Transcranial Direct Current Stimulation (tDCS) Induces Acute Changes in Brain Metabolism
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Objective: To investigate the real-time effects of transcranial direct current stimulation (tDCS) on brain activity as a potential marker of therapeutic benefit.

Background: tDCS is a noninvasive brain stimulation technique used to facilitate rehabilitative outcomes and improve symptom management. While clinical benefits are presumed to result from neuromodulation, the underlying mechanism of tDCS remains largely unknown. We employed a simultaneous tDCS and magnetic resonance imaging (MRI) system and tested those with a chronic neurological disorder (multiple sclerosis or MS) and healthy controls.

Design/Methods: Participants MS and healthy controls (HC) were recruited to complete simultaneous tDCS and MRI. Imaging was performed with a 3T MRI (Prisma, Siemens) while wearing an MRI-compatible tDCS device (Soterix Medical) that delivered 15 minutes of 2.0 mA tDCS to the frontal lobe (dorsolateral prefrontal cortex montage, left anodal). The TRUST MRI technique was used to assess participants' cerebral metabolic rate of oxygen (CMRO2), an indicator of overall brain activity. Neuronal reactivity was calculated as the percentage change of CMRO2 in response to tDCS.

Results: All participants (n=3 MS and n=9 HC) tolerated the stimulation and scan sequences well with no occurrence of adverse events or imaging artifacts. All participants showed significantly higher CMRO2 (mean±SD: 169.9±16.1 μmol/minute) during tDCS as compared with baseline (150.3±13.2; p<0.01), indicating that tDCS induces increased cerebral oxygen metabolism. While there was no significant difference in baseline CMRO2 levels between the two groups, statistically lower improvement in neuronal reactivity (NR) was observed in MS participants after receiving tDCS (HC: 14.2±2.1%; MS: 9.6±0.9%; p<0.01). Such modest NR change implies decreased neuronal oxygen consumption in MS, possibly due to their brain pathophysiology.

Conclusions: This study provides preliminary evidence that tDCS causes acute changes in brain metabolism as evidenced by increased CMRO2 levels and NR. NR may serve as a potential biomarker that predicts patients' clinical outcomes to tDCS treatment.