Mapping and Manipulating Neural Oscillations with Non-Invasive Brain Stimulation

Thursday, Jun 21: 8:00 AM - 9:15 AM
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Symposium
Thursday - Symposia AM

Neuronal oscillations are believed to organize information processing and communication between brain structures. Mapping of brain oscillations with EEG and MEG demonstrated that they are ubiquitous throughout the brain, that particular oscillatory patterns are associated with specific cognitive functions, and that those patterns can be disturbed in states of disease. This link, however, remains correlative unless experimental manipulations of brain oscillations establish their causal contribution to brain function. In humans, this can be achieved by transcranial brain stimulation techniques, such as magnetic or alternating current stimulation (TMS/TACS). Alongside the raising interest in these techniques, there is a rousing debate about the neural effects they elicit, highlighting the timeliness of this topic. We will discuss recent landmark advances allowing to map immediate stimulation effects via concurrent EEG, MEG, or fMRI, but also to deliberately target specific oscillatory brain states in real-time. We will introduce novel techniques to the OHBM community that enable stimulation at unprecedented spatial and temporal precision. This symposium is organized around the work of four early-career researchers, developing novel and complementary approaches of mapping and manipulating brain oscillations in humans. The four talks will explore (1) real-time EEG-triggered TMS to study excitation/inhibition and synaptic plasticity, and TACS-MEG for neuronal entrainment, (2) real-time EEG-triggered TACS and auditory stimulation to interact with oscillations during sleep, (3) combined TACS-fMRI to map and manipulate large-scale cortical networks in healthy and injured brains, and (4) the novel use of temporally interfering electric fields to target deep brain structures.

Objective

1. Become acquainted with novel multimodal approaches that combine imaging and electrophysiological techniques with non-invasive brain stimulation.
2. Learn about the relevance of novel stimulation approaches to investigate the role of neural oscillations in cognitive processes and its applications in disease.
3. Understand the potential of feedback-controlled approaches for real-time triggering of non-invasive brain stimulation

Target Audience

This symposium will target the growing interests of the OHBM community in brain stimulation and its combination with neuroimaging. We hope to promote the use of these novel approaches in the broader community and highlight its potential to guide therapeutic applications. We thus anticipate it to be of special interest to those researchers addressing the function of neural oscillations in cognition, neuro-enhancement, and therapy.

Co Organizer

Til Ole Bergmann, Eberhard Karls University of Tübingen

Organizer

Ines Violante, University of Surrey

Presentations

Combining transcranial brain stimulation with EEG/MEG to study the function of neuronal oscillations (index.cfm?do=ev.viewEv&ev=1626)

Til Ole Bergmann will review the principal experimental approaches to combine transcranial brain stimulation (TMS and TDCS/TACS) with electrophysiology (EEG/MEG) to map and manipulate neuronal oscillations noninvasively in humans. He will further introduce the novel approach of brain state-dependent brain stimulation, which allows to trigger TMS/TACS in real-time to target specific oscillatory states. Til will present work using EEG-triggered TMS to study the function of mu-alpha oscillations (10-14 Hz) in the sensorimotor cortex, in particular their amplitude- and phase-dependent modulation of cortical excitability and synaptic plasticity. Finally, he will present compelling evidence from combined TACS-MEG work for the capability of low frequency TACS in the alpha range to entrain neuronal activity in the visual cortex and cause a behaviourally relevant phasic modulation of visual stimulus-induced gamma oscillations. Til will also highlight and discuss key conceptual and technical caveats of these experimental approaches.

Presenter

Til Ole Bergmann, Eberhard Karls University of Tübingen

EEG feedback-controlled sleep stimulation approaches to establish the influence of sleep network dynamics on brain and body health (index.cfm?do=ev.viewEv&ev=1627)

Caroline Lustenberger will present findings on how non-invasive, temporally precise electrical stimulation and auditory stimulation can be used to modulate dominant sleep oscillations such as sleep spindles and slow waves. She will focus on her work in which she established the role of sleep spindles in motor memory consolidation using precise targeting of sleep spindles by EEG feedback-controlled tACS. Furthermore, Caroline will review auditory stimulation approaches for sleep oscillation manipulation and provide evidence that rhythmic auditory stimuli have the potential to enhance sleep spindles. She will provide insights into recent developments of portable closed-loop auditory stimulation devices for in-home sleep manipulation. Finally, she is going to critically discus the necessity of long-term, large-scale clinical trials to elucidate the consequences of such interventions on brain and body health.

Presenter

Caroline Lustenberger, University of North Carolina at Chapel Hill

Mapping the effect of oscillatory transcranial electrical stimulation on brain function (index.cfm?do=ev.viewEv&ev=1628)

Ines Violante will review evidence showing that fMRI can provide meaningful information regarding how brain networks are affected by transcranial brain stimulation. She will focus on evidence that changes in network dynamics are sensitive to the stimulation profile, propagate beyond the cortical site of stimulation and can result in changes of activity and/or local and long-range connectivity in a manner that is sensitive to the endogenous brain state and the exogenous oscillatory profile. Ines will further discuss the importance of combining multimodal approaches to reveal insights about the mechanisms associated with cognitive functions in humans, and to develop clinical tools to target dysfunctional brain dynamics occurring as a result of brain pathologies. Finally, she will present work using simultaneous TACS-fMRI to modulate the function of large brain networks involved in heathy controls and patients with brain injuries.

Presenter

Ines Violante, University of Surrey

Noninvasive Deep Brain Stimulation via Delivery of Temporally Interfering Electric Fields (index.cfm?do=ev.viewEv&ev=1629)

Nir Grossman will report on a noninvasive strategy for electrically stimulating neurons at depth. Electrical brain stimulation is a key technique in research and clinical neuroscience studies, and also is in increasingly widespread use from a therapeutic standpoint. However, to date all methods of electrical stimulation of the brain either require surgery to implant an electrode at a defined site, or involve the application of non-focal electric fields to large fractions of the brain. By transcranially delivering to the brain multiple electric fields at frequencies too high to recruit neural firing, but which differ by a frequency within the dynamic range of neural firing, we can electrically stimulate neurons throughout a region where interference between the multiple fields results in a prominent electric field envelope modulated at the difference frequency. This temporal interference (TI) concept was validated via modeling and physics experiments, and verified that neurons in the living mouse brain could follow the electric field envelope. Further demonstrations of the utility of TI stimulation can be observed by the observation that stimulating neurons in the hippocampus of living mice did not recruit neurons of the overlying cortex. It will be shown that by altering the currents delivered to a set of immobile electrodes, we can steerably evoke different motor patterns in living mice. Finally, to start testing whether TI stimulation is safe and can recruit activity in the human brain, we applied the TI stimulation to the motor cortex of small cohort of healthy volunteers and measured BOLD signals concurrently using fMRI.

Presenter

Nir Grossman, Imperial College London