The Top-down and Bottom-up Approaches to Studying Motor Learning

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Previous studies have demonstrated the critical role of motor cortical plasticity during both acquisition of new motor skills and recovery of motor functions from an injury such as stroke. A complete understanding of the plastic mechanisms involved necessitates the clarification of learning-induced changes at multiple levels of the motor system. I will discuss two separate experiments respectively designed for elucidating mechanisms of motor learning (and re-learning) through the top-down and bottom-up approaches. In the first experiment, we study how a motor-cortical stroke may change coordination strategies of muscle activations. We recorded electromyograms (EMGs) from 12–16 upper arm and shoulder muscles from both the unaffected and the stroke-affected arms of stroke patients. Analyses of the muscle synergies embedded within the EMGs revealed that the muscular compositions of the synergies for both the unaffected and the affected arms were strikingly similar to each other despite differences in lesion sizes and locations across patients. This suggests that post-stroke relearning of motor skills may be accomplished by modulating the activations of selected muscle synergies.
In the second study, we seek to discover differentially regulated genes in the motor cortex at different time points of motor learning through an unbiased genome-wide screening, accomplished by comparing the motor cortical transcriptomes before and after motor learning in the rat. We found that in the early phase of learning genes related to axonal growth and synaptic functions were modulated; in the later phase, as performance plateaued genes related to signal transmission across neurons and cell motility were differentially expressed. These results imply that skill acquisition involves first rewiring of motor cortical neurons, and then stabilization of the newly formed synapses through Hebbian mechanisms.