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Mechanisms underlying neuronal variability and its impact on perceptual decisions

The activity of cortical neurons seems inevitably variable. In sensory circuits, this variability predicts perceptual decisions. This relationship, quantified by choice probability, seems to arise from sensory variability biasing behavior as well as from top-down signals reflecting behavior. It is not clear, however, (1) what causes sensory variability and (2) how bottom-up and top-down mechanisms work together because, in a putatively recurrent network, bottom-up sensory signals can recruit top-down inputs that in turn could modulate sensory signals. We will present a hierarchical network model composed of reciprocally connected sensory and integration circuits to study the dynamics of choice probability. We will first investigate the underlying mechanisms causing correlated firing among sensory neurons. We will show that shared inputs, the commonly though mechanism giving rise to correlations, can yield nearly uncorrelated spiking provided the circuit, composed of excitatory and inhibitory neurons, works in the balanced regime. We will then simulate a fixed-duration motion discrimination task and analyze the dynamics of choice probability. We will show that this is generally composed of both bottom-up and top-down components with complementary time-courses arising from the recurrent interaction across the hierarchy. We will finally test some of the predictions of the model using recordings from monkey area MT. Finally we will discuss the functional consequences of top-down feedback in the dynamics of sensory integration. Our findings contribute to build a unified understanding of the circuit dynamics linking neural and behavioral variability.