



5th International Brain Stimulation Meeting – Abstracts

Acceptance type: Symposium oral
S1a.1

LARGE-SCALE NEUROMODULATION FOR TARGETED PLASTICITY IN PRIMATES

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Symposium title: Emerging technologies for brain stimulation

Symposium description: This symposium focuses on emerging technologies for brain stimulation, with an emphasis on recently developed pre-clinical technologies that improve the durability, stability, efficiency, and/or functionality of brain stimulation devices. Our symposium covers advances in neural engineering including novel materials and fabrication strategies for interfacing with the brain, advanced optical and ultrasonic tools for targeted neuromodulation and large-scale access for stimulation and read-out of neural circuits across multiple brain regions. The collection of talks in our symposium covers a breadth of technologies with demonstrated utility in rodents and primates and clear promise in clinical translation. In particular these technologies have a strong focus on targeted and patterned neuromodulation enabling opportunities for neural circuit interventions at unprecedented scales. Furthermore, we discuss closed-loop neuromodulation in the context of these advanced technologies providing opportunities for state-dependent and personalized neuromodulation. These emerging technologies create testbeds for understanding brain circuits and function and pave paths towards developing more efficient stimulation-based therapies for a wide variety of neurological disorders.

Abstract

The brain shows marked plasticity across a variety of learning and memory tasks as well as during recovery after injury. Many have proposed to leverage this innate plasticity using brain stimulation to treat neural disorders. Implementing such treatments requires advanced engineering tools and a thorough understanding of how stimulation-induced plasticity drives changes in network dynamics and connectivity at a large scale and across multiple brain areas. We have developed a novel large-scale interface for non-human primates that achieves these goals and enables us to manipulate neural activity with high spatial and temporal resolution via virally transduced neurons containing light-sensitive ion channels, i.e. using optogenetics. In addition to its potential for greater spatial and cell-type specificity, this technique offers the significant advantage of artifact-free electrophysiological recording during stimulation. Our interface consists of state-of-the-art electrophysiology and optogenetics to simultaneously record and manipulate activity from about 5 cm² of cortex in awake behaving macaques. Using this interface, for the first time, we have shown the feasibility of inducing targeted changes in cortical networks using optogenetics. Furthermore, we have incorporated the capability of producing ischemic lesions in the same interface enabling us to stimulate the cortex around the site of injury and monitor functional recovery via changes in blood flow, neurophysiology, and behavior. These technologies have a great potential to provide critical insight into the fundamentals of brain plasticity and the power of targeted cortical stimulation to drive rehabilitative reorganization following injury, and may have a profound impact on future therapeutic interventions for neurological disorders such as stroke.

Research Category and Technology and Methods

Basic Research: 13. Other Brain Stimulation Technology

Keywords: Optogenetics, Optogenetics, Non-human primates, stroke

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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

S1a.2

NOVEL MATERIALS AND FABRICATION STRATEGIES FOR MULTIMODAL NEUROELECTRONICS

Flavia Vitale, Raghav Garg. *University of Pennsylvania, Philadelphia, PA, USA*

Abstract

Neuroelectronic technologies are essential tools to treating neurological disorders, restoring and repairing lost functions, and modulating neural circuitry to control mood and behavior. Traditionally, metals and silicon have been the materials of choice for neuroelectronics. However, these materials are intrinsically inadequate to address the mechanical, chemical, and electrical properties of neural tissues. Furthermore, they are complex to source and process, which makes the manufacturing of neuroelectronic devices time consuming and expensive. Thus, the development and successful clinical translation of safe, biocompatible, and long-term stable neuroelectronics require significant innovations in both materials and fabrication strategies. In this talk, I will discuss how nanoscale soft conductors can be engineered into high-resolution, minimally invasive neuroelectronic interfaces designed to seamlessly record and stimulate neural circuits at multiple scales. Specifically, I will introduce 2D transition metal carbides (a.k.a. MXenes), discuss their electrochemical properties at the interface with biological tissues, and show how they translate into significant impedance and noise reduction when MXene-based microelectrode arrays are used in vivo. Then, I will present novel scalable, rapid manufacturing processes designed to translate the exceptional material properties at the molecular scale into high-resolution, low impedance neuroelectronic interfaces that are also compatible with clinical neuroimaging modalities, such as magnetic resonance imaging (MRI) and computerized tomography (CT). Finally, I will present examples of applications in both implantable and wearable interfaces for neural recording and stimulation.

