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The computational role of the feedforward inhibition in the striatum network

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Basal ganglia are a major neural system implicated in important behavioral tasks such as action selection, reward-based learning and motor control. Striatum is the main input stage of the basal ganglia and receives massive convergent cortical afferents. Although a wealth of anatomical and electrophysiological data have been accumulated about the striatum, computational models to understand information processing in the striatum network are lacking.

To understand information processing in the striatum, we developed a spiking neuron network model of the striatum based on existing physiological and anatomical data. The network was simulated using a Python interface to NEST [1]. We considered two populations of neurons, namely, medium spiny neurons (MSNs) and fast spiking interneurons (FSIs). MSNs are the main cell type in the striatum and represent over 95% of the neuron population. The recurrent connections among MSNs provide weak and sparse feedback (FB) inhibition. The major type of GABAergic interneurons in the striatum is FSI, which projects to the MSNs extensively and forms strong feedforward (FF) inhibition.

First we studied the role of FF and FB inhibitions in shaping the dynamics of the striatum network. The FF inhibition set a brief time window for the MSNs to spike and thus reduced the overall excitability of the network. Further, strong FF inhibition synchronized the firing pattern of the MSNs. On the other hand, the weak and sparse FB inhibition among the MSNs had a desynchronizing effect.

In addition, we characterized the input-output transfer function of the striatum network for correlated and uncorrelated inputs that mimic the cortico-striatal afferents by selectively activating a subset of MSNs and FSIs. Such activation resulted in a corresponding decrease in the spiking of unstimulated neurons mainly mediated by the FF inhibition. This is similar to the neural activity recorded in striatum in behaving rats [2]. Thus, the FF inhibition plays a critical role in improving the signal-to-noise ratio of the cortical inputs in the striatum.

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