This Week in The Journal

Competitive Interactions Shape Mature Spinal Circuits

Yu-Qiu Jiang, Boubker Zaaimi, and John H. Martin

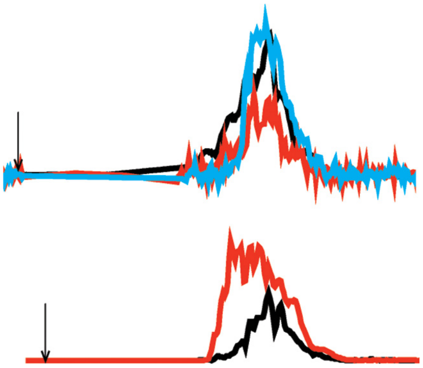
(see pages 193–203)

Early in nervous system development, far more axons are produced than are required for optimal target innervation. These axons compete with each other for synaptic space, and the winner expands its synaptic territory while the loser(s) retract. In most cases, the winner is determined by the activity patterns of the innervating axons, and experimenters can bias the outcome with appropriate electrical stimulation.

Such refinement is less apparent in the mature nervous system. For example, experimental manipulations typically fail to elicit significant axonal remodeling after a developmental critical period. But after spinal cord injury, spared axons sprout into denervated tissue, suggesting competitive interactions persist in adulthood. Jiang et al. tested this possibility by manipulating the activity of muscle proprioceptive afferents and examining the effect on innervation patterns in rat spinal cord.

As expected, transecting afferent nerve roots led to substantial loss of proprioceptive fibers and their synaptic terminals on motor neurons in the dorsal horn. The lesion did not affect the distribution of corticospinal tract (CST) axons in the spinal cord, but it did increase the density of synapses formed between CST axons and cholinergic interneurons and motor neurons, and it increased the number cholinergic terminals on motor neurons. These changes were associated with increases in the amplitude of muscle responses to motor cortical stimulation [motor evoked potentials (MEPs)] and decreased response latencies in the muscle. In contrast, stimulating forelimb muscle afferents for 10 d caused the area occupied by proprioceptive fibers in the dorsal horn to expand and increased the number of afferent terminals on motor neurons. At the same time, the density of CST axons and the number of CST synapses in the spinal cord were reduced, as was the number of cholinergic terminals on motor neurons. Correspondingly, there was a decrease in MEP amplitude after primary-afferent stimulation.

These experiments suggest that activity-dependent competitive interactions help to maintain circuits in the mature spinal cord. This may have important clinical implications: minimizing competition from peripheral afferents might promote sprouting of CST axons, which may improve functional recovery after injury. Conversely, electrically stimulating muscles, which has been proposed as a mechanism to speed functional recovery, may have detrimental effects by inhibiting CST sprouting.



Averaged electromyograph recordings from rat extensor carpi radials muscles during stimulation of primary motor cortex before (black), right after (red), and 1 month after (blue) prolonged electrical stimulation of the muscle (top) or dorsal root transection (bottom). Electrical stimulation reduced the response amplitude, whereas transection increased the amplitude. See Jiang et al. for details.

Corollary Discharge Signal in Thalamus Shapes Perception

James Cavanaugh, Rebecca A. Berman, Wilsaan M. Joiner, and Robert H. Wurtz

(see pages 31–42)

As we observe a scene, our eyes dart from place to place, allowing our foveae to obtain high-resolution images of different objects. During each saccade, the position of every object's image on the retina shifts, and at the end point, the retina sends the brain a new snapshot of the world. Despite receiving a stream of shifting images, however, the brain perceives a stable, largely stationary world, and we can distinguish object displacements resulting from our own eye movements from those resulting from object motion. How we accomplish this seemingly effortless task is only partially understood, but it clearly requires visual processing areas to know the amplitude and direction of each saccade. Coherent movement of object images and proprioceptive feedback from ocular muscles provide some information about eye movement, but the most important source of information is the corollary discharge: a copy of the saccade command that is sent to visual processing centers.

In monkeys, a corollary discharge travels from the superior colliculus to the medial dorsal nucleus of the thalamus (MD), and from there to the frontal eye fields, where it causes neuronal receptive fields to shift in anticipation of the saccade endpoint. Whether this signal contributes to perception has been debated, but Cavanaugh et al. now provide evidence that it does. They had monkeys report whether a target was displaced to the left or the right of its original position while a saccade was in progress. Previous work has indicated that a corollary discharge signal, rather than the postsaccade eye position, is used to make this judgment. Inactivating the MD impaired monkeys' performance on this task without changing the amplitude or direction of saccades.

These results support the hypothesis that the corollary discharge signal that passes through the MD contributes to perception. Specifically, this signal helps observers differentiate retinal displacements resulting from their own eye movements from displacements caused by movement of the observed stimulus. Whether it also contributes to visual stability remains to be demonstrated. In any case, a similar deficit to the one observed here has been reported in schizophrenics, and therefore these results support the hypothesis that some deficits in schizophrenia result from impaired use of corollary discharges.

This Week in The Journal is written by Teresa Esch, Ph.D.