High-definition transcranial direct current stimulation (tDCS) alters resting-state connectivity in cognitively intact older adults

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Background: Spatial navigation is essential in everyday life but declines with normal aging and further in neurodegenerative disease, possibly due to reduced parietal lobe functioning. This randomized, double-blind, crossover study examined whether high-definition (HD) tDCS over the parietal lobe alters subsequent parietal functional connectivity as measured by resting-state MRI.

Methods: Twelve cognitively intact older adults each completed 3 sessions in which they received 20-minutes of anodal, cathodal, or sham HD-tDCS (2mA) over site Pz (Stimulation order counterbalanced across subjects). Participants underwent resting-state MRI after each session (~15 minutes post-tDCS). MR data was acquired on a 3T Siemens Trio scanner, using an EPI sequence (TR/TE/FA=3s/24ms/90°) with 2.4x2.4x3mm resolution. Resting data was acquired for 192 volumes, with eyes open. Resting-state data was preprocessed using the CONN toolbox (reference), including head motion correction, white matter and CSF nuisance regression, 8mm FWHM Gaussian smoothing, and band-pass filtering (0.01-0.1 Hz). Bilateral seed regions were placed in superior parietal cortex (MNI: ±9,-64,54; based on prior task work), to form functional connectivity maps for each condition. These were then Fischer z-transformed, and the difference maps between anode and cathode conditions were used in a paired t-test to identify significant connectivity differences.

Results: Relative to the cathode session, anodal stimulation increased parietal connectivity to more frontal regions, including the medial frontal gyrus and anterior cingulate (see Figure 1). Relative to the anode session, cathodal stimulation had more widespread distributed increases in parietal connectivity to the inferior frontal gyrus, cingulate, middle temporal gyrus, and cerebellum.

Conclusions: These findings suggest HD-tDCS modulates both localized regions and distributed brain networks. Ongoing work examines these effects in patients with mild cognitive impairment (MCI) to evaluate HD-tDCS’s therapeutic potential to help engage alternative neural networks or cognitive processes during task performance.

Figure 1. Significant (p<0.05) differences in parietal connectivity between anode and cathode conditions. Red - higher connectivity after anode tDCS; blue after cathode.