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Using congruent activity from primary motor cortex and the cognitive attention network to improve the specificity of the BCI control signal.

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Introduction: Both primary hand motor cortex (M1) and dorsalateral prefrontal cortex (DLPFC) have been proven to allow for robust BCI control using electrocorticographic (ECoG) signals [1,2]. However, to date no BCI system engaged in long-term 24-hour-a-day use has been reported. Thus, most BCI studies have focused on neural features that are sensitive to modulation when subjects are engaged in BCI control and have not investigated activity patterns when subjects are not actively attending to the control task. One of the most important aspects of a 24/7 BCI system is its ability to remain sensitive to intentionally generated control signals without being susceptible to changes in brain activity when the user is not actively engaged in control. In this work we test the hypothesis that by combining signals from M1 and DLPFC the BCI signal can be made less sensitive to non-task engaged activity (i.e.: false positive (FPs)) without sacrificing BCI performance. We are motivated by the observation that engagement in BCI using M1 leads to increased connectivity from DLPFC to M1 [3].

Material, Methods and Results: This study used ECoG signals from 5 subjects with implanted electrodes for clinical use. The gamma band (65-95Hz) power from bipolar electrode signals (potential difference between nearby clinical grid electrodes, < 3cm center-to-center) was computed for at least one location over both M1 and DLPFC for each subject. The signals were then turned into a series of gamma events by finding instances when the z-scored power remained above a threshold for at least 10ms for M1 and 50ms for DLPFC. Congruent events (CEs) were defined as instances in which an event in DLPFC was followed by an event in M1 within a specific time period. CEs were tested in terms of performance during an overt movement BCI task and number of PFs during a 3 minute rest task and compared with M1 events. The M1 event thresholds were defined on the BCI data files as the lowest threshold that resulted in at least 80% performance. The CE interval was then chosen as the smallest interval for which 80% performance could be achieved using any DLPFC threshold. The DLPFC threshold was chosen as the highest possible value that still resulted in 80% performance given the chosen M1 threshold and interval. Using this strategy the mean z-score thresholds for M1 and DLPFC were 1.48 and 0.47 respectively and the mean interval was 230ms. The difference between M1 and CEs BCI performance was then tested using a paired t-test across parameters settings and data files. The results show that the mean BCI performance for M1 events is just above 80%, as per design, but the CE performance is significantly higher (Figure 1A). As we hypothesized, the number of FPs with CEs was dramatically and significantly lower (Figure 1B).

Significance: Here we present first attempts to use the cognitive network in combination with primary motor cortex to increase the specificity of the BCI signal and thereby reduce FPs and enhance the quality of permanent BCI solutions.

References
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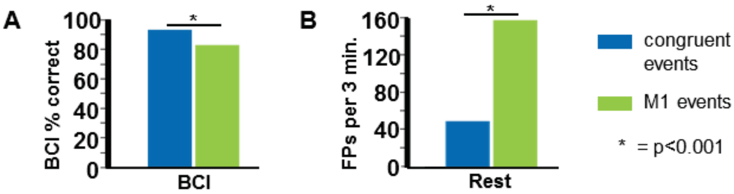

Figure 1: *A: Mean BCI performance. B: Number of false positives (FPs).Blue bars report the results using congruent events. Green bars report the results using M1 events.*