Keynote

Oscillatory Dynamic and Brain Machine Interface Systems

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ABSTRACT

Understanding the neural basis of cortical processing promises to lead to advances in Human-Machine Systems with immense implications for both the normal population and patients with devastating neurological disorders. Our work related cortical processing and neurological disorders shows that brain machine interface (BMI) is viable in humans using brain oscillations to control peripheral devices such as prosthetic limbs and potentially to generate language.

Studies to date reveal that every cognitive process examined including language, attention, memory and motor control generates high frequency oscillatory activity in the range of 70-250 Hz (high gamma, HG). Importantly, the HG band of the human ECoG has the most precise spatial localization and task specificity of any frequency we and others have examined. For instance, during language processing, HG precisely tracks the spatio-temporal evolution of language from comprehension in posterior temporal areas to production structures in frontal brain regions. Importantly, these HG changes track the subjects behavioral performance in real-time over the course of the 1200 milliseconds needed to comprehend the word, select a noun and articulate a response.   Motor activity is also tracked by brain oscillations and studies will be discussed that use these brain oscillations to control peripheral devices in humans with implanted electrodes. Similarly, we have developed means to extract linguistic information from brain activity suggesting that thus approach may be useful for speech production.

The HG response is phase locked to the trough of theta rhythms (4-8 Hz) in the neocortex. This HG-theta coupling occurs in a task specific manner with different cognitive tasks eliciting unique distributed spatial patterns of HG-theta coupling. These results indicate that transient coupling between low- and high-frequency brain rhythms may provide a mechanism for effective communication in distributed neural networks engaged during cognitive, language and motor processing in humans.

Future BMI real-world applications will involve the integration of theory and concept from cybernetics, human-machine, and systems science and engineering areas.

Biography

Bob Knight is the Evan Rauch Professor of Neuroscience and Director of the Helen Wills Neuroscience Institute at UC Berkeley. He received a B.S. in Physics from the Illinois Institute of Technology in 1970, his M.D. from Northwestern University Medical School in 1974, trained in Neurology at UC San Diego from 1976-1978 and did his post-doctoral work in human neurophysiology at the Salk Institute for Biological Studies from 1978-1980. He was a faculty member in the Neurology Department at UC Davis from 1980-1998 and has been in the Psychology Department and the Helen Wills Neuroscience Institute at UC Berkeley since 1998. Knight's research focuses on the role of prefrontal cortex in human behavior. His laboratory aims to understand the neural mechanisms underlying frontal cortex control of distributed neuronal ensembles critical for both cognitive and social behavior. The laboratory employs neuropsychological, electrophysiological, fMRI and neuroanatomical techniques to study prefrontal function in neurological patients. His laboratory also records the electrocorticogram directly from the human cortex in neurosurgical patients to obtain information on the oscillatory dynamics supporting human behavior. As part of this neurosurgical effort his lab has recently become interested in the area of brain machine interface. He is the recipient of a Jacob Javits Neuroscience Investigator Award from the National Institute of Neurological Disorders and Stroke, an IBM Award in Cognitive Computing and a Humboldt Prize in Neurobiology.