Data acquisition: Functional (TR 2000ms, TE 30ms, FA 90deg, matrix 64x64, FOV 240mm, slice thickness 5mm, gap 1mm, 20 axial slices) and 3-D anatomic MRI of the whole brain was acquired (GE, Signa VH/i 3.0T). The gradient-recalled EPI technique was used for the fMRI acquisition.

Data analysis: The fMRI data were analyzed with SPM99. After preprocessing (realignment, normalization and spatial smoothing) of data, a box-car function convolved with hemodynamic response function was used as a reference function. The voxels showing high correlation between measured data and the reference function were detected. A group analysis was done using random effect model [1]. In addition, tactile sensory loss due to TENS was assessed by von Frey hair test, and change of cortical sensation was evaluated by two-points discrimination test.

Results
In the TENS task, the activated volume in the primary motor cortex (M1) decreased from immediately after somatosensory stimulation (Fig. 1). This reduction lasted for 30 min after TENS. Medial frontocentral cortex (MFC) including the supplementary motor area showed similar tendency across the four sessions in the TENS task, but it was not so obvious as in the M1. As for the No-TENS task, the volume of cortical activation was consistent for the sessions of before, 0 min and 15 min. At the session of 30 min, however, the activation suddenly dropped off in the M1 as well as MFC. Both of the sensory assessments, i.e., von Frey hair and two-points discrimination tests did not show significant difference between the TENS and No-TENS task.

Discussion
The results showed that short-term somatosensory stimulation plastically changes motor cortical representation in the different way from the use-dependent plasticity [2,3,4]. The same motor outputs were achieved by the activation of smaller volume of the M1, suggesting that motor cortex works more efficiently after somatosensory stimulation. Short-term somatosensory stimulation may be useful to rehabilitate motor-disabled patients after brain damages [5].

References

Figure 1.
Cortical activation after somatosensory stimulation (TENS task) and without stimulation (No-TENS task)