

Effects of tDCS on Precision of Finger Force Control and Rhythmic Tapping Movements

Keith Harrigan^{1,2}, Nikita Kuznetsov³, & Dagmar Sternad^{2,3,4}

Departments of Mathematics¹, Physics², Biology³, and Electrical and Computer Engineering⁴, Northeastern University

Background

Transcranial direct current stimulation (tDCS) is currently being explored as a promising new tool for movement rehabilitation (stroke, Parkinson's disease, dystonia) and for enhancement of motor performance (video gamers, musicians, soldiers).

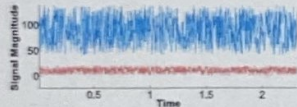


tDCS is a non-invasive and safe technique for brain neuromodulation that can increase or decrease spontaneous level of neural activity in the brain in a montage-specific way (Nitsche et al., 2008).

Neural activity increases under the anode and decreases under the cathode.

Anodal tDCS delivered to the primary motor cortex promotes long-term retention of skill on tasks involving precision and timing of finger control (Reis et al., 2009).

Hypotheses



We conjectured that in addition to changing the spontaneous rate of neural activity, tDCS also increases "neural noise."

H1: tDCS stimulation over the motor cortex (E1) and cerebellum (E2) increases variability of isometric finger force with and without visual feedback.

H2: Stimulation of the cerebellum (E2) increases timing variability during finger tapping.

tDCS Montage

Motor Cortex

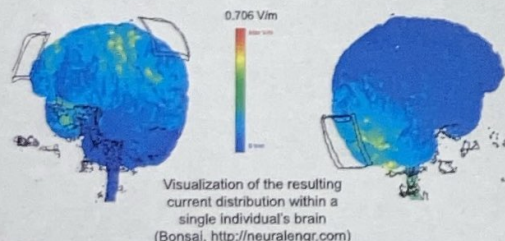


1 mA anodal stimulation over the motor cortex (C3-Fp2 location) using saline soaked sponges (35cm²).

Cerebellum

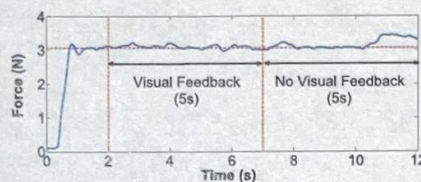


2 mA cathodal stimulation over the right cerebellum for using saline soaked sponges (25cm²).



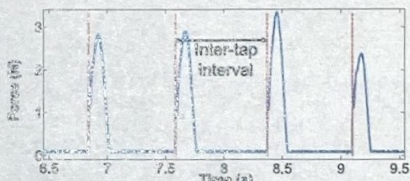
Experimental Tasks and Design

Visual Display



Task 1: Participants reached the target force level (3N) as fast as possible and maintained it for 10s, first with visual feedback and then without.

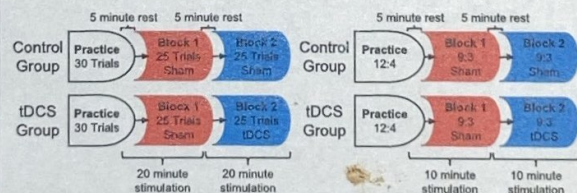
Dependent Measures: Standard deviation of finger force during visual feedback and without visual feedback segments of the trial.



Task 2: Participants synchronized with auditory metronome (800ms period) for 10 beats by tapping on the force sensor. The beats terminated and participants continued tapping at the same rate for 40s.

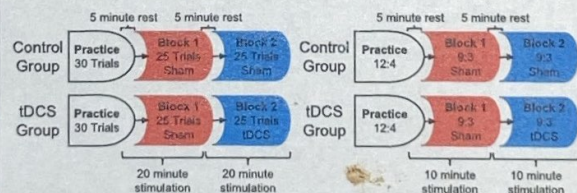
Dependent Measures: Standard deviation of inter-tap interval (ITI) during continuation tapping.

Experiment 1: Motor Cortex Stimulation



Participants: 24 healthy right-handed young adults (22.0±2.4 yrs) in Exp-1.
28 healthy right-handed young men (20.9±3.7 yrs) in Exp-2.

Experiment 2: Cerebellum Stimulation



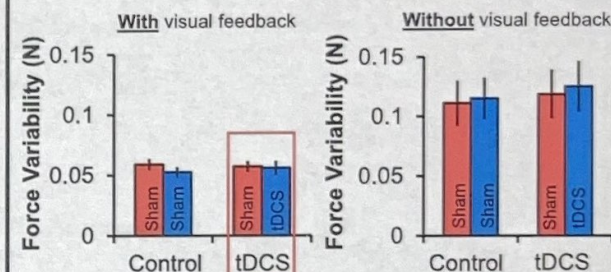
Discussion

Lack of tDCS effect on variability of isometric force may be due to high inter-individual variability or too short stimulation duration.

