Multiple facets of the cerebello-cerebral coupling in motor systems

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Abstract

Motor sequence learning has been shown to involve several brain structures, including the cerebellum, the basal ganglia and the motor cortex. The cerebellum is connected to the two other structures by way of distinct pathways. Here, we evaluated the contribution of the cerebello-thalamic pathways targeting the basal ganglia and motor cortex to the acquisition, consolidation and maintenance of a skilled locomotor task in mice.
We first found a decrease in the cerebellar nuclei activity during the consolidation and maintenance phases but not in the acquisition phase of the task, while motor cortex and striatum activity increased during the acquisition phase. We found that the activity in the intralaminar thalamus, which projects to the basal ganglia, increased in all the phases while the activity in the motor thalamus, which projects to the motor cortex, only increased in the acquisition and consolidation phases. We then examined the impact on learning of a specific and transient inhibition of cerebellar nuclei neurons using hM4Di-DREADDs. The inhibition of cerebellar nuclei neurons produced impairment in the

beginning of the consolidation phase and during the maintenance phase, suggesting that cerebellum has a dual contribution to learning. We then targeted specific cerebello-thalamic pathways by combining injections of viruses in the thalamus and in the cerebellar nuclei. The results revealed
that the pathways targeting the intralaminar and motor thalamus contributed respectively to the maintenance and consolidation phases of learning. In conclusion, our results suggest that two parallel cerebellar-thalamic pathways perform distinct computations operating on distinct timescales in motor learning.

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