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Redundant Population Encoding of Movement by the Basal Ganglia and Thalamus

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Introduction

The use of deep brain stimulation (DBS) to treat children with secondary dystonia is challenging since the optimal target can be difficult to localize. At Children's Hospital of Los Angeles, patients with secondary dystonia, undergo a monitoring procedure, using depth electrodes to identify DBS targets. Single-cell action potentials, LFP, EEG and EMG activity are recorded over a period of 5 days. This provides a wealth of neurophysiology data over a range of spatial scales in awake patients. Here, we focus on characterizing multineuron interactions in basal ganglia and thalamic nuclei.

Methods

We record from basal ganglia and thalamic nuclei in children with secondary dystonia. Spike data is sorted and the firing patterns of groups of 3-5 neurons are measured. We fit three types of maximum entropy models: an independent model, without interactions between neurons; a pairwise model with interactions between all pairs of neurons; and a common-input model where all neurons receive a common synaptic drive. We then compare the rates of firing patterns observed to the model predictions. To determine the effect of movement, we perform the described analysis conditioned on left or right-sided EMG activity.

Results

We find that the independent model frequently fails to predict the observed firing patterns, but the pairwise model is an almost perfect model. Interestingly, the common-input model, which has fewer parameters than the pairwise model, performs almost as well. Using the firing patterns conditioned on movement direction, we find that correlations between neurons act to decrease the amount of information transmitted – a form of redundant coding.

Conclusions

Pairwise interactions nearly completely account for the structure of multineuron firing patterns within the basal ganglia and thalamus. A model of common synaptic input is a reasonable approximation. Movement encoding is redundant allowing for information transmission even when some data is lost.

Learning Objectives

By the end of the talk, participants should be able to understand the effect of movement direction on neuronal population activity in the basal ganglia and thalamus.

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