Research Category and Technology and Methods

Basic Research: 13. Other Brain Stimulation Technology

Keywords: Neuroelectronics, Neural interfaces

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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

S1a.3

MRI-GUIDED FOCUSED ULTRASOUND NEUROMODULATION OF DEEP BRAIN REGIONS AND CIRCUITS WITH REAL TIME FEEDBACK

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Abstract

Transcranial focused ultrasound (tFUS) is an emerging technology and has been regarded as the next generation of neuromodulation tools. tFUS is noninvasive and offers high precision targeting and stimulation of any brain region, including deep brain structures. Combined tFUS with MRI, such as MR-acoustic radiation force imaging (MR-ARFI) and functional MRI (fMRI), adds capabilities of real-time feedback on the FUS beam location and functional monitoring of FUS in action. In addition, advanced MRI contrasts provide tFUS safety assessment. In this presentation, I will review our progress on developing these methods for human applications and discuss how they are applied to modulate brain function in nonhuman primates. I will show data acquired at 7T and 3T MRI scanners and present results showing that tFUS exerts bidirectional (excitatory and inhibitory) modulation of brain BOLD fMRI signals at both somatosensory cortex and thalamus nucleus and their functional networks in a state-dependent manner. We are currently testing the hypothesis that varying intensities of tFUS selectively activate different types of neurons, resulting in bidirectional modulatory effects.

Research Category and Technology and Methods

Translational Research: 13. Other Brain Stimulation Technology

Keywords: Transcranial focused ultrasound, MRI guidance, BOLD, Somatosensory and pain system

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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

S1a.4**SEEING THE SOUND: NOVEL OPTICAL AND ULTRASONIC METHODS FOR NEUROMODULATION**

Xiang Wu, Nicholas Rommelfanger, Guosong Hong, *Stanford University, Stanford, CA, USA*

Abstract

Today's optical neuromodulation methods enable causal manipulation of neural activity with light to dissect complex circuit connections underlying certain behaviors. In these optical neuromodulation approaches, visible light with wavelengths between 430 nm and 640 nm is commonly used, thus limiting penetration depth in vivo and resulting in an invasive fiber-tethered interface that damages the endogenous neural tissue and constrains the animal's free behavior. In this talk, I will present two recent methods to address this challenge via novel optical and ultrasonic brain interfaces: sono-optogenetics and infrared optogenetics. In sono-optogenetics, we demonstrate that mechanoluminescent nanoparticles can act as a systemic light source to convert focused ultrasound into localized light emission for noninvasive optogenetic neuromodulation in live mice. In infrared optogenetics, we demonstrate 1064-nm near-infrared-II light can enable tether-free and implant-free neuromodulation throughout the entire brain in freely behaving mice. I will conclude my talk by presenting an outlook on how these approaches may advance neuroscience research in live animals and even humans.

Research Category and Technology and Methods

Basic Research: 13. Other Brain Stimulation Technology

Keywords: Sono-optogenetics, TRP channels, mechanoluminescence, infrared

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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

S1b.1**NEUROMODULATION OF MEMORY NETWORK IN PATIENTS WITH ALZHEIMER'S DISEASE**

Andres Lozano, *University of Toronto, Canada*

Symposium title: Strengths and weaknesses of intracranial electrical stimulation in localizing functions and treating dysfunctions in the human brain

Symposium description: Some of the most distinguished leaders in the field will present an overview of how the human brain can be studied with intracranial direct cortical stimulation and how neuropsychiatric disorders can be treated with this approach. They will discuss promises and weaknesses of this approach and suggest future directions.

Abstract

Alzheimer's disease (AD) is characterized by a profound disruption of cortical networks subserving memory and cognitive function. In an ongoing clinical trial, deep brain stimulation (DBS) of the fornix is being examined to modulate these networks to improve their function. In addition, emerging evidence from animal models and patients suggests that electrical stimulation of these circuits can restore metabolic function, improve cognition, and have reparative and regenerative effects. An update on the state of DBS approaches to treat circuit dysfunction in AD will be presented, along with a discussion of lessons learned.

Research Category and Technology and Methods

Clinical Research: 1. Deep Brain Stimulation (DBS)

Keywords: DBS, Intracranial, Direct Cortical Stimulation

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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

S1b.2**NEUROMODULATION OF EMOTION NETWORKS IN PATIENTS WITH DEPRESSION: LESSONS LEARNED**

Helen Mayberg, *Icahn School of Medicine at Mount Sinai, USA*

Abstract

It is now almost 20 years since the first case of subcallosal cingulate deep brain stimulation (SCC DBS) for treatment-resistant depression (TRD). Ongoing research using small experimental cohorts has continued to progress, with the implementation of refined techniques for surgical targeting and emerging clues as to which patients are most likely to benefit. Close clinical monitoring and systematic long-term follow-up have provided additional perspectives on the time course, trajectory, and long-term sustainability of DBS-mediated effects. Acute and chronic monitoring using next-generation stim/sense DBS systems has further characterized this chronology at the neural level, demonstrating distinct early and late physiological changes that suggest network plasticity and remodeling maintain the observed long-term clinical effects. Physiological measures are now combined with computer vision, and machine learning approaches to detect more subtle changes in core depression features relevant to DBS optimization. Together these experimental approaches provide a unique opportunity to link first-person experiences to changes in brain state toward a more comprehensive understanding of illness and recovery.

Research Category and Technology and Methods

Clinical Research: 1. Deep Brain Stimulation (DBS)

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