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A multiarea model predicts the changes in thalamocortical beta oscillations caused by dopamine depletion in basal ganglia and cerebellum

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Research on parkinsonism underscored the central roles of basal ganglia alterations and dopamine level reductions in symptom emergence [7]. Recent studies, however, hint at cerebellar involvement in altered parkinsonian brain activity [8, 2]. To unravel the role of this region in parkinsonism, we developed an innovative multiscale, multiarea brain model, aiming to investigate neural dynamics in both healthy and parkinsonian states. This model integrates microcircuits of the BG [4] and cerebellum [3], employing spiking neural networks (SNN), which also simulate dopamine depletion mechanisms, and includes a three-equation mass model of the cortex, thalamus and reticular nucleus, reproducing the loops these areas engage in [9]. After validation with respect to the stand-alone SNN circuits, [3, 4], we tested the model first in a generic motor state. We found that the resemblance between our simulations and experimental data [5, 6], as indicated by matching population firing rates and enhanced beta band oscillations, was notably more pronounced when dopamine-depletion effects occurred in both the cerebellum and BG (compared to BG alone), emphasizing a more direct involvement of the cerebellum in parkinsonism. Lastly, we simulated a behavior protocol, eyeblink classical conditioning, incorporating plastic mechanisms at the cerebellar level [1] under both physiological and pathological conditions. Results indicate that despite altered cellular structure, the cerebellum exhibits adaptive capabilities, albeit with reduced effectiveness compared to the physiological state. In summary, our findings stress the significance of recognizing the cerebellum's role in parkinsonism to fully grasp the intricate neural mechanisms underlying the related disorders.

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Talk (& optional poster)

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Topic area

Models and applications

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