Real-time BOLD functional MRI neuro-feedback: connectivity changes observed in an imagery task

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INTRODUCTION: In the last few years, real time fMRI has been used as a neuro-feedback tool [1-2]. This method allows monitoring, in real time, of a subject's brain activity from a region of interest. Information about this activity is fed back to the subject. The goal of the technique is to help subjects modulate the activity in the target region. However, the physiology of neuro-feedback reminds unclear. Our *hypothesis is that the presence of the feedback alters the connectivity between brain regions*, *and that these changes will persist in a subsequent non-feedback session if learned.*

METHODS: Nine subjects were scanned on a 3T GE after giving informed consent. Participants were asked to either perform a finger-tapping task (MOVE) or imagine they were moving their right hand fingers (IMAGERY); the tasks were performed in seven runs of five 20s task and six 20s rest block each. There were two MOVE runs, one to set the ROI (GO=without feedback), and the other to introduce the feedback (FBK) modality. There were five IMAGERY runs: one GO to use as baseline; three FBK; one GO used as transference (TRANSFER).

Data processing was performed using AFNI. After pre-processing, the last 15s of each task period were selected and concatenated for further connectivity analysis. Seed region was set in the motor cortex, the same region shown to the subject in the neuro-feedback task. We computed: 1) connectivity maps for each run; 2) paired t-test between IMAGERY GO vs TRANSFER to measure the effectiveness of the neuro-feedback; and 3) ANOVA to measure interactions.

RESULTS: 1) Connectivity during Imagery GO showed overall less connectivity to the seed than during finger tapping (MOVE) in the pre and post central gyrus and supplementary motor areas ($p<0.05$, cluster size 500). The presence of FBK during the imagery task made the correlations similar to the MOVE condition (see fig 1). 2) Connectivity of the motor cortex was significantly different between GO and TRANSFER even though the experimental task was the same, suggesting subjects have learned to modulate brain activity during the FBK runs, and the learning was maintained when feedback was not shown. The main differences were seen in anterior cingulate cortex (GO > TRANSFER) and post central gyrus (TRANSFER > GO) (fig 2). 3) Interactions between the different conditions were significant ($p<0.001$, cluster 200) in the supplementary motor area, left post central gyrus and at the left rolandic operculum/ insular cortex (fig 3).

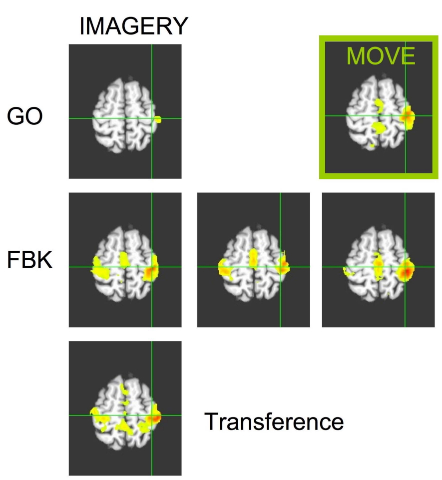


Figure 1: Connectivity maps for each task. P<0.001, cluster 200

Figure 2: t-test of connectivity for GO vs Transfer; Imagery task. P<0.01 cluster 200.

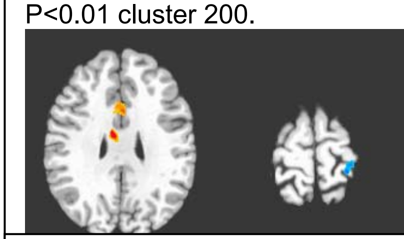
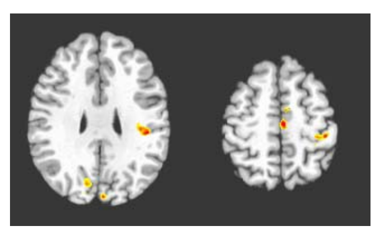


Figure 3:
Task x Method Interaction.
P<0.001 cluster 200.



DISCUSSION: Neuro-feedback increased the connectivity between nodes of the motor system, and these changes had a lasting effect that allowed subjects to maintain the learned connectivity pattern during the transference run, which was performed without the presence of neuro-feedback. These results confirm that changes in connectivity occur due to neuro-feedback training, and suggest this technique can be used in clinical settings.

REFERENCES: [1] Yoo , Neuroreport, 13 (2002), pp. 1377-81. [2] R. C. deCharmsNeuroimage, 21 (2004), pp. 436-43