



## Supervised Mechanisms for Locomotor Learning Driven by Climbing Fibers

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Motor learning is essential to move in a continuously changing environment, but the underlying neural mechanisms are still poorly understood. This is critical for locomotion, a fundamental but complex behavior, which requires simultaneous control of multiple limbs across the body. The cerebellum plays a key role in motor learning [1], generating anticipatory corrective movements through supervised error-based mechanisms, driven by instructive signals in response to perturbations - in accordance with the canonical theory [2,3]. For simple tasks, climbing fibers originating in the inferior olive and projecting to the cerebellum drive supervised learning [4-6]. However, for complex whole-body behaviors like locomotion, whether and how climbing fibers encode instructive signals is still unknown. We recently demonstrated [7] that mice running on a split-belt treadmill - where the speeds under each side of the body are controlled independently - exhibit a form of motor learning called locomotor adaptation, which is cerebellum-dependent and reflects learned changes in interlimb symmetry. Here, we applied closed-loop optogenetics controlled by real-time tracking of limb kinematics to test the hypothesis that the timing of climbing fiber signals encodes instructive signals for supervised learning during locomotion. We find that optogenetic perturbations of climbing fibers, precisely locked to specific phases of the locomotor cycle, are sufficient to drive bidirectional, learned changes in interlimb symmetry, depending on the phase of the locomotor cycle in which they occur. We are now combining these behavioral results with electrophysiological measurements, temporal basis functions and supervised learning rules to model how this remarkable precision of climbing fiber timing is used by the cerebellum to effectively and robustly drive learning during locomotion.

**locomotor adaptation, supervised learning, cerebellum, optogenetics, electrophysiology**