Research Category and Technology and Methods
Translational Research: 14. Brain-computer Interface
Keywords: Intracortical microstimulation, Visual cortex, Vision restoration, Macaque

http://dx.doi.org/10.1016/j.brs.2023.01.200

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

F55.4

BIOLGICAL AND BIONIC HANDS: NATURAL NEURAL CODING AND ARTIFICIAL PERCEPTION

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Abstract
Microstimulation of somatosensory cortex has been shown to evoke vivid touch sensations that are experienced on the hand, a phenomenon that may be leveraged to restore touch to individuals with spinal cord injury via sensorized bionic hands. Toward this end, we seek to understand how the parameters of stimulation shape the evoked sensory experience by stimulating the somatosensory cortex of non-human primates (NHPs) and humans. In parallel, we characterize how natural touch is encoded in somatosensory cortex with the hope of leveraging our understanding of natural neural coding to inform the development of artificial touch via microstimulation. First, we have shown that somatosensory neurons throughout the neocortex respond more strongly to contact transients (onset and offset) than to maintained contact. In light of this, we are developing “biomimetic” stimulation regimes which also emphasize transients. In collaboration with other groups, we have shown that biomimetic stimulation regimes elicit more natural touch sensations than do the standard flat trains. Second, we have shown in psychophysical experiments with NHPs that microstimulation frequency affects perception in a manner that is separable from perceived intensity. Our collaborators at the University of Pittsburgh showed that, in humans, changes in frequency can lead to salient changes in the quality of the evoked touch sensation. Third, we found that microstimulation of somatosensory cortex produces highly patterned activity in motor cortex, and this electrically evoked activity disrupts our ability to decode motor intent from motor cortex when microstimulation-based touch feedback is provided. This disruptive effect is reduced with biomimetic feedback, which requires less tonic microstimulation and thus elicits weaker activity in motor cortex. Moving forward, we hope to continue to develop sensory feedback algorithms that give rise to ever more natural and intuitive touch sensations without disrupting motor decoding.

Research Category and Technology and Methods
Clinical Research: 14. Brain-computer Interface
Keywords: Intracortical microstimulation, Somatosensory cortex, Neural coding, Biomimetic feedback

http://dx.doi.org/10.1016/j.brs.2023.01.201

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

F55.5

MULTI-CHANNEL INTRA-CORTICAL MICRO-STIMULATION ROBUSTLY EVOKES STABLE, SOMATOSENSORY PERCEPSES; WITH REACTION TIMES SIGNIFICANTLY FASTER THAN NATURAL OCCURRING STIMULI IN A HUMAN PARTICIPANT

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Symposium title: Human intracortical microstimulation: basic science and the restoration of function
Symposium description: Recording brain activity and behaviors evoked through electrical stimulation has been an integral part of neuroscience research. It has been an essential tool to further our understanding of neural mechanisms in the brain and in the development of therapeutic treatments. A long history in animal models of intracortical microstimulation (ICMS) through penetrating electrodes has shown the potential to provide therapeutic benefits. Human clinical trials for ICMS have become more widespread in recent years. These have contributed significant progress in understanding the basic science needed to further develop therapeutic devices and produced proof-of-principle demonstrations of restored function. Stimulation has been applied in sensory and visual cortices. In sensory cortex, ICMS has demonstrated the potential to restore sensation. In visual cortices, ICMS has been implemented towards restoring functional vision in individuals with profound blindness. In this symposium, we will explore the most recent results from studies involving intracortical microstimulation in humans for the restoration of function and to advance basic science.

Abstract
Somatosensory brain-machine-interfaces (BMIs) can create naturalistic sensations by modulating activity of neural populations in the brain. By utilizing different spatial or temporal patterns of intra-cortical microstimulation (ICMS) in primary sensory cortex (S1), human patients suffering somatosensory loss can experience both cutaneous and proprioceptive sensory feedback. As evidenced by motor deficits in deafferented patients, rapid somatosensory feedback is critical for dexterous motor ability, in part because visual feedback is much slower than naturally occurring somatosensory input. However, somatosensory BMI studies typically report significantly longer cognitive processing latencies for cortical electrical stimulation than for naturally occurring somatosensory sensations or visual sensations. In this study, multi-channel electrical stimulation patterns elicited naturalistic somatosensory percepts in a human tetraplegic participant. Crucially, somatosensations evoked by multi-channel ICMS are cognitively processed significantly faster than naturally evoked visual and cutaneous stimuli, as measured via a simple reaction time test. Further investigation demonstrated multi-channel stimulation could significantly reduce minimum amplitude detection thresholds and such reductions in charge density resulted in more frequent “natural” sensation descriptors reported by the human participant. Multi-channel ICMS patterns also evoked percepts with highly stable somatotopic locations. While some single-channel ICMS patterns evoked sensations 20-80% of the time, most multi-channel patterns could evoke sensations with 100% repeatability, an important step in demonstrating BMI device reliability. These improvements are all significant advances towards state-of-the-art sensory BMIs. The addition of such low-latency artificial sensory feedback to motor BMIs is expected to improve movement accuracy and increase embodiment for human users.

Research Category and Technology and Methods
Translational Research: 14. Brain-computer Interface
Keywords: stimulation, somatosensory, intracortical microstimulation, brain-machine interface

http://dx.doi.org/10.1016/j.brs.2023.01.202

Abstract key: PL- Plenary talks; S- Regular symposia oral; FS- Fast-Track symposia oral; OS- On-demand symposia oral; P- Posters

F55.6

MICROSTIMULATION OF HUMAN SOMATOSENSORY CORTEX EVOKES TASK-DEPENDENT, SPATIALLY PATTERNED RESPONSES IN MOTOR CORTEX

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Abstract
Intracortical microstimulation (ICMS) of somatosensory cortex (S1) can be used to restore tactile feedback to people with spinal cord injury via brain controlled bionic hands. Anatomical and neurophysiological evidence from various animal species points to a communication pathway between motor and somatosensory cortex, but this pathway’s normal function, and its relevance to neuroprosthetics, remains to be elucidated. To fill this gap, we...