State-dependence of stimulation: force production may interfere with tDCS.

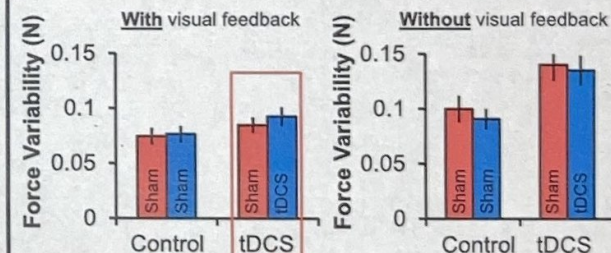
Increase in variability with tapping is consistent with the noise hypothesis: cerebellum normally inhibits motor cortex, and cathodal stimulation reduced that inhibition.

Results Exp-1: Motor Cortex Montage

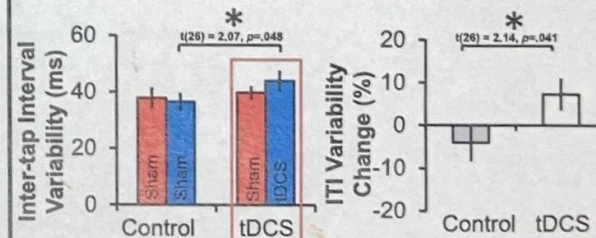


No statistically significant change in force variability with visual feedback and without visual feedback.

Results Exp-2: Cerebellar Montage



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Variability of inter-tap interval increased.

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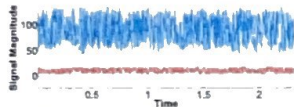


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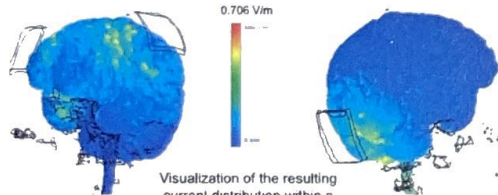


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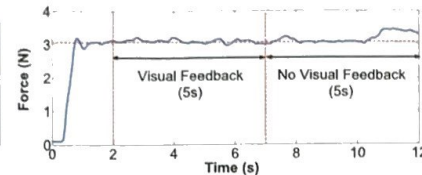
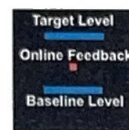
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Visualization of the resulting current distribution within a single individual's brain (Bonsai, <http://neuralengr.com>)

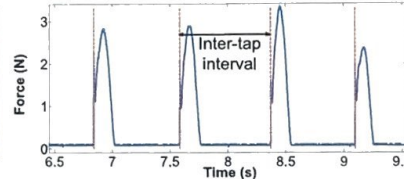
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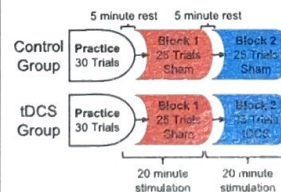
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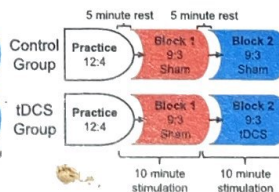
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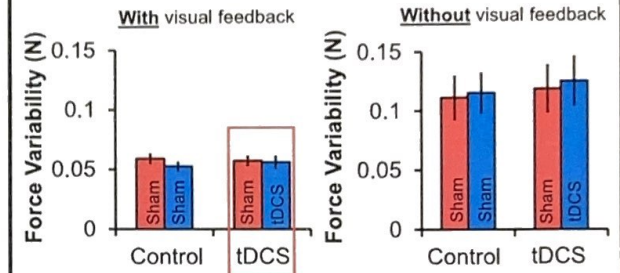
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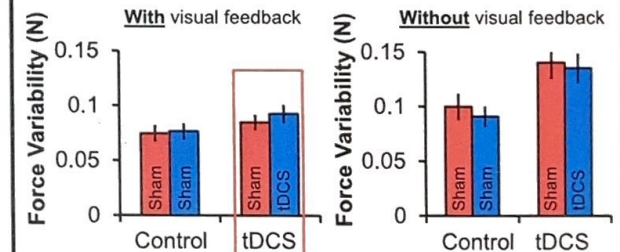
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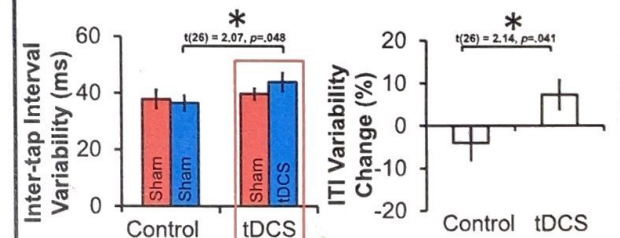


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