Reanimating limb movement via a Brain Machine Interface: Using electrical stimulation to restore both efferent and afferent connectivity

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Abstract

Brain Machine Interfacing (BMI) is an exciting new technology that allows direct connections to be made between the brain and a computer. While BMIs have thus far shown tremendous promise in routing brain commands around a spinal cord injury to control movement of a computer cursor or a robotic arm, our laboratory has focused on the potential of BMI to restore more natural-seeming movement directly to a paralyzed limb itself. Patients with spinal cord injury also lack proprioception, the ability to absorb information communicated very rapidly to the brain from sensors in the muscles. Even patients that are not paralyzed, who have nonetheless lost proprioception, make movements that are slow, poorly coordinated, and require great concentration. Existing BMIs rely exclusively on slower visual feedback, which may account, in part, for their as yet relatively limited performance as a practical solution for paralyzed subjects. My laboratory group, in experiments with monkeys, has developed a BMI that could allow patients with a spinal cord injury to regain voluntary control of their paralyzed muscles. We have further begun to develop an interface that will provide information to the brain, rather than extract information from it. By stimulating the brain with implanted microelectrodes, we hope to mimic normal proprioceptive feedback. Finally, we are investigating the adaptive changes that occur within the brain as the monkey adapts to these artificial interfaces. A process called Hebbian association, thought to underlie learning, normally causes the connections between neurons to be strengthened when they experience correlated patterns of activity. Relying on Hebbian association, we intend to use appropriately patterned stimulation to cause changes that would assist a

monkey's—and, we hope in the not too distant future, a human patient's--adaptation to a BMI.

Recommended references with the talk

- *Limb-state information encoded by peripheral and central somatosensoryneurons: Implications for an afferent interface*. Douglas J. Weber, Brian M. London, James A. Hokanson, Christopher A. Ayers, Ricardo R. Torres, Boubker Zaaimi, Lee E. Miller.

- Prediction of Muscle Activity from Cortical Signals to Restore Hand Grasp in Subjects with Spinal Cord Injury. Emily R. Oby, Christian Ethier, Matthew J. Bauman, Eric J. Perreault, Jason H. Ko, Lee E. Miller. CHAPTER 11 *A Novel Application of a Brain-Machine.*

- *Progress in Brain Research. Enhancing Performance for Action and Perception. Multisensory integration, Neuroplasticity and Neuroprosthetics, Part II.* Edited by Andrea M. Green, C. Elaine Chapman, John F. Lakaska, Franco Lepore. Chapter 6. Stimulus-driven changes in sensorimotor behavior and neuronal functional connectivity: application to brain–machine interfaces and neurorehabilitation. James M. Rebesco and Lee E. Miller.