A flexible optimization framework for transcranial electric stimulation, temporal interference stimulation and tumor treating fields

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simple transformation of coil positions from MNI space to the individual heads regularly led to physically impossible configurations. This also affected the electric fields calculated in the cortex, with peak differences of medians around 15% of the peak field strength. In addition, the new method outperformed grid search-based optimization in maximizing the electric field of a standard figure 8 coil.
In summary, our novel method enables optimizing the position, shape and electric field of flexible coils while accounting for individual head anatomies. Ignoring shape deformations was demonstrated to considerably affect the simulated electric fields. Consequently, our approach serves as a necessary step for realistic electric field simulations of unfocal coil designs, as it removes the practical hurdles that so far hampered accurate simulations. This opens the possibility to systematically compare dose-response relationships across the coil designs employed in therapy.
Research Category and Technology and Methods
Translational Research: 19. Modeling and computational methods
Keywords
TMS, electric field modeling, deep TMS, placement optimization

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FS4G.4

A FLEXIBLE OPTIMIZATION FRAMEWORK FOR TRANSCRANIAL ELECTRIC STIMULATION, TEMPORAL INTERFERENCE STIMULATION AND TUMOR TREATING FIELDS

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Symposium title
New Frontiers in Targeting-Optimizing and Modeling Non-Invasive Brain Stimulation
Abstract
I will introduce a novel flexible optimization framework that is designed to optimize electrode configurations for various treatment modalities which employ scalp electrodes to induce electric fields in the brain. Unlike existing optimization methods that require multi-channel systems and rely on a predetermined discretization of the electrode positions on the scalp, the proposed leadfield-free algorithm is aimed at electrodes of arbitrary shape that are placed freely on the head surface. It is based on a geodetic coordinate system for the efficient parametrization of electrode positions, shapes and configurations, and a finite-element method optimized for the repeated fast evaluation of varying electrode configurations on the head surface. It ensures absence of spatial intersections between the electrode shapes and electrode arrays, and their placement within a suited head region avoiding the face and ears.
The new optimization was validated on various application examples, including standard two-electrode Transcranial Electrical Stimulation (TES), focal center-surround TES (4x1-TES), Temporal Interference Stimulation (TIS) and Tumor Treating Fields (TTF), demonstrating reliability and robustness. It supports several quantities of interest (QoI), including the electric field strength in a brain ROI, the field component normal to the cortical surface orientation, and the TI envelope. It enables both the maximization of the QoI in the ROI, and the optimization of the intensity-focality tradeoff between the QoI in the ROI and the rest of the brain. Despite its flexibility, the computational requirements are kept moderate, allowing it to run on regular desktop computers and laptops, promoting widespread use in basic and clinical research.
Overall, the presented optimization framework offers high flexibility to optimize several practically employed electrode configurations. It will be distributed as part of SimNIBS, including example scripts and documentation for each modality to assist users in implementing this approach as part of their experimental studies.
Research Category and Technology and Methods
Translational Research: 19. Modeling and computational methods
Keywords
TES, electric field optimization, TIS, electrode configuration optimization

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FS4G.5

CORTICAL THICKNESS IN TEN YEAR-OLDS TWO YEARS PRIOR TO ONSET OF NON-SUICIDAL SELF-INJURY: RELATIONSHIPS TO IMPULSIVITY

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Symposium title
Target to Trial: Translating brain lesions and networks to therapeutic brain stimulation targets - from self-injury to anxiety, anorexia, and dystonia
Abstract
Background: Non-suicidal self-injury (NSSI) is the deliberate destruction of bodily tissue without suicidal intent. NSSI is associated with negative outcomes including increased impulsivity and suicide. Prospective studies of NSSI are needed to identify biomarkers of NSSI risk that can inform development of novel treatments such as non-invasive brain stimulation.
Methods: This was a secondary analysis of data from the Adolescent Brain Cognitive Development (ABCD) Study. Participants were 241 youths who reported no NSSI, suicidal ideation or attempt at baseline (aged 10), but who reported NSSI at 2-year follow-up (Y2). Individually demographically matched controls were 241 youths without NSSI at baseline or Y2. T1w baseline MRIs were preprocessed using the ABCD-HCP-pipeline. Impulsivity was measured using the Urgency, Perseverance, Premeditation and Sensation-Seeking, Positive Urgency scale (UPPS-P). Vertex-wise cortical thickness was calculated for each subject and groups compared using Permutation Analysis of Linear Models (10,000 permutations), covarying sex and ICV, using threshold-free cluster enhancement. Significance was $p < .05$, corrected.
Results: The NSSI group had greater cortical thickness than controls in left posterior cingulate cortex, precuneus, cuneus, and superior parietal lobe and right superior temporal gyrus and bilateral parahippocampal gyrus. The NSSI group had lower cortical thickness than controls in right dorsal anterior cingulate cortex and gyrus rectus. In males with NSSI, this reduced thickness correlated negatively with UPPS-P Lack of Perseverance but in male controls this thickness correlated positively with Lack of Planning.
Conclusion: In the first study of structural brain changes that precede NSSI, we found reduced cortical thickness in regions involved in reward and inhibition in NSSI and increased cortical thickness in posterior default mode regions. Although associations with behaviour require disambiguation, disruption of the normal relationship between reward, inhibition and default mode circuits could be a mechanism of future NSSI suggesting non-invasive brain stimulation could be used to treat NSSI.
Research Category and Technology and Methods
Clinical Research: 26. Structural Brain Imaging
Keywords
non-suicidal self injury, cortical thickness, impulsivity, ABCD study

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