Training on an eye-controlled game: a functional neuroimaging pilot study

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ABSTRACT

This functional MRI work investigates changes in brain activity related to the practice on eye control of virtual objects. One female participant was trained for two weeks in an eye-controlled version of the Matching Pairs (Memory) card game. After the training period, increases of activity were observed in the supplementary motor area, a region involved in different aspects of motor learning. These results have a potential application as a new game-based neurorehabilitation approach to enhance motor activity without resorting to limb movements.

1. INTRODUCTION

We have shown that the control of virtual elements with the eye enhances brain activity in sensory and motor brain regions (Modroño et al., 2015). Here we continue evaluating this neurorehabilitation approach by using an eye controlled version of the *Matching Pairs* (or *Memory*) game during a training period. On the basis of our previous works (Gebert et al., 2017), we expect to find activations in sensorimotor brain regions after such a training period.

2. METHODS

We included data of a neurologically healthy right-handed female (age = 24). The training task was a version of the *Memory* card game (Silva da Cunha et al, 2016). The participant had to match pairs of cards by moving a virtual cursor with the eyes (via eye tracking). She practiced this task 20 minutes per day during two weeks. One day before and one day after the training period, we registered her brain activity using fMRI; meanwhile she was engaged in an eye-controlled continuous tracking of a target (Figure 1) (Jones, 2015). The experiment consisted of two conditions: *movement* (tracking blocks) and *fixation* (focus the gaze on a gray cross: a basal condition). fMRI data processing was done using SPM12. Four conditions (*fix-Day1, movement-Day1, fix-Day2, movement-Day2*) were modelled. Motor performance was estimated using the mean absolute error.

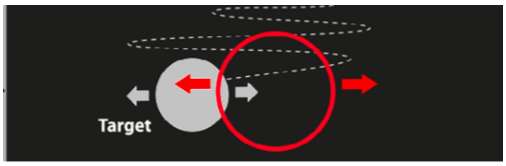

Figure 1. Continuous tracking task performed with the eyes during fMRI (pre and post-test).

3. RESULTS

Figure 2A shows the results of two contrasts: *movement-Day1 > fix-Day1* (red voxels) and *movement-Day2 > fix-Day2* (yellow voxels). Both contrasts show activations in the sensorimotor system, including the supplementary motor area (SMA), the premotor cortex, parietal regions, basal ganglia and cerebellum. Activations of the second day are similar but more extended than those observed for the first day. Figure 2B shows the direct comparison between the movement conditions of the two days (*movement-Day2 > movement-Day1*). This contrast revealed activations in the SMA. Furthermore, the subject improved her performance by 15% during the second day.

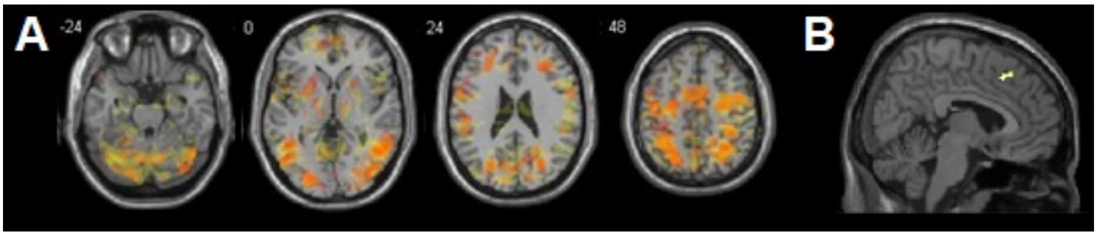

Figure 2. A: Sensorimotor activations during pre (red voxels) and post-test (yellow voxels). B: Yellow voxels: increases of activity in the supplementary motor area after the training period (*movement-Day2 > movement-Day1*). p<0.001 (unc.), minimum cluster size = 15 voxels.

4. DISCUSSION

The execution of the eye controlled continuous tracking task was associated to extended activations in sensorimotor regions, what is consistent with a previous motor control experiment based on a different eye-controlled task (Modroño, 2015). Furthermore, results show an increase of activity after the training period in the SMA, associated to a better performance. In this way, our experiment extends our previous results (Gebert et al., 2017) to the scope of motor transfer (Censor, 2013), that is, the application of a learned skill in a different context or task. Because this is a preliminary study without a control condition, it could be argued that the activation in the SMA may reflect a factor other than training. However, this region consistently underlies motor learning (Hardwick et al.,2013) thus it seems reasonable to think that transfer of motor learning plays a fundamental role in the activation found. In the context of our previous studies (Modroño et al.,2015; Gebert et al., 2017; Modroño et al., 2020) we conclude that the training on eye control of virtual objects can induce neural changes in sensorimotor regions, what could be used as a new game-based neurorehabilitation approach.

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