Towards precise brain stimulation - DTU Orbit (22/10/2019)

Towards precise brain stimulation: Is electric field simulation related to neuromodulation?

Background: Recent research on neural and behavioral consequences of transcranial direct current stimulation (tDCS) has highlighted the impact of individual factors, such as brain anatomy which determines current field distribution and may thus significantly impact stimulation effects. Computational modeling approaches may significantly advance our understanding of such factors, but the association of simulation-based tDCS-induced fields and neurophysiological outcomes has not been investigated. Objectives: To provide empirical evidence for the relationship between tDCS-induced neurophysiological outcomes and individually induced electric fields. Methods: We applied tDCS during eyes-closed resting-state functional resonance imaging (rsfMRI) and assessed pre-post magnetic resonance spectroscopy (MRS) in 24 participants. We aimed to quantify effects of 15-min tDCS using the “classical” left SM1-right supraorbital area montage on sensorimotor network (SMN) strength and gamma-aminobutyric acid (GABA) and glutamate concentrations, implementing a cross-over counterbalanced design with three stimulation conditions. Additional structural anatomical MRI sequences and recordings of individual electrode configurations allowed individual electric field simulations based on realistic head models of all participants for both conditions. Results: On a neurophysiological level, we observed the expected reduction of GABA concentrations and increase in SMN strength, both during anodal and cathodal compared to sham tDCS, replicating previous results. The magnitudes of neurophysiological modulations induced by tDCS were significantly associated with simulation-based electric field strengths within the targeted left precentral gyrus. Conclusion: Our findings corroborate previous reports on tDCS-induced neurophysiological modulations and further advance the understanding of underlying mechanisms by providing first empirical evidence for the association of the injected electric field and neuromodulatory effects.

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