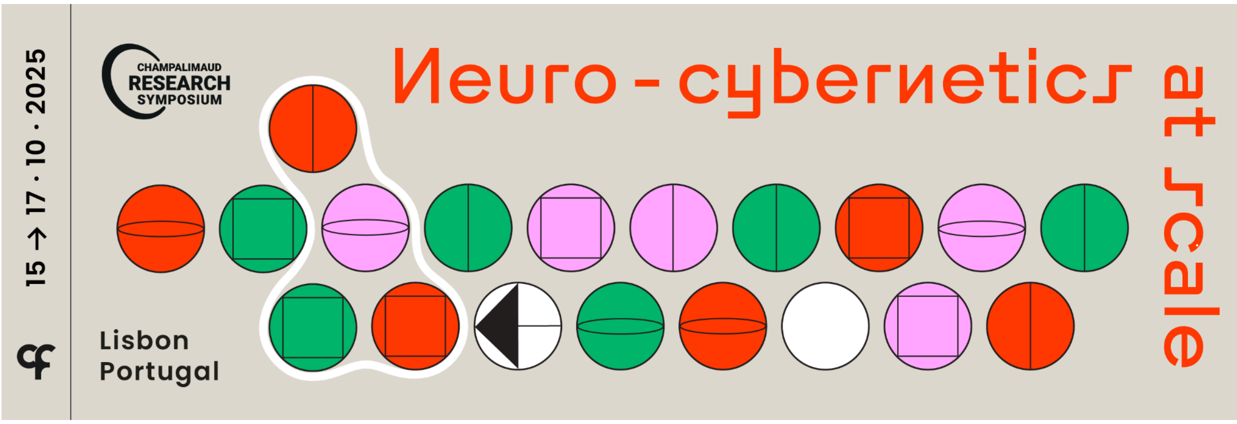

A Transient Neural Code for Feedback-Driven Motor Corrections During Reaching

Nina Kudryashova [1], Cole Hurwitz [2], Matthew G. Perich [3-4], Matthias H. Hennig [1]
1. School of Informatics, University of Edinburgh; Informatics Forum, 10 Crichton St, Newington, Edinburgh EH8 9AB, United Kingdom
2. Zuckerman Institute, Columbia University; 3227 Broadway, New York, NY 10027, United States
3. Département de neurosciences, Faculté de médecine, Université de Montréal; Pavillon Roger-Gaudry, 2900 Edouard Montpetit Blvd, Montreal, Quebec H3T 1J4, Canada
4. Mila, Quebec Artificial Intelligence Institute; 6666 Rue Saint-Urbain, Montréal, QC H2S 3H1, Canada

Neural activity in motor cortical areas is well-explained by latent neural population dynamics: the motor preparation phase sets the initial condition for the movement while the dynamics that unfold during the motor execution phase orchestrate the sequence of muscle activations [1-2]. While preparatory activity explains a large fraction of both neural and behavior variability during the execution of a planned movement [1], it cannot account for corrections and adjustments during movements as this requires sensory feedback not available during planning.
Here, we provide evidence that feedback-driven corrections during movement correspond to transient deviations from an autonomous neural population trajectory, which cannot be found by unsupervised inference methods. Yet, since these deviations are intimately tied to behavioral states, they can be captured with behavior supervision.
We analyzed neural recordings from monkeys performing a center-out reaching task with a force field perturbation (data from [3]). Movement in the force field gave rise to oscillations in hand velocity. These hand oscillations can be decoded by a biRNN decoder, yet the corresponding latent dynamics cannot be identified by unsupervised inference methods (e.g. AutoLFADS [4-5] or CEBRA [6]).
We introduce the new Behavior-Aligned Neural Dynamics (BAND) model, which exploits semi-supervised learning to extract latent dynamics that predicts both planned and unplanned movements from neural activity in the motor cortex. Our analysis using BAND suggests that motor corrections during movement are 1) encoded on the population level in small neural variability in primary motor (M1), but not dorsal premotor (PMd) cortex; 2) correspond to transient deviations from an autonomous neural population trajectory; and 3) are driven by sensory feedback, which reaches the motor cortex with an approximately 90 ms delay.

feedback-driven motor control, sensorimotor coupling, latent neural dynamics, behavior supervision