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Sensorimotor Rhythm BCI with Simultaneous High Definition-Transcranial Direct Current Stimulation Alters Task Performance

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Introduction: A challenge for broad applications of sensorimotor rhythm based brain-computer interface (BCI) is its need for extensive training in order to acquire useful control of a cursor or physical object [1-2]. Transcranial direct current stimulation (tDCS) has been used to alter the excitability of neurons within the cerebral cortex in order to improve motor learning and performance when tDCS was applied prior to and simultaneous with performance [3]. We aim to test the hypothesis that utilizing high definition tDCS (HD-tDCS) will alter the performance of sensorimotor rhythm based BCI within a single session and across sessions over multiple training days.

Material, Methods and Results: 29 healthy subjects (14 female; 26 right handed) naïve to BCI control were randomized into anodal, cathodal, and sham groups and participated in three experimental sessions of 1D left/right motor imagination performance. A 64-channel EEG system was used to record and a 4x1 HD-tDCS was used to stimulate all subjects, with the center electrode located between C3 and CP3 and return electrodes located between adjacent 10/20 EEG electrodes. Subjects performed motor-imagery BCI tasks before, during, immediately after (I-Post), and 30 minutes after (D-Post) 20 minutes of tDCS stimulation.

We report a decreased time-to-hit for right hand trials after anodal stimulation both within and across sessions (Fig 1). Additionally, we found differing after-effects of stimulation on the electrophysiology of the stimulated sensorimotor cortex during online BCI task performance for right hand trials based on the stimulation type. Sham and anodal stimulation groups both had increased online alpha power in C3 and CP3 for right hand trials immediately after stimulation, however the cathodal stimulation group did not show this increase. These differences were not seen in left hand imagination trials nor were they seen in sensorimotor electrodes in the contralateral hemisphere for either left or right hand trials.

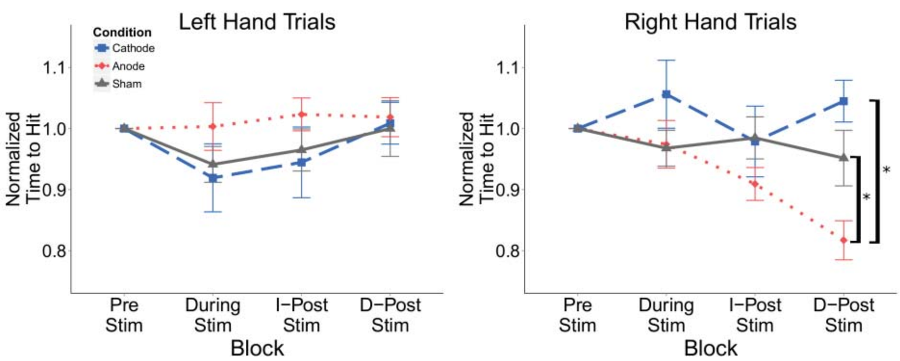

Figure 1. *Time to hit for right and left trials within a session normalized to the pre-stimulation baseline for each session. The anodal group had a reduced time-to-hit for right hand trials following stimulation at the delayed time point. Values: Mean +/- S.E. *p<0.05 for Wilcoxon rank sum test.*

Discussion: Unilateral HD-tDCS alters electrophysiology and behavior during BCI performance based on task specific neural activation within and across experimental sessions. The decreased time to hit right hand targets after anodal stimulation suggests that this stimulation may allow subjects to modulate their sensorimotor rhythm power faster than sham and cathodal stimulation. The decreased C3/CP3 alpha power after cathodal stimulation suggests this stimulation may impair a subject's ability to modulate their sensorimotor rhythm power during task performance.

Significance: We find differential effects of anodal and cathodal stimulation on behavioral and electrophysiological measures. These effects should be considered when applying noninvasive brain stimulation to improve BCI performance by altering the underlying physiology.

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