Refinement of Corticospinal Neuron Activity During Skilled Motor Acquisition

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Live Webinar
via Zoom Conference

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Abstract

The corticospinal tract is the principal mediator of skilled motor control. Cortical motor representations, or maps, depend on the underlying output of corticospinal and other corticofugal neurons. These maps are plastic and reorganize in response to skilled, but not unskilled, motor training. Modern optogenetic tools allow us to evaluate these networks by imaging endogenous activity of defined neurons over longitudinal studies. We used multiphoton imaging in concert with a head-fixed isometric pull task to record the effects of both skilled and unskilled training on the corticospinal circuit. Both tasks utilize the same muscle movements, and therefore are likely to engage the same motor circuits; however, only the skilled behavioral task was found to be dependent on the corticospinal system. We tracked forepaw corticospinal neuron activity over the course of motor task learning and found critical differences in the response to skilled and unskilled learning paradigms. The development of expertise occurred rapidly on an unskilled task and showed no significant correlation between corticospinal activity and movement kinetics; whereas development of skilled expertise required a refinement of movement kinetics and corresponding task-associated corticospinal neuron activity. Additionally, we found that disrupting corticospinal circuits results in a decorrelation of corticospinal neuron activity.

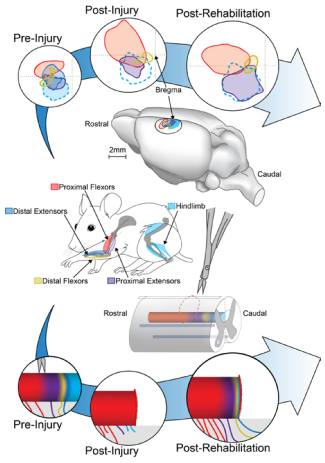

Figure. Model for plasticity within the motor cortex and spinal cord after SCI. Repeated optogenetic mapping of evoked motor maps (top insets) shows the early adaptation of maps after C5 dorsal column injury with increased forelimb flexor representation (red) and concurrent reduction of motor responses caudal to C5. Rehabilitation coincident with corticospinal regeneration promotes map reorganization: expansion of proximal extensor maps into de-efferented hindlimb regions. Serradj et al. Neurosci Lett (2017).

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2. Gu Z, Serradj N, Ueno M, Liang M, Li J, Baccei ML, Martin JH, Yoshida Y. Skilled Movements Require Non-apoptotic Bax/Bak Pathway-Mediated Corticospinal Circuit Reorganization. Neuron. 2017 May 3;94(3):626-641.e4. PubMed PMID: 28472660; PubMed Central PMCID: PMC5510485.
3. Serradj N, Paixão S, Sobocki T, Feinberg M, Klein R, Kullander K, Martin JH. EphA4-mediated ipsilateral corticospinal tract misprojections are necessary for bilateral voluntary movements but not bilateral stereotypic locomotion. J Neurosci. 2014 Apr 9;34(15):5211-21. PubMed PMID: 24719100; PubMed Central PMCID: PMC3983801.

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