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ASSOCIATION BETWEEN tDCS INDUCED GABA CHANGE AND ESTIMATED ELECTRIC FIELD IN THE CORTEX

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Symposium title: Individualization and validation of electric field modeling for prospective dosing in noninvasive brain stimulation
Symposium description: Transcranial electrical stimulation (tES) is a widely used form of noninvasive brain stimulation in neurological, physiological, and psychiatric research. However, tES is currently limited by interindividual variability of responses, which may be due to anatomical differences between participants. Electric field (E-field) modeling is an analytical approach using structural MRI scan segmentation, meshing, and simulation of electrical current to estimate how the stimulation intensity at the cortical level. Thus, E-field modeling could be a useful tool in determining an individualized tES dose at the scalp level to produce an individualized biologically active intensity at the cortical level. This symposium focuses on the latest research working toward individualizing tES dosing, which could ensure that each person receives an appropriate stimulation intensity. Specifically, we will highlight approaches to personalize tES dose and refine the stimulation threshold and new open source tools they have developed. These approaches include: 1. Comparing E-field computational simulations to tES-induced GABA changes measured during magnetic resonance spectroscopy (MRS). 2. A new meta-analytic approach using E-field modeling to investigate the effects on stimulation intensity at different brain regions underlying working memory improvements. 3. 2-Sample Prospective E-Field Dosing (2-SPED), an approach using stability analyses in one sample to inform the dosing intensity of a second sample, and GetTissueThickness (GTT), an open-source software package that automatically extracts tissue layers to elucidate what most impacts the E-field intensities. 4. The impact of prospective individualized dosing and electrode design on E-field strength, and how this affects motor response in an ongoing trial. Taken together, this symposium covers the latest computational developments in E-field modeling, describes how E-field strength impacts behavioral responses in working memory, provides a mechanistic explanation for the effects of tES, outlines how to refine dosing based on new techniques, and illustrates why prospective dosing might produce more consistent behavioral responses.

Abstract
Transcranial direct current stimulation (tDCS) has wide ranging applications in neuro- behavioural and physiological research, and in neurological rehabilitation. However, it is currently limited by inter-subject variability in responses, which may be explained, at least in part, by anatomical differences that lead to variability in the actual electric field in the cortex. Our aim was to examine whether the variability in electric fields, estimated using computational simulations, explains the variability in tDCS induced GABA changes measured using magnetic resonance spectroscopy (MRS). Data from five studies (total $N = 56$ complete cases) were combined. The anode and cathode were placed over the left M1 (3 studies, $N = 24$) or right temporal cortex (2 studies, $N = 32$), and contralateral supraorbital ridge respectively. GABA to total Creatine ratios were measured and estimated, before and after tDCS application. sLASER MRS data were analysed using LCModel, and MEGA-PRESS using FID-A and Gannet. The electric fields were simulated in a finite element model of the head, based on individual MPRAGE images, using SimNIBS. Twelve linear mixed effects models were run, one for each E-field variable (mean and 95th percentile of magnitude, normal and tangential components), and separately for the M1 and temporal data. We found that in M1, E-field in the MRS voxel is related to the GABA drop, adding to the accumulating evidence that supports individualised dosing of tDCS. We also found an interaction with grey matter volume within the MRS voxel, emphasising the need to appropriately choose and evaluate any outcome measures which we expect to be related to E-field. While we did not find a similar association in the temporal region, given the challenges of modelling the E-field in this region and possible homeostatic metaplastic effects, such an association cannot be ruled out.
Research Category and Technology and Methods
Translational Research: 19. Modeling and computational methods
Keywords: tDCS, Electric field, Dosing

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Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

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META-ANALYTIC ELECTRIC FIELD MODELING

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Abstract
Several studies have shown that transcranial direct current stimulation (tDCS) is able to modulate cognitive performance. However, there is also a considerable number of null-results. Indeed, traditional meta-analytic approaches suggest only a (very) small effect size of tDCS on behavioral performance. The differences in findings can partially be explained by inter- and intra-individual variability. However, inter-experimental variability, pertaining to differences in methods and procedures, also significantly adds to the overall variance. Specifically, differences in tDCS electrode montages and applied intensities lead to different electric field (E-field) distributions in the brain. Given the broad parameter space across studies, it is hard to aggregate this data in a traditional meta-analytic approach
In this presentation, I will talk about our efforts in combining traditional meta-analyses with electric field modeling to investigate the effects of tDCS on working memory. This novel meta-analytic method relates behavioral effect sizes to electric field strength, to identify brain regions underlying the largest tDCS-induced WM improvement. Simulations on 69 studies targeting left prefrontal cortex showed that tDCS electric field strength in lower dorsolateral prefrontal cortex (Brodmann area 45/47) relates most strongly to improved WM performance. This brain region could be a target area for future tDCS studies. Our metanalytic framework can be applied to other stimulation modalities and behavioral measures.
Research Category and Technology and Methods
Basic Research: 9. Transcranial Direct Current Stimulation (tDCS)
Keywords: Electric field (E-field) modeling, tDCS, Meta-analysis, Cognition

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USING HEAD MODELS TO MINIMIZE ELECTRIC FIELD STRENGTH VARIABILITY INDUCED BY tES: INTRODUCING GETTISSUETHICKNESS (GTT) AND 2-SAMPLE PROSPECTIVE E-FIELD DOSING (2-SPED)

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Abstract
A vast body of evidence underscores the potential of transcranial electrical stimulation (tES) to both investigate the fundamental neurophysiological mechanisms of neural processing and to improve cognitive and motor behavior. However, widely variable results across studies and individuals present a major hurdle, as they give rise to ambiguous conclusions, incertitude about tES effectiveness, and small effect sizes.
Per standard, tES protocols apply a fixed current intensity via surface electrodes to the scalp of each person, irrespective of individual head anatomy. However, previous modeling work has shown that anatomical idiosyncrasies can cause electric (E-)field strengths to vary with a magnitude of up to 100% across persons. Given that E-field strength is the