Department of Applied and Computational Mathematics and Statistics Colloquium

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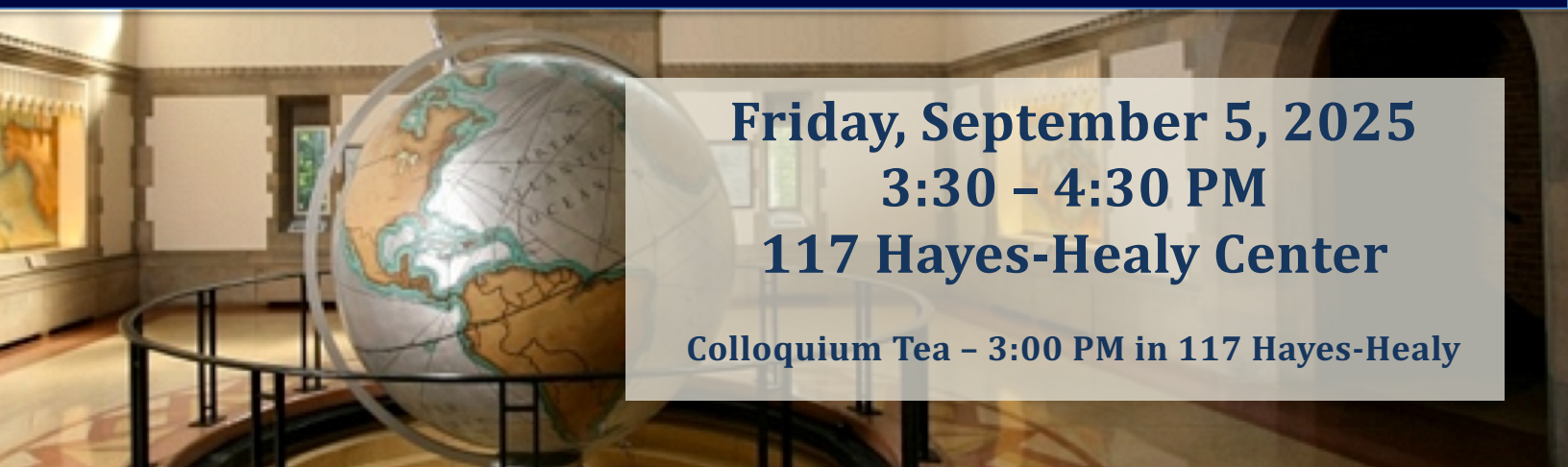
Firing Rate Diversity Lowers Population-Wide Neuronal Variability

Populations of neurons produce activity with two central features. First, neuronal responses are very diverse -- specific stimuli or behaviors prompt some neurons to emit many action potentials, while others remain relatively silent. Second, the trial-to-trial fluctuations of neuronal response occupy a low dimensional space, owing to significant correlations between the joint activity of neurons. These two features define the quality of neuronal representation. We link these two aspects of population response using a recurrent circuit model and with techniques from Free Probability theory applied to random matrices we derive the following relation: the more diverse the firing rates of neurons in a population, the lower the effective dimension of population trial-to-trial coverability. This surprising prediction is tested and validated using multiple population datasets from numerous brain areas in mice, non-human primates, and in the motor cortex of human participants. Using our relation, we present a simple theory where a more diverse neuronal code leads to better fine discrimination performance. In line with this theory, we show that neuronal populations across the brain exhibit both more diverse mean responses and lower-dimensional fluctuations when the brain is in more heightened states of information processing. In sum, we present a key organizational principle of neuronal population response that is widely observed across the nervous system and acts to synergistically improve population representation.



Friday, September 5, 2025
3:30 – 4:30 PM
117 Hayes-Healy Center

Colloquium Tea – 3:00 PM in 117 Hayes-Healy