TIME PRECISION OF HIPPOCAMPAL CA3 NEURONS

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The time precision with which neurons fire action potentials (APs), together with the reliability of this process limit the possible spectrum of neuronal codes used by the nervous system (NS). Such codes probably evolved in the NS under a selective evolutionary pressure, which optimally bypass "weaker" and exploit "stronger" features of the NS to preserve during processing as much information as possible. It would be therefore convenient for the NS to use neuronal codes that enable neuronal responses to be maximally reproducible, supposing they represent a product of neuronal computation of spatio-temporal relations between synaptic inputs. Different concepts about neuronal coding have been proposed, some of them suppose information is encoded by precise occurrences of APs (*temporal codes*; Abeles et al., 1994), the others state that only average frequency, measured during relevant time window, represents information (*rate codes*; Shadlen and Newsome, 1994). For *temporal codes* be plausible, neurons should be endowed with mechanisms enabling them to generate APs with sufficient reliability and time precision. To what extent are neurons able to employ *temporal coding* depends partly on the temporal richness of their inputs, on the arrangement of neuronal "hardware" and also on the neuronal noise interfering with the signal. The last feature causes the process of spike encoding is noisy, which results in variable timing of individual APs in response to identical inputs (Schneidman et al., 1998). In many sensory systems it is relatively easy to assess this time precision experimentally, however in other systems the neuronal activity do not correlate with available stimuli so apparently. This does not imply such neurons are less precise, and we tried to demonstrate this by analyzing available hardware of such neurons using the biologically realistic modeling.

In the software environment GENESIS 2.2, we constructed a multicompartmental model of rat CA3 hippocampal neuron, consisting of soma, dendritic tree and axonal initial segment (IS). In the model channel and thermal noise were implemented, corrupting the propagation of postsynaptic signal at the soma-dendritic (SD) membrane and the AP initiation at the IS. During simulations, random spatio-temporal patterns of synaptic activity were presented to the neuron repeatedly and elicited sequences of APs were analyzed by peri-stimulus time histograms (PSTHs) and statistically processed. Various levels of synaptic redundancy – representing number N of unreliable synapses that each presynaptic neuron send to the SD membrane – and various probability P of synaptic vesicle release, were studied. The time precision and reliability of AP generation by repeated stimulation with identical input reflect the reproducibility of neuronal response. The reproducibility was mostly influenced by unreliable synaptic transmission and was strongly dependent on the values N and P. The channel noise was about an order less corruptive than the synaptic unreliability, causing the time precision of neuronal responses to vary from submilliseconds to tens of microseconds, depending on the spatiotemporal arrangement of synaptic events and on the synaptic redundancy.

Acknowledgments
Supported by the GAUK grant no. 203212 32/05 and by the GACR grant no. 305/05/P198.

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