Computation as dynamic control of neural and synaptic manifolds

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Over the past decades, technological advances have allowed neuroscience to shift its focus from single neurons to populations. A prevailing framework has emerged, characterizing neural activity dynamics in different brain areas as low-dimensional manifolds within the N-dimensional state space of neural activity. Across cognitive, sensory, and motor domains, patterns of neural activity can be understood as trajectories in this state space. When an animal learns or flexibly performs a sequence of behaviors, neural trajectories and the neural manifold dynamically adapt and change on slow and fast timescales. My work aims to uncover circuit mechanisms that can dynamically control neural trajectories and the neural manifold to support flexible behavior and learning. To do this, we map mechanisms in the circuit to statistics of neural activity and ultimately to features of neural trajectories and the manifold. The idea is to find “control knobs” in the circuit that may be exposed to other interconnected brain regions, with the hypothesis that the brain uses these knobs to implement behavioral flexibility on fast timescales and to learn better representations on slower timescales.