Neuromodulation of Disrupted Brain Networks: Mechanisms, optimal targeting, and individual treatment

Yihong Yang, PhD Organizer
National Institute on Drug Abuse
Neuroimaging Research Branch
Baltimore, MD
United States

Symposium

The major themes of the symposium are novel and timely, which address important scientific and clinical questions in the emerging field of neuromodulation-based therapy. The presentations will integrate basic scientific research with clinical applications, and thus would attract a broad range of OHBM attendees as well as promote dialogue and engagement across OHBM membership. The audience will learn state-of-the-art developments in neuromodulatory treatments of brain disorders from the presentations and will have an opportunity to interact with the speakers through panel discussion.

Objective

As a result of attending this symposium, the audience should be able to:
- Understand the neural mechanisms of several brain stimulation modalities using concurrent neuroimaging techniques;
- Be aware of the potentials of network-based approaches to effectively target disrupted brain networks;
- Recognize the improvement of treatment efficacy by imaging-based individualized optimization.

Target Audience

Neuroscientists, neurologists, psychiatrists and biomedical engineers interested in neuromodulation-based treatment of brain disorders.

Presentations

Concurrent Mapping of Electromagnetic Field and Neurophysiological Effects of tDCS using MRI

Despite being a popular neuromodulation technique, clinical translation of transcranial direct current stimulation (tDCS) is hampered by variable responses observed within treatment cohorts. Addressing this challenge requires an effective means of mapping the neuromodulatory electromagnetic fields together with the brain's response. In this talk, novel MR imaging techniques will be presented that enable mapping of the tDCS current induced magnetic field (along Bz) and neurophysiological changes (as BOLD-contrast and ASL perfusion). These techniques show high promises using both standard and high-definition (HD) tDCS montages and would be used to evaluate target engagement in clinical applications of tDCS.

Presenter

Danny Wang, PhD, University of Southern California Los Angeles, CA United States

---

Targeting the Disrupted Brain Networks: A framework towards accurate neuromodulatory treatments of psychiatric disorders

Growing evidence has demonstrated disrupted brain networks in psychiatric patients that might serve as targets for neuromodulation-based treatments. However, a framework that identifies optimal stimulation sites to achieve maximal treatment efficacy is still lacking. In this presentation, a novel computational framework of network targeting based on functional connectome of the brain and meta-analysis of altered brain networks in specific psychiatric diseases will be proposed and discussed. On three independent clinical datasets, the model predicts individual treatment outcomes from their stimulated locations and the prediction is symptom specific, suggesting the model is effective and can be generalized to different disorders. This framework provides a novel guidance for accurate neuromodulation-based treatments for psychiatric disorders.

Presenter

Yihong Yang, PhD, National Institute on Drug Abuse, Neuroimaging Research Branch, Baltimore, MD, United States

---

Dosing by Design: using functional and structural architecture to improve TMS outcomes

Transcranial Magnetic Stimulation (TMS) has emerged as a promising treatment for various psychiatric disorders. The optimal dose and stimulation location for each patient, however, remains elusive. Using the scaffolding of a large clinical trial, we retrospectively analyzed the influence of neural architecture and functional topography on treatment outcomes in a TMS trial for alcohol use disorder. In a cohort of heavy alcohol users that received 10 sessions of real or sham TMS delivered to the medial prefrontal cortex during an intensive outpatient treatment program, anatomical data from the MRI scan was used to calculate the actual TMS electric field that was delivered to the MPFC in each individual. Our analysis show that individuals with electric fields that intersected areas with elevated functional activity had the highest sobriety over the 4-month duration of the experiment and a greater change in depression and anxiety symptoms relative to individuals with non-overlapping fields and functional MRI activity. These findings suggest that precision TMS targeting the loci of cue-reactivity may be a fruitful strategy in reducing the observed variance in TMS-AUD treatment response.

Presenter

Colleen Hanlon, PhD, Wake Forest School of Medicine Winston-Salem, NC, United States

Functional Network Neuromodulation of the Motor System: MRI based connectivity analysis can reveal clinical, behavioral and neural consequences of DBS in Parkinson's disease

Chronic electrical high-frequency deep brain stimulation (DBS) of the STN is now a standard clinical approach in patients with parkinsonian symptoms. Yet much remains unclear about which circuits and functions it modulates, and how. Here we took a multimodal diffusion MRI, fMRI connectomics and computational network modelling approach to better understand the pathways that are affected by STN DBS. PD patients undergoing STN DBS performed a visuomotor tracking task under two conditions, one requiring executive control and the other not. Individual electrode locations were mapped into MNI space and connectivity analyses were conducted using openly available datasets (www.lead-dbs.org). For the executive condition, DBS sped up reaction times, even compared to healthy controls (suggestive of impulsivity). Connectomic fiber-tracking from active DBS contact locations revealed a significant correlation of the reaction time change with the number of hyperdirect corticosubthalamic fibers from (pre) supplementary motor area. Independent of the condition, DBS improved movement velocity, which correlated with the improvement in clinical symptoms. We developed individual computational models for each participant, using fiber tracking and behavioral data. We show that 'lesioning' the hyperdirect pathway best predicted the reaction time (executive effect), whereas lesioning the indirect pathway best predicted the movement velocity effect. These results suggest that the different behavioral outcomes of DBS stimulation relate to anatomically-specific impacts on different STN-related pathways. Specifically, DBS that affects the putative hyperdirect (pre) SMA-STN pathway may disrupt a conflict function and induce impulsivity, while also potentially improving indirect basal ganglia function to increase movement velocity.

Presenter

Wolf-Julian Neumann, MD, Charité - University Medicine, Berlin, Germany