"The Challenge of Closed-Loop Control for Brain-Machine Interfaces: Dissociating Motor Cortex from the Motor."

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During closed-loop control of brain-machine interfaces that use neuron spike firing rates to control a cursor, many neurons change their preferred direction, limb movements diminish, and eventually muscle contractions stop. Cortical neurons then continue to discharge in dissociation from the body movements they normally control. When switched from manual control to brain control, how does the brain realize that body movements are no longer necessary? Unless the decoding algorithm through which recorded neuron activity controls the cursor is perfect, the visual feedback of cursor motion no longer matches proprioceptive feedback coming from the moving body part. The brain then tailors its activity to drive the cursor, without regard to body movements, which therefore may cease.

But how can the activity of motor cortex neurons become dissociated from the body movements they normally control? Although spinal alpha-motoneurons have an obligatory synaptic linkage to muscle fibers, no other central neurons do. Many motor cortex neurons are known to be dissociable from movement. Some discharge in relation to the position of visual targets, dissociated from the direction of limb movement. Some represent kinematics, dissociated from the underlying forces (kinetics). And some cortical neurons that provide direct input to alpha-motoneurons can be functionally disconnected from those motoneurons. With such dissociations, the activity of many cortical neurons can continue in the absence of the body movements. Improved understanding of which cortical neurons can be most readily dissociated from bodily movement, and conditioned instead to function together in a new ensemble under voluntary control, may be of value in going beyond the capabilities of current brain-machine interfaces.