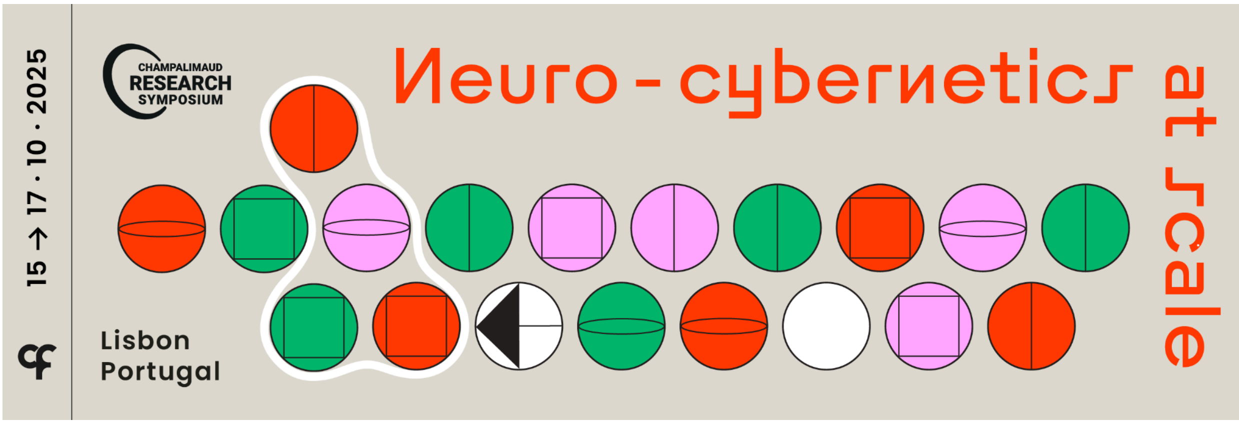


# Motor Cortex Encodes Speed Through Temporal Scaling of Latent Population Dynamics

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Skilled movements require precise control of their speed, yet how the motor cortex encodes speed remains unresolved. One proposal—the axis hypothesis—suggests that different speeds of the same movement are generated by distinct trajectories of neural activity along a speed axis. An alternative, the traversal hypothesis, posits that different speeds are generated by how quickly a fixed neural trajectory unfolds over time. To evaluate these competing accounts, we analysed intracortical recordings from PMd and M1 in monkeys performing a random-target arm reaching task [1]. Since movement speed and length co-vary in reaching tasks, we isolated the effects of speed by analysing only reaches of a fixed length. We found that neural trajectories diverged before movement onset in proportion to the angular difference between upcoming movement directions. RNN modelling of the traversal hypothesis predicted that these trajectories' maximum divergence should occur later for slower movements and that their maximum traversal rate should correlate with upcoming movement speed; both predictions were confirmed in PMd and M1 data. To directly contrast the hypotheses, we asked if neural trajectories for the same direction of upcoming arm movement were ordered by its speed, but found they were not; indeed they were no more distinct than were trajectories of the same upcoming movement speed before the start of movement preparation, contradicting the axis hypothesis. These results support the traversal hypothesis, suggesting that movement speed is encoded not by switching between distinct neural trajectories, but by modulating the timing of transitions within a shared neural state sequence. Understanding this encoding mechanism could improve the design of brain-machine interfaces by enabling more precise decoding of intended movement speed from neural activity.

**motor cortex, speed encoding, population dynamics, motor control**