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Irregular firing activity of globus pallidus neurons

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In vitro electrophysiological recordings were made on globus pallidus neurons of rat (14-28 d) brain slices using cell attached, whole cell, and perforated patch clamp techniques. The cells fired spontaneously in a rhythmic single spiking pattern under control conditions. The interspike interval (ISI) distribution showed a prominent peak, and the spike time autocorrelogram showed periodicity corresponding to the dominant average frequency of the cell. But a substantial standard deviation (SD) associated with spike to spike variability of the ISIs was observed. This variability persisted even under pharmacological blockade of GABA-A, GABA-B, AMPA and NMDA receptors. The cell population (more than 20 cells) fired at a variety of average frequencies (ranging from 3 Hz to 30 Hz) with the corresponding ISI histogram widths varying with their mean. Faster cells showed narrower ISI distributions, and slower cells showed broader distributions. The SD of the intervals was found to be related to its firing rate via a simple and approximate hyperbolic relationship. Long duration recordings (up to an hour) of spontaneous activity of the cells showed that each cell undergoes spontaneous changes in firing rates. Such changes spanned windows of 1 Hz to 10 Hz or more, and the corresponding SDs vs. the local mean firing rates again showed a hyperbolic relationship similar to the population trend. Experimental modification of firing rates by steady applied current also reproduced the hyperbolic relation. The variability in the population can thus be accounted for by asynchronous variations of spike times of single cells. Our ISI sequence analysis indicates that the ISI variability stems from fluctuations of cycle lengths, probably caused by discrete oscillatory mechanisms, rather than noise driven threshold crossings of the membrane.