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Reorganization of Motor Network by Dual-mode Noninvasive Brain Stimulation in Stroke Patients

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Objective

Noninvasive brain stimulation (NBS) using repetitive transcranial magnetic stimulation (rTMS) or transcranial direct current stimulation (tDCS) has recently been adopted for modulating motor function in stroke patients. We investigated the effect of simultaneous dual-mode stimulation using rTMS and tDCS over the bilateral primary motor cortices (M1) to assess its efficacy as compared to single stimulation using rTMS for the recovery of motor function in subacute stroke patients.

Materials and Methods

Twenty-four patients participated; 12 participants were assigned to the dual-mode stimulation group (DSG, 8 males, 56.0±13.4 years) while the other 12 participants were assigned to the single stimulation group (SSG, 9 males, 54.8±15.5 years). We assessed each patient's motor function using the Fugl-Meyer Assessment (FMA) score and acquired their resting-state fMRI data at two times: prior to stimulation and 2 months after stimulation. Healthy subjects participated as an age-matched healthy control group (8 males and 4 females, age 56.1±14.3 years). To investigate the altered connectivity, M1 intrahemispheric and interhemispheric connectivity, and graph measures were used. The alterations in the motor network connectivity were analyzed using MATLAB (Mathworks, Inc.). The repeated measures ANOVA was applied to determine whether there are any significant differences between single and dual-mode stimulations.

Results

There were significant differences in motor network connectivity between groups. The strength of interhemispheric connectivity of the contralesional M1 was drastically increased in the DSG compared to the SSG. Interhemispheric connections significantly increased in the DSG and the change showed a noticeable increase compared that to the SSG (Figure 1). The values of network efficiency in motor networks of the DSG increased post-stimulation. Moreover, the increase of the network efficiency in the DSG was remarkable compared to that of the SSG (Figure 2).

Conclusions

Our results could demonstrate a different change of motor network connectivity induced by dual-mode or single stimulation in subacute stroke patients. The interhemispheric connectivity and network efficiency, which are the important indicators of function in the brain network of stroke patients, were significantly increased in the dual-mode compared to the single stimulation group. This evidence may provide insight into multi-site stimulation strategies for enhancing the effects of conventional single site NBS method for neurorehabilitation of stroke patients.

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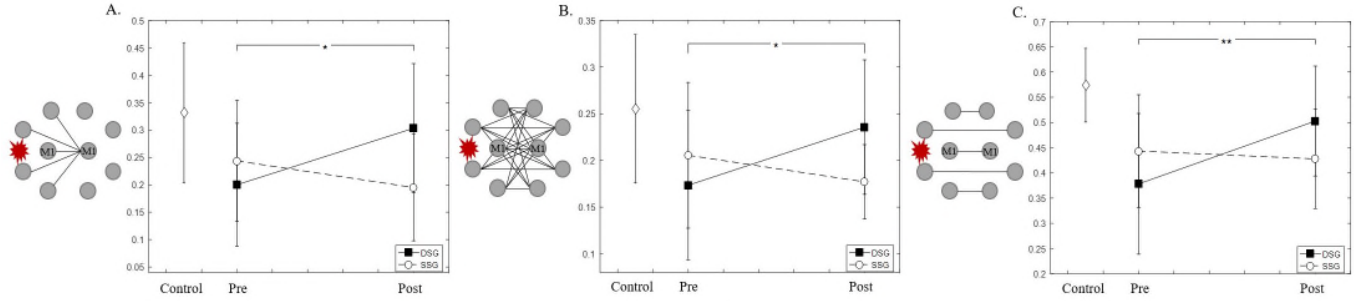

Figure 1. Altered connectivity caused by stimulation. A is the average strength of the interhemispheric connectivity of contralesional M1. B and C are the average strength of the overall interhemispheric connectivity and interhemispheric connectivity of the homotopic regions. Interhemispheric connectivity of the contralesional M1 and, overall interhemispheric connectivity was significantly increased in the DSG compared to the SSG post-stimulation (* p<0.05; ** p<0.01, respectively).

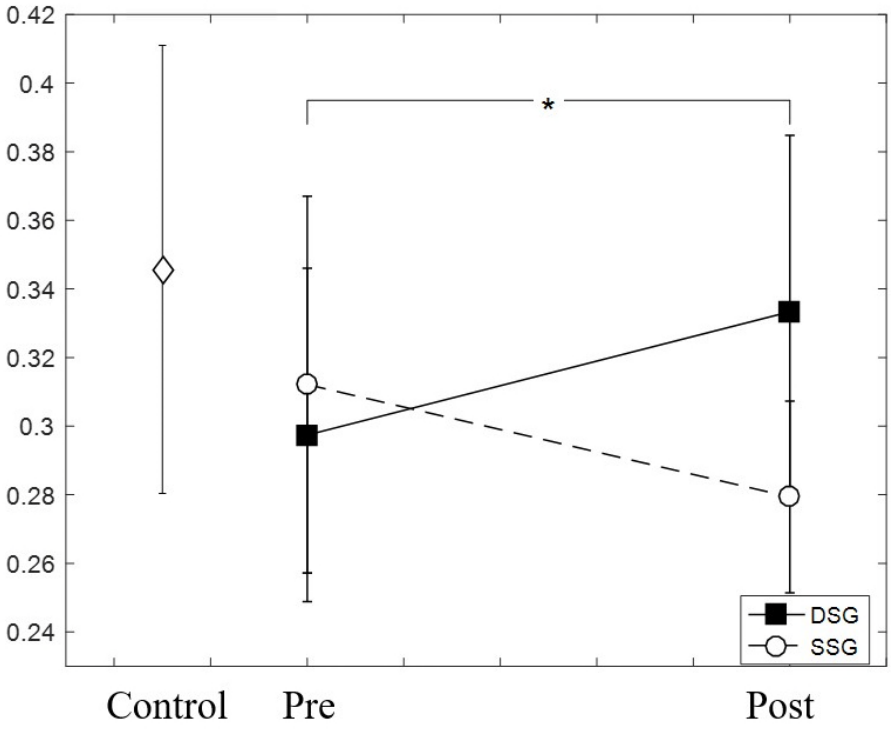

Figure 2. Changes in network efficiencies caused by stimulation. The network efficiency were significantly increased in the DSG compared to the SSG post-stimulation (* p<0.05).