Cortico-Muscular Coupling to control a hybrid Brain-Computer Interface for upper limb motor rehabilitation

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Introduction: Hybrid Brain-Computer Interfaces (hBCIs) for upper limb motor rehabilitation after stroke pursue the reinforcement of "more normal" brain and muscular activity. Cortico-muscular coherence (CMC) has been proved to capture motor abnormalities after stroke [1] and thus potentially be employed as a hybrid BCI feature in this context. Here we optimized the translation of CMC computation and CMC-based movement detection from offline to online.

Material, Methods and Results: EEG (61 electrodes) and EMG (8 sensors per upper limb) signals were acquired from 13 healthy subjects (HS) and 12 stroke patients during finger extension (Ext) and grasping (Grasp) performed with both hands, separately [2]. A pseudo-online analysis was performed on HS to identify the best parameters, to be set for real-time CMC computation, which allow the best trade-off between accuracy and speed in CMC-based movement detection. 4 out of the 13 enrolled HS were called back to execute an online session, in which CMC features were computed in real-time according to the best parameters identified in the previous analysis [2] and used to detect movements (Fig 1A). Overall, movements were always detected (hit rate=100%) with a delay of 480ms ± 0.04 (mean ± standard error) with respect to EMG onset. The feasibility of CMC-based movement detection was then pseudo-online tested on stroke patients. Hit rate was around 90% for Ext executed with both affected (AH) and unaffected (UH) hands, whereas it is reduced to 80% during Grasp with affected hand (Fig. 1B). Mean delay was around 580ms for both movements executed with both hands (Fig. 1C).

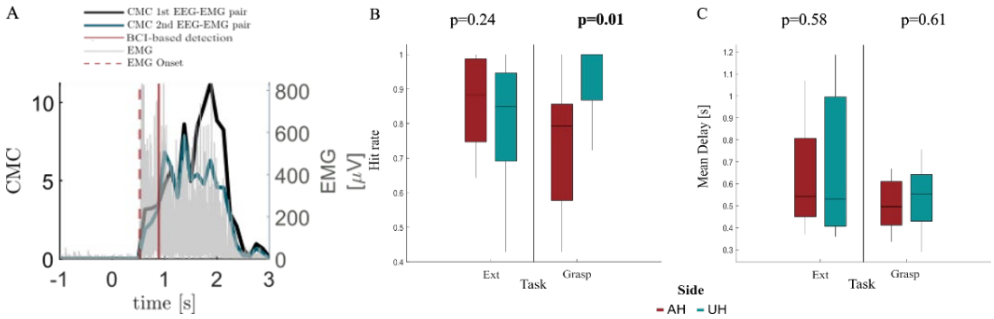

***Figure 1**. A) CMC and EMG trends in 1 healthy subject during an online movement repetition. Dashed vertical line represents movement onset detected offline from EMG (EMG onset), whereas continuous vertical line stays for the time the CMC-based BCI detected the movement in real-time. B-C) Distribution (boxplots) of pseudo-online classification performances in 12 stroke participants: hit rate (B) and a MD (C). Similar results were obtained for AH and UH in Ext whereas hit rate resulted to be lower in AH than UH for Grasp (paired t-test, α=0.05).*

Discussion: This study indicated the feasibility of CMC in detecting movements attempted by a population of stroke subjects in an accurate and timely manner. Online testing on such population is ongoing.

Significance: The results obtained will ground the design of a novel hBCI in which the control feature is derived from a combined EEG and EMG connectivity pattern estimated during upper limb movement attempts.

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References

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