Interaction Between Mirror Visual Feedback and Goal-Directed Task Shows Increased Cortical Excitability in Untrained Hemisphere; Possible Stroke Rehabilitation Applications

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Introduction: Stroke is the leading cause of long term disability in the US, and about 80% of all stroke survivors are affected by weakness or the inability to move one side of the body, known as hemiparesis.1 Current therapy techniques require repetitive movements by the affected limb. This limits rehabilitation options for severely hemiparetic patients who are unable to participate in these activities. Mirror therapy involves use of a mirror to give patients the visual illusion that movements performed with the unimpaired hand are being executed with the impaired hand. Emerging evidence shows that mirror therapy can activate regions of the brain involved in volitional control of the affected limb known to be important to recovery2. It is important to consider what training task should be performed during mirror therapy to optimize therapeutic effects. Previous research has shown that goal-directed movements result in increased bilateral activity compared to free movements3. Thus, the purpose of this study is to explore how training with mirror visual feedback (MVF) and goal-directed movements affects the excitability and functional ability of the untrained side.

Materials and Methods: Six right handed healthy subjects (3 females; mean age 28±8 years) performed 4 blocks (2 minutes/block) of right handed index-finger flexion movements at a rate of 0.25 Hz in a virtual environment. These movements mainly actuate the first dorsal interossoseus (FDI) muscle. Each subject completed four experimental protocols in separate sessions: veridical feedback with goal-directed movements (VG); veridical feedback with free movements (VF); MVF with goal-directed movements (MG); and MVF with free movements (MF). MG and VG required flexion to three different targets (20º, 40º, 60º) while MF and VF required non-targeted flexion movements. Transcranial magnetic stimulation (TMS) (Magstim Rapid2, 70mm double coil, 110% resting motor threshold) was used to collect motor evoked potentials (MEPs) (Delsys, Trigno) from the untrained FDI to track cortical excitability in untrained motor cortex prior to training and following each block. A behavioral test of the goal-directed task with visual feedback removed was conducted before and after each protocol to gauge changes in functional ability. Average MEP amplitudes were analyzed using a multifactorial repeated measures ANOVA using within subjects factors of visual feedback condition (4 levels, MG, MF, VG, VF) and length of training (5 levels, Pre, Post2, Post4, Post6, Post8). Functional ability was measured by calculating magnitude of absolute error between the target angle and the movement angle, which was then averaged across subjects and condition.

Results and Discussion: Cortical excitability in the untrained hemisphere increased throughout MG, fell during VF, and remained relatively constant during VG and MF protocols (Fig 1). There was no significant effect of visual feedback condition (p=0.196) or length of training (p=0.065), however, there was a significant interaction between main effects (p=0.002). Post-hoc one-way ANOVAs revealed a significant effect of length of training for the VF (p=0.027) and MG (p=0.027) conditions, and a significant effect of visual feedback condition at the POST6 (p=0.033) and POST8 (p=0.022) time points. Paired t-test with Bonferroni correction for multiple comparisons revealed no specific differences for significant effects in post-hoc tests. Regarding functional ability, while there were no statistically significant differences, there was a greater decrease in error of the untrained hand following the MG condition.

Conclusions: The combination of MVF and goal directed movements produced increased excitability in the untrained hemisphere that was not found in other conditions. The decrease in movement error of the untrained hand following the MG protocol points toward some occurrence of transfer between the trained and untrained sides. Future studies will further investigate neurophysiological correlates of mirror therapy induced interhemispheric transfer of motor skill as a potential therapy for stroke.

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