The Center for Adaptive Neural Systems presents a symposium on

"Promoting Neural Plasticity"

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TITLES & ABSTRACTS FOR SPEAKERS

1. **1. Eberhard E. Fetz, Ph.D.**

TITLE: "Adaptive neural control and implantable recurrent brain-computer interfaces"

ABSTRACT: A variety of brain-computer interfaces [BCI] have been developed to transform neural activity into signals that control a computer cursor or other external devices. Given visual or proprioceptive feedback, the subject can learn to optimize volitional control of the device by appropriately modulating the neural activity. While the usual BCI paradigm involves brain control of cursors or external devices, a recurrent BCI [R-BCI] generates output that is directly fed back into the nervous system or muscles. We are investigating an implantable R-BCI consisting of autonomously operating electronic circuitry, including a computer chip, that interacts continuously with the brain of a monkey. The so-called "Neurochip" [Mavoori et al, J. Neurosci. Meth. 2005] detects the activity of a motor cortex cell and arm muscles, and can store activity under free behavioral conditions for subsequent download via an infrared port. In a recurrent mode, the Neurochip can convert cell activity to electrical stimuli delivered back to the cortex, spinal cord or muscles. Chronic implantation of the battery-powered R-BCI allows continuous operation and could permit the monkey to incorporate the artificial connection into normal behavior. Looking ahead, two applications of the R-BCI have therapeutic potential. First, the artificial recurrent connection could bridge impaired biological connections and allow the subject to learn to generate the neural activity that is appropriate to compensate for the lost pathway. Second, by delivering stimuli synchronized with cell activity, continuous operation of the R-BCI can strengthen weak existing biological connections through Hebbian mechanisms [Jackson et al, Nature, 2006]. The R-BCI paradigm has numerous potential applications, depending on the input signals, the computed transform and the output targets.

2. Leonardo G. Cohen, MD

TITLE: "Effects of stimulation of the primary motor cortex on skill acquisition and formation of a motor memory"

ABSTRACT: It has been proposed that a motor skill is acquired and consolidated in stages. Recent studies have shown that non-invasive cortical stimulation can influence motor learning but the differential effects of such stimulation on specific stages of skill acquisition and retention have not been examined. In this study, subjects performed a visuomotor skill task for 5 consecutive days of training. This prolonged time course for learning allowed us to study the effects of transcranial direct current stimulation (tDCS) over the primary motor cortex (M1) on the rate of skill acquisition both within (online gains) and between (offline gains) training sessions. Skill was operationally defined as the ability to sustain or improve accuracy despite increased performance speed, and was quantified with a single parameter derived from the skill task's speed-accuracy trade-off function. We also examined the effect of tDCS during or after training on subsequent skill retention over multiple time points up to 3 months. We found that: First, anodal tDCS led to an average level of skill at the end of the 5 days of training that was better than even the best of the sham-stimulated controls. Second, skill improvement was mediated through enhancement of offline gains rather than enhancement of learning rate within session. Third, anodal tDCS did not enhance retention of the acquired skill across the 3 months following training. Finally, performance in the anodal tDCS group remained superior to that of any other tested group at 3 months, most likely because subjects finished at a higher skill level at the end of the 5 days of training. The specificity of the effect of anodal tDCS for offline gains, as opposed to within-session gains or long-term retention, provides further evidence that motor skill learning is made up of mechanistically distinct stages that can be differentially modulated by noninvasive cortical stimulation, a finding of relevance in neurorehabilitation.

3. Reggie Edgerton, Ph.D.

TITLE: "Bioengineering strategies to recovery control of posture and locomotion after a spinal cord injury: solutions at our fingertips"

ABSTRACT: V. Reggie Edgerton, Ph.D., Roland R. Roy, Ph.D. Ronaldo Ichiyama, Ph.D.,Igor Lavrov, Ph.D.,Grégoire Courtine, Ph.D., Yury Gerasimenko, Ph.D., Andy Fong, Ph.D., Y. C. Tai, Ph.D., Joel Burdick, Ph.D. Departments of Physiological Science and Neurobiology, Brain Research Institute, UCLA, Los Angeles, California, Department of Engineering, Caltech, Pasadena California.

There have been major advances in our understanding of the integrated properties of the spinal neural networks commonly characterized as central pattern generation and of the ability of these networks to process meaningful proprioceptive information related to standing and stepping. In combination with the continuing and parallel technical improvements in our ability to monitor and stimulate these spinal neural networks under in vivo conditions, these advances provide a reasonable approach to enhance the level of neuromotor function after a severe spinal cord injury. When these interventions are combined with step and stand training protocols and with pharmacological modulation to further modulate the physiological state of these spinal neural circuits in absence of direct supraspinal control, improvements in motor function are even greater. The possibilities of these approaches are even more encouraging when considering the fact that these interventions can be applied with minimal invasiveness and with the application of relatively minor, but critically fine-tuned, changes in the engineering capabilities that presently exist. A key to the success of these interventions is the capability of the spinal circuitry to process proprioceptive input associated with weight-bearing and the development of electrode arrays placed epidurally to stimulate safely with constancy and precision.