This Week in The Journal

Layer-Specific Effects of Inhibition on V1 Properties

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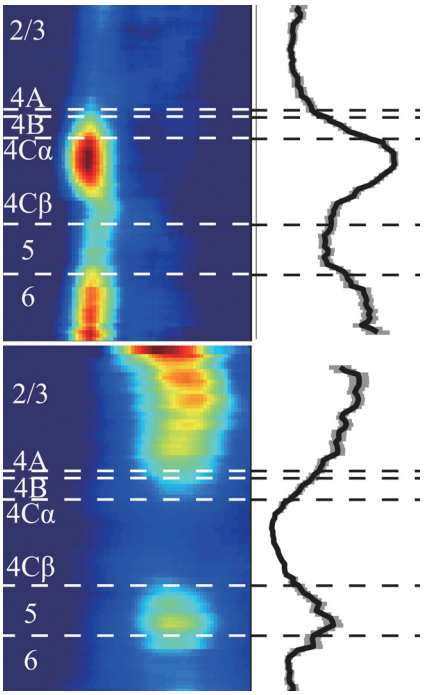
(see pages 7436–7450)

The cerebral cortex has a laminar organization with layer-specific cell types and connectivity patterns. Although much is known about the overall organization of cortical circuits, how each layer contributes to cortical function remains poorly understood. Questions remain even about one of the best studied cortical functions: the encoding of orientation selectivity in primary visual cortex (V1). Hubel and Wiesel suggested that neurons in layer 4c (L4c) of V1 generate orientation selectivity by combining input from several thalamic neurons that respond to adjacent points in space. Yet how this orientation selectivity develops over time across V1 layers and how local inhibition shapes these responses are less clear.

To address these questions, Wang et al. used linear electrode arrays to record neurons across all V1 layers as monkeys viewed flashing gratings of various orientation. As expected, the main thalamorecipient cortical layers (L4c and L6) responded to visual stimuli before neurons in output layers (L2/3, L4b, and L5). Population responses to gratings of the preferred orientation decayed more slowly than responses to the orthogonal, nonpreferred orientation, and responses decayed more slowly in output layers than in input layers. Notably, responses to nonpreferred stimuli sometimes dipped below baseline in input layers ~50–60 ms after stimulus onset, and responses to preferred stimuli reached a negative peak in output layers ~100 ms after stimulus onset. Computer modeling indicated that these responses could be explained by a linear combination of one excitatory component and two suppressive components: a fast component targeting input layers, and a slow component targeting output layers. Additional analyses revealed that the strength of orientation tuning in both L4c and L2/3 was negatively correlated with the strength of fast suppression in L4c. Slow suppression had minimal impact on orientation tuning, but was positively correlated with response suppression when the visual stimulus was larger than optimal.

These data suggest that fast suppression in L4c of V1 enhances orientation selectivity by reducing responses to nonpreferred stimulus orientations, whereas slow suppression in L2/3 contributes to surround suppression. Other mechanisms likely enhance orientation selectivity in L2/3. Similar combinations of excitation and suppression may contribute to other forms of feature selectivity in V1 and in other cortical regions.



Mean strength of fast (top) and slow (bottom) suppression across cortical depth (*y*-axis) and time after stimulus onset (*x*-axis). Dashed lines indicate layer boundaries. See Wang et al. for details.

Exercise, Stress Resilience, and Locus Ceruleus Galanin

Rachel P. Tillage, Genevieve E. Wilson, L. Cameron Liles, Philip V. Holmes, and David Weinshenker

(see pages 7464–7474)

Regular exercise improves mood and cognition, reduces stress, and increases resilience to subsequent stressors. These effects are mediated by multiple signaling pathways that affect synaptic plsticity and neuronal health in several brain areas. Much evidence suggests that exercise promotes stress resilience by increasing production of the neuropeptide galanin in the locus ceruleus, a structure that drives stress responses by releasing norepinephrine throughout the brain. Galanin is expressed in most locus ceruleus neurons, and it can inhibit spontaneous spiking in noradrenergic neurons. Notably, chronic exercise increases galanin levels in the locus ceruleus of rats, and intracerebroventricular infusion of a galanin antagonist blocks the ability of exercise to increase stress resilience. Moreover, intracerebroventricular infusion of galanin increases stress resilience in rats. Because intracerebroventricular treatments can affect galanin signaling in many brain areas, including hypothalamic nuclei involved in stress responses, Tillage et al. examined the effects of overexpressing galanin selectively in noradrenergic neurons in mice.

The authors first confirmed that 3 week access to a running wheel increased exercise, galanin expression, and stress resilience in mice. Indeed, mice ran 10–16 km/d by the third week of wheel access, and galanin expression in the locus ceruleus of these mice was higher than in sedentary controls. Notably, locus ceruleus galanin levels were correlated with the amount of running and with levels of anxiety-like behavior after footshock stress. In particular, whereas stress caused sedentary mice to spend less time in the open arms of an elevated zero maze the next day, it had no effect on mice that had exercised. Importantly, overexpressing galanin in noradrenergic neurons replicated the effects of exercise—preventing stress-induced increases in anxiety-like behavior in the elevated zero maze—but had no effect on baseline behavior or on acute responses to footshock. Finally, optogenetic activation of the locus ceruleus replicated the effects of footshock stress, and overexpressing galanin in the locus ceruleus blocked this effect.

These data strengthen the hypothesis that increases in galanin expression in the locus ceruleus mediate the effect of exercise on stress resilience. Whether this effect stems from suppression of noradrenergic neuronal activity, effects on locus ceruleus target regions, or both should be examined in future studies.

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