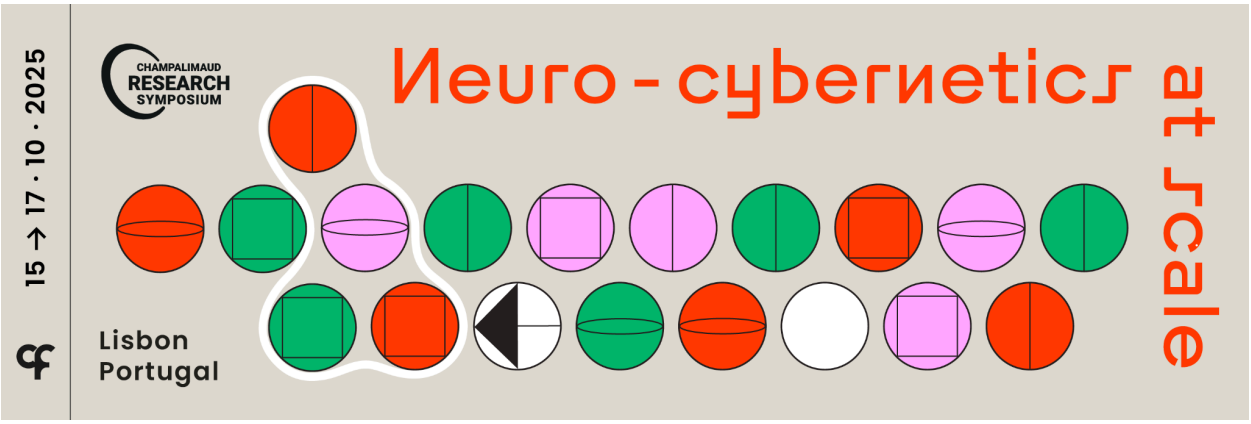

Contributions of Basal Ganglia and Cerebellum to Discrete and Continuous Behavioral Control

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Adaptive behavior requires selecting appropriate actions and executing them effectively, a process that depends on coordinated activity across distributed brain systems, including the basal ganglia (BG) and cerebellum (CB). Lesions to either structure produce distinct impairments, suggesting they function as dissociable modules within a hierarchically organized yet parallel network [1,2,3,4]. To assess their respective roles in motor control, we examined the effects of BG and CB ablations in mice performing multiple variants of a water reaching task. We found a striking double dissociation: CB-ablated mice succeeded in the head-fixed task but failed in the freely moving version, which requires full-body coordination; BG-ablated mice showed the opposite pattern, failing in the head-fixed task where demands on action selection are greater. Additionally, CB-ablated mice could recruit piecewise primitives for reaching, but their movements were less smooth and reach trajectories were more stereotyped, within and across animals. In contrast, BG-ablated mice preserved movement execution but exhibited biases towards richer sensory-feedback movements, abnormal action transitions, and failure to suppress competing actions. To build on these results, we developed the select-and-collect task, a paradigm designed to temporally parse demands on action selection and execution. Simultaneous recordings from BG and CB revealed distinct dynamics: BG activity spanned the trial and peaked at reward collection, while CB activity was locked to movement and modulated by ongoing kinematics. Notably, CB activity consistently led reach kinematics, whereas BG activity lagged. These findings support a functional dissociation, where BG supports discrete control–intermittently selecting actions and modulating vigor; while CB supports continuous control–refining movement in high-dimensional spaces.

motor control, basal ganglia, cerebellum, behavior, electrophysiology