Enhancing Sensorimotor Activity of Stroke Patients by Controlling Virtual Objects with Gaze

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INTRODUCTION: Motor deficits are one of the main negative consequences of brain damage. Complications that affect the upper limbs are among the most disabling [(1)]. Most treatments consist of physical therapy, which requires the preservation of certain motor skills in the affected limbs [(2,3)]. However, these capacities may be very limited or even not present, especially in the early stages of the injury. For this reason, many times other types of approaches are required to help to recover functions without resorting to limb movements [(4)]. In addition, activating the sensorimotor cortex benefits the recovery of functions in motor deficits [(4,5)] This way, increasing brain activity is essential for the recovery of motor functions [(6,7)].

In a previous neuroimaging study [(8)] we have shown that the control of virtual elements with the eye enhances brain activity in sensory and motor brain regions of healthy volunteers. This finding can be useful for the field of the neurorehabilitation as a new approach to generate activation of the sensorimotor system and support the recovery of the motor functions of motor patients. In the present research we continue evaluating this approach, this time in clinical populations. Our aim is to explore the brain activity of stroke patients who manipulated a virtual object by using their gaze. On the basis of our previous works[(8,9)], we expect to find activations in sensorimotor brain regions associated with eye control of virtual objects.

METHODS: We registered brain activity of three subacute stroke patients (mean age = 65; SD = 8.1; one female) using fMRI. Inside the MRI scanner, the participants were engaged in a continuous tracking of a target moving horizontally in a sine–cosine waveform [(10)]. To do this, they controlled a circle with the eyes by using an MRI-compatible eye-tracking system. Visual stimuli were given via MRI-compatible eyeglasses. The experiment consisted of two conditions: *movement* (tracking blocks) and *fixation* (focus the gaze on a gray cross on a black screen; this is a basal condition). The fMRI run consisted of 10 tracking blocks of 20 s, separated by 20 s fixation blocks. Axially oriented functional images were obtained by a 3T Signa HD General Electric MRI scanner. High resolution sagittally oriented anatomical images were also collected for anatomical reference. fMRI data processing was done using SPM12 (www.fil.ion.ucl.ac.uk/spm/). A block design in the context of a general linear model was used to look for differences in neural activity during the *movement* and the *fixation* conditions. Statistical maps were set at a voxel-level threshold of $p<0.05$, FDR corrected, $k = 5$.

RESULTS: Individual results of the patients revealed extended bilateral activations during the *movement* condition in cortical and noncortical regions typically involved in visuomotor tasks (8,10), including the supplementary motor area, the premotor cortex, the basal ganglia, and the cerebellum.

DISCUSSION: As expected, the execution of the eye-controlled tracking task was associated with extended activations in sensorimotor regions, what is consistent with previous experiments based on eye-controlled tasks and healthy volunteers (8,10,11). The effects of training on eye control of virtual objects can be studied in future research using behavioral and neural measures before and after a training period. To the best of our knowledge, this is the first work in clinical populations studying brain activity related to the eye control of virtual elements. The present results may be of interest in neurorehabilitation to activate the motor systems and help in the recovery of motor functions in stroke patients without resorting to limb movements, which is not always possible because of limitations in the affected limbs.

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