 DOI: 10.3217/978-3-85125-962-9-68

Tackling Motor Imagery Based BCI Illiteracy through a Novel Augmented Reality Paradigm

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Introduction: Motor imagery (MI) - the mental rehearsal of movement without motor output - is widely used as a control strategy for Brain-Computer Interface (BCI) because it elicits similar neural responses as real movement, while it is low cost, non-invasive and safe [1]. However, 15-30% of MI-based BCIs users are 'BCI illiterates': they are not able to control the system [2]. To overcome this, we propose a paradigm combining MI with action observation (AO) -deliberate and structured movement observation- supported by augmented reality (AR), to explore its effects on motor-related brain responses that could potentially enhance MI-based BCI paradigms.

Material, Methods and Results: Twenty-five healthy participants performed a reaching task - either imagined (Motor Imagery-MI) or real (Movement Execution-ME) - with the right arm using a touch panel (Fig. 1A). The task was repeated with (REAL CONDITION) and without AR (AUGMENTED CONDITION) in a randomized order, the former showing a virtual right arm in order to provide an AO cue. We analyzed electrophysiological (EEG) signals by computing event-related desynchronization (ERD) in the alpha and beta band during movement execution/imagination, with a baseline of 500 ms before movement onset.

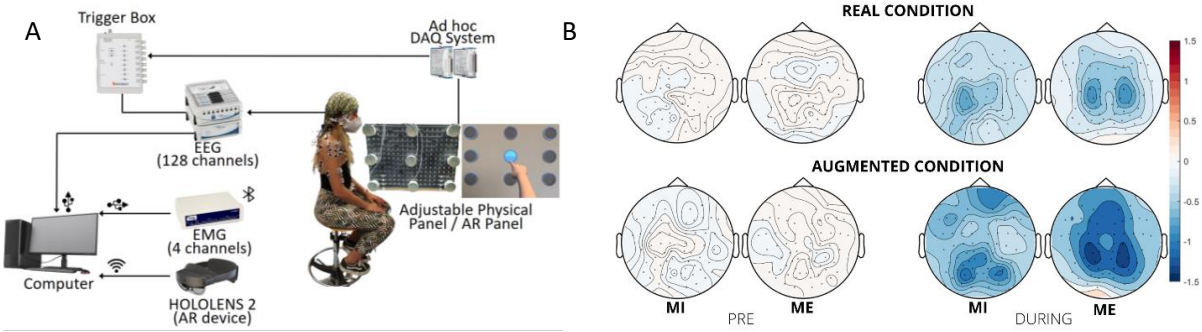

Figure 1. *a) Experimental setup. b) Topographical map showing ERD (dB) from Motor Imagery (MI) and Motor Execution (ME) before (PRE) and during (DURING) motor imagination/execution in physical and augmented condition.*

We found no significant difference between MI and ME groups in terms of ERD power (one-way ANOVA, $p<0.05$). Moreover, we observed that AR produced movement-related ERD power in specific brain areas (such as in parietal, frontal and central regions), comparable to pure motor execution brain activity (Fig 1B).

Discussion & significance: Our results support previous research suggesting that simultaneous usage of first-person perspective AO (through AR) and MI act in an additive manner over several brain areas [3]. Our main finding is that our novel MI paradigm elicits an ERD response that is comparable to movement execution, [4]. This suggests that the implementation of auxiliary tools/techniques like AR -that facilitates MI by enhancing sensory cues- could drastically improve MI-based BCI training and usability by eliciting stronger brain responses that can be more easily detected and classified by the BCI system. This strategy might boost the application of BCIs in neurorehabilitation and the interaction between human motor control and assistive technologies.

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