Dissociating the Roles of the Cerebellum and Motor Cortex During Adaptive Learning: The Motor Cortex Retains What the Cerebellum Learns

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Abstract

Adaptation to a novel visuomotor transformation has revealed important principles regarding learning and memory. Computational and behavioral studies have suggested that acquisition and retention of a new visuomotor transformation are distinct processes. However, this dissociation has never been clearly shown. Here, participants made fast reaching movements while unexpectedly a 30-degree visuomotor transformation was introduced. During visuomotor adaptation, subjects received cerebellar, primary motor cortex (M1), or sham anodal transcranial direct current stimulation (tDCS), a noninvasive form of brain stimulation known to increase excitability. We found that cerebellar tDCS caused faster adaptation to the visuomotor transformation, as shown by a rapid reduction of movement errors. These findings were not present with similar modulation of visual cortex excitability. In contrast, tDCS over M1 did not affect adaptation, but resulted in a marked increase in retention of the newly learned visuomotor transformation. These results show a clear dissociation in the processes of acquisition and retention during adaptive motor learning and demonstrate that the cerebellum and primary motor cortex have distinct functional roles. Furthermore, they show that it is possible to enhance cerebellar function using tDCS.