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Long-term effect on EEG sensorimotor responsiveness to motor imagery after a BCI training for stroke rehabilitation

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Introduction: Previous studies demonstrated the efficacy of EEG-Brain-Computer Interfaces based on Motor Imagery (MI-BCI) in post-stroke functional motor recovery of upper limbs [1]; however, the maintenance of such effects in the long-term is still partially unexplored. Here we tackled this long-term aspect of MI-BCI induced positive effects on rehabilitation outcomes by analyzing an EEG dataset acquired from subacute stroke patients recruited in the longitudinal Randomized Controlled Trial reported in [2]. The oscillatory activity in the EEG beta band known as related to MI tasks within BCI contexts [1], [3], was studied at different time points in two groups of participants one performing MI practice with BCI assistance (BCI group) while the other performing MI training alone (CTRLgroup).

Material, Methods and Results: EEG data of 17 patients (8/9, BCI/CTRL), performing MI of grasping and finger extension with their affected hand (same tasks employed in the intervention training), were analyzed. The 61 EEG channels were 1-45 Hz bandpass filtered. After artifacts rejection data were segmented in task (N=20±1) vs rest (N=20±1) 4s-trials. Then the Common Average Reference was applied. Power spectral density (PSD) was computed following Welch's method with a 0.3 Hz resolution and 1s Hamming window. Averaged beta PSD in task vs rest condition was compared between participants, in both groups separately, with a 2 tailed-paired t-test pre- (T0) and post-training (T1) and after 1, 3 and 6 months (T2, T3 and T4). The t-values obtained are plotted in Figure 1. In the BCI group at T1, the activation focuses on sensorimotor channels bilaterally with a greater involvement of the healthy hemisphere which wanes from T2 to T4 maintaining a more physiological topography with a balance between the hemispheres. In the CTRL group, a diffuse activation is visible with no apparent temporal evolution. As expected, both groups improved upper limb motor function as assessed by Fugl-Meyer Assessment (FMA) (tab.1).

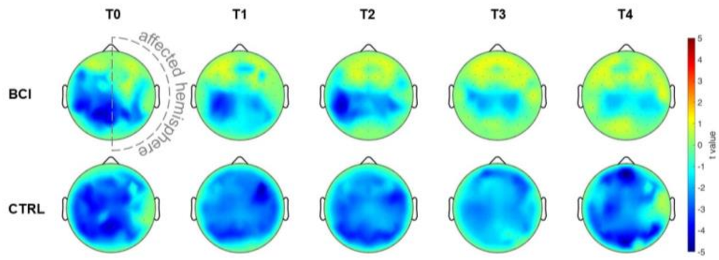

Table 1 *Average (±Standard Error) of the Fugl-Meyer Assessment (FMA) before (T0) and after (T1) the treatment for BCI/CTRL groups.*

	FMA(T0)	FMA(T1)
BCI	14.8 ± 5.9	27.4± 6.9
CTRL	19.4 ± 4.7	32.6± 7.8

Figure 1. *t-values distributions obtained from the comparison in the beta band of task and rest conditions at timepoints T0, T1, T2, T3, T4 for the BCI group (first row) and for the CTRL group (second row). The affected hemisphere is the right one for all as the channels flipping was applied for those patients with left affected hemisphere. Data of grasping and finger extension imagination were pooled.*

Discussion: Our results suggest that MI-BCI modifies EEG reactivity to the MI task. We impute this modification to the effect of MI training in a closed-loop, which results in a more uniform behavior among patients in the BCI group.

Significance: This preliminary study reveals long-term effects of MI-BCI on sensorimotor EEG reactivity. Furthermore, the rebalancing of activity between the hemispheres suggests brain plasticity changes whose relationship with functional recovery will be investigated in future studies.

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