

Symbiosis of fMRI and Transcranial Electrical Stimulation: Methodology, Implications and Challenges

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Symposium

Recent work shows that transcranial electrical stimulation (tES) produces widespread changes in human brain activity at the site of stimulation and also in remote regions. The effects of stimulation are influenced by network state at the time of stimulation and the structure of the network. Robust effects on network activity are seen with relatively short durations of stimulation, providing a way to casually investigate the relationship between brain stimulation and network activity. Individualized head models of current distribution along with fMRI might provide an additional level of state/trait-based predictability for neural response to tES. There is a large variability in tES-fMRI study designs and parameters, such as site, intensity and frequency. These provide great flexibility in experimental design but also challenge for optimizing the parameters of stimulation. In this symposium, we will explore the challenges of designing combined tES and fMRI studies, the potential questions that might be addressed and the conclusions that can be drawn from the studies conducted to date. The speakers invited are drawn from labs across the world that have contributed to this methodological development and innovative study designs.

Objective

Identify the applications and use of fMRI for tES

Evaluate methodological concerns in a sample experiment design and hardware when combining tES and fMRI

Design a sample study to answer predictive or mechanistic questions about tES via fMRI

Target Audience

This symposium targets wide range of human brain mapping (HBM) audience who are interested to know more about potential applications that brain stimulation technologies could provide to the field of HBM.

Presentations

demonstrate the importance of incorporating information about network connectivity into the analysis and interpretation of the behavioural and physiological effects of tES. The work has particularly important implications for planning and interpreting clinical studies in populations where patients have altered structural connectivity. I will discuss this issue in relation to a clinical study that has used the same stimulation approach in TBI patients with impairments of executive function and white matter damage produced by axonal injury. This shows that the effects of stimulation on behaviour and physiology are dependent on network structure and confirms that tES therapy needs to be tailored to the individual depending on specific patterns of brain network damage.

Presenter

David Sharp, Imperial College London, AK
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FMRI and Head Modeling: Addressing State and Trait Predictors in Response to tES

This talk describes the various strategies to combine functional imaging (fMRI, EEG, fNIRS) with anatomical-image derived current flow models. Functional imaging can be used before tES to identify anatomical ROIs that are they targeted by current flow models. Functional imaging before and after tES can be used to measure outcomes of tES. Individual functional imaging before tES can be correlated with current flow models to test hypothesis about the interaction of activity and current flow in ROIs with outcomes. Thus, combining functional imaging and current flow models can increase the rigor of tES trials as well as support optimization of intervention including individuals' assessments. However, combining tES and functional imaging requires nuances understand of the features and limitations of both modulation and measurement techniques, with potential for artifactual outcomes. Specific topics includes: 1) using imaging to validate current flow models; 2) techniques and considerations for online tES and imaging; 3) unexpected interactions when combining and imaging study design techniques that are suitable in isolation; 4) leveraging functional targeting, when individual brain state determines the outcomes of stimulation; 5) state-of-the-art consideration for reliable image-derived current flow models vs tools for automated high-throughout modeling.

Presenter

Marom Bikson, City University of New York New York, NY
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Methodological Parameter Space in Combining tES and fMRI: From Mechanism to Prediction

Combination between non-invasive brain stimulation techniques and neuroimaging methods have enabled researchers to go beyond the correlational associations between brain activity and behavior. Functional (f)MRI in combination with transcranial electrical stimulation (tES), have helped researchers to understand the effects of tES beyond the stimulated area and the mechanisms by which tES produces changes across different levels of the nervous system. To explore variability in the tES-fMRI methodological parameter space (MPS), I will report a systematic review on tES-fMRI studies and their MPS along with our experiences in running tES-fMRI studies. Based on the role of fMRI, tES-fMRI studies are classified to mechanistic, predictive, and electrode positioning. I will present potential explanations on how tES modulates activation and connectivity beyond the stimulated areas especially with prefrontal stimulation. However, in our systematic review, there were no two studies with same

MPS to replicate their results. Potentials and challenges for consensus guidelines to harmonize MPS in future studies will be discussed.

Presenter

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