Cortical map constraint on neuronal learning

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Abstract

Topographic representations of the peripheral sensory organs are a prominent feature of primary sensory areas in the cerebral cortex. In particular, the primary somatosensory cortex of rodents is composed of spatially separated "barrel" columns, corresponding each to a different whisker on the snout of the mice. Although this topographical representation of the peripheral sensory organ has been characterized for decades, its functional role remains unknown. This is partly due to the lack of methods to control arbitrary somatosensory inputs in the awake behaving mouse. Here we train mice to a task in a cortical closed-loop brain-machine interface that includes an optogenetic feedback that activates each individual barrel of the barrel cortex topographical organization. We show that the biomimetic topographical organization of the feedback is necessary to ensure that learning occurs, and we provide evidence that the mouse enhanced performance stems from stronger integration of sensory feedback in the motor control. These findings support the view that cortical maps are necessary for efficient cortical sensory-motor integration, and should therefore be fully considered when designing a closed-loop cortical brain-machine interface for clinical applications.

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sciencesconf.org:neuralnet2019:296980