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Lateralization patterns for movement execution and imagination investigated with concurrent EEG-fMRI and EEG-fNIRS

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Introduction: According to the neural simulation of action theory, movement execution (ME) and imagination (MI) of the same movement are different stages on a continuum and are therefore based on similar neuronal networks [1]. MI may facilitate experience-driven cortical reorganization and functional restoration, even in the absence of residual voluntary limb movement. Moreover, it has been shown that neurofeedback enhances task-specific activity and MI learning. Despite the clinical importance, it remains not known which neuroimaging technique adequately captures cortical lateralization induced by ME and MI, the latter being the basis for most MI neurofeedback applications. The present investigation therefore compared ME and MI induced lateralization using concurrent EEG-fMRI and concurrent EEG-fNIRS recordings.

Methods: Two datasets were analyzed. In both experiments MI naïve young healthy adults performed one block of ME and three blocks of MI. The first experiment (N = 22, mean age: 23.9 years) comprised two sessions, one simultaneous EEG-fMRI and one EEG session. As ME execution corrupted the EEG signal obtained inside the fMRI scanner beyond recovery, only the ME EEG data obtained outside the scanner were considered. This was justified because, as reported previously, the MI induced ERD of offline corrected EEG data and EEG data obtained outside the MRI scanner were significantly correlated [2]. The second experiment (N = 19, mean age: 24.4 years) comprised one session of simultaneous EEG-fNIRS. For each experiment and imaging modality separate repeated measures 2 x 2 ANOVAs with the factors condition (execution, MI) and lateralization (contralateral, ipsilateral) were performed, and in case of significant interaction followed up with t-test.

Results: fMRI BOLD activity was more lateralized during ME than during MI (Fig. 1A, $F_{1,21} = 166.35$, $p < .001$, $\eta^2 = .89$). Descriptively, this pattern is confirmed by both fNIRS measures, oxygenated (HbO) and deoxygenated (HbR) hemoglobin concentration changes, but only for HbO was the effect of lateralization significant (HbO: Fig. 1B, $F_{1,18} = 9.77$, $p = .006$, $\eta^2 = .35$; HbR: Fig. 1C, $F_{1,18} = 2.92$, $p = .1$, $\eta^2 = .14$). In contrast, electrophysiological activity, specifically 8 to 30 Hz band power, was found to be more lateralized during MI than during ME in both datasets (Exp 1: Fig. 1D, $F_{1,21} = 9.46$, $p = .006$, $\eta^2 = .31$; Exp 2: Fig. 1E, $F_{1,18} = 7.82$, $p = .012$, $\eta^2 = .30$).

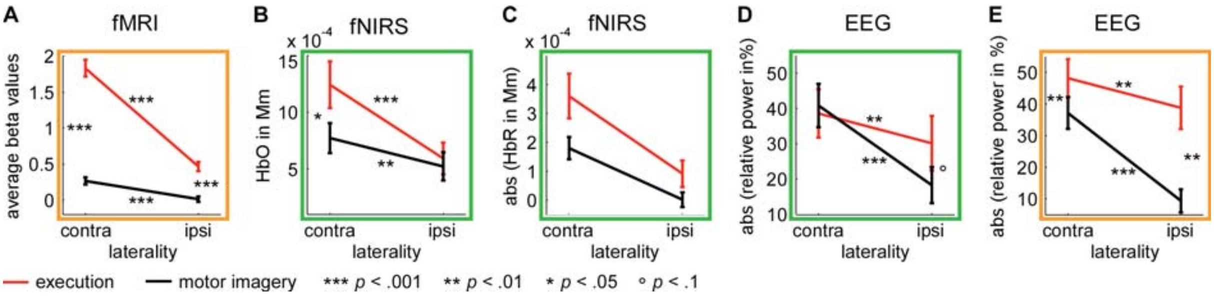

Figure 1. *Interactions of task (ME, MI) and lateralization (contralateral, ipsilateral) for fMRI (A), fNIRS (B, C) and EEG data (D, E). Data from experiment 1 and 2 are respectively highlighted in orange and green.*

Discussion: Both studies revealed a clear consistent dissociation between hemodynamic and electrophysiological signatures regarding ME and MI induced cortical lateralization. Future work investigating this dissociation on EEG source level seems important to better understand the patterns of cortical activation induced by MI supported by neurofeedback. This would help to advance MI neurofeedback applications towards use in motor recovery after stroke.

References

[1] M. Jeannerod, “Neural simulation of action: a unifying mechanism for motor cognition.,” *Neuroimage*, vol. 14, pp. 103–9, Jul. 2001.
[2] C. Zich, S. Debener, C. Kranczioch, M. G. Bleichner, I. Gutberlet, and M. De Vos, “Real-time EEG feedback during simultaneous EEG-fMRI identifies the cortical signature of motor imagery,” *Neuroimage*, 2015.