Session 247 - Reaching: Neurophysiology

Add To Itinerary

247.25 / TT7 - Error-related motor cortical activity transforms from output-null to output-potent dimensions

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Presenter at Poster
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Session Type
Poster

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Disclosures

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Abstract

The sensorimotor system must continuously monitor afferents so as to detect movement errors, compute a response, and then output this command to muscles. This constrains the system: error-related computation must be decoupled from causing movement until it has progressed enough to generate the appropriate correction. We investigated how this separation is achieved in the primary (M1) and dorsal premotor (PMd) cortex, areas in which activity can drive movement and strongly reflects sensory inputs signaling errors. We found that the 'output-null hypothesis' (Kaufman et al., 2014, Druckmann & Chklovskii 2012) is a mechanism by which error processing can occur in motor cortex without prematurely "leaking out" as output. This proposed mechanism takes advantage of the many-to-few mapping between motor cortex and its downstream movement-generating targets: because of this redundancy, there are many ways in which cortical neurons' activities can change while still "canceling out" as far as the downstream readout is concerned. For a simplified linear model of the network, this is equivalent to restricting motor cortical changes to the null space of the matrix mapping firing rates to movement.
To study neural dynamics following errors, we recorded from M1 and PMd of two rhesus macaques as they performed a 2D cursor task to which we added random mid-trial 'cursor jump' perturbations. In the first experiment, the monkeys controlled a computer cursor with their hand. We approximated the relationship between cortex and movement with a linear mapping, W, between firing rates and hand velocity. When we projected perturbation-evoked firing rate changes into the output-null and output-potent spaces of W, we observed that an output-null response preceded (putatively) output-potent changes by as much as 55 ms. While this result is consistent with our hypothesis, we recognize that W is only a rough estimate of the relationship between motor cortical activity and muscles. To address this limitation, we performed a second experiment in which the monkeys controlled the cursor via a brain-machine interface (BMI). This paradigm removes all intermediaries between motor cortex and its effector: the cortical output command is solely determined by the recorded neural population via a mapping, M, that we have full knowledge of. We observed output-null changes as early as 66 ms after perturbation, followed by (definitively) output-potent changes after 103 ms. This result shows that motor cortex can indeed isolate early error-

related activity through an internal output-null mechanism. It also suggests that sensory-evoked cortical activity need not interfere with ongoing BMI use.