Presentation Title:

How input can drive neural firing throughout movement

Movement direction is strongly encoded in the firing rate of neurons throughout the nervous system. This robust signaling, recorded from the motor cortex, can be used directly to control prosthetic devices for those suffering from paralysis. In addition, this signaling can be used as a foundation for analytical techniques used to describe the way information propagates through biological networks.

In our applied studies, we have shown how firing rates recorded in parallel from populations of motor cortical neurons can be decoded to control a prosthetic arm and hand with 10 degrees-of-freedom. Using this technology, paralyzed human subjects can operate the prosthetic device to perform sophisticated, natural movements allowing them to carry out a variety of daily-living tasks.

We are studying the modulation of cortical neurons during reaching with the hypothesis that it is driven by various behavior-derived input taking place in distinct parts of the movement. Directional tuning of this input induces correlational structure capable of generating the directionality of motor cortical activity. Widespread correlation of neuronal firing is easily recognized with analyses using dimensionality reduction and can explain the temporal dynamics of motor cortical populations during reaching. Rather than considering motor function as deterministic, organized before the movement begins, these results show how ongoing input can drive neural firing throughout movement.

Correlational structure of neural activity is a prominent feature of the nervous system. A better understanding of how this structure comes about how it is used for information transmission will enhance our ability to build better decoders for restoring movement to those who are paralyzed.

Bio

Dr. Schwartz received his Ph.D. from the University of Minnesota in 1984 with a thesis entitled "Activity in the Deep Cerebellar Nuclei During Normal and Perturbed Locomotion". He then went on to a postdoctoral fellowship at the Johns Hopkins School of Medicine where he worked with Dr. Apostolos Georgopoulos, who was developing the concept of directional tuning and population-based movement representation in the motor cortex. While there, Schwartz was instrumental in developing the basis for three-dimensional trajectory representation in the motor cortex. In 1988, Dr. Schwartz began his independent research career at the Barrow Neurological Institute in Phoenix. There, he developed a paradigm to explore the continuous cortical signals generated throughout volitional arm movements.

This was done using monkeys trained to draw shapes while recording single-cell activity from their motor cortices. After developing the ability to capture a high fidelity representation of movement intention from the motor cortex, Schwartz teamed up with engineering colleagues at Arizona State University to develop cortical neural prosthetics. The work has progressed to the point that human subjects can now use these recorded signals to control motorized arm and hand prosthetics to feed themselves and perform other tasks of daily living. Schwartz moved from the Barrow Neurological Institute to the Neurosciences Institute in San Diego in 1995 and then to the University of Pittsburgh in 2002. In addition to the prosthetics work, he has continued to utilize the neural trajectory representation to better understand the transformation from intended to actual movement using motor illusions in a virtual reality environment.