Stochastic mechanism for improving selectivity of olfactory projection neurons

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Primary reception of odors happens in the olfactory receptor neurons (ORN). The ORNs synapse onto the mitral cells of olfactory bulb. These cells, known as bulbar projection neurons (PN), or secondary neurons convey odor signals to olfactory cortex. It is known that discriminating ability in PN is better than that in ORN. An established point of view is that better selectivity in PN is due to lateral inhibition. Lateral inhibition of PNs happens due to activity of inhibitory bulbar neurons. Recruitment of the inhibitory neurons takes place for high odor concentrations and decreases with decreasing concentration. Therefore, efficacy of lateral inhibition in improving selectivity of PNs should decrease for low concentrations. Such a decrease has been observed experimentally.

In this talk, another mechanism is proposed for selectivity gain in PNs, which is independent of lateral inhibition and could be as well efficient for low concentrations. This mechanism takes place for individual PN without involvement of other bulbar cells. The prerequisites of this mechanism are as follows: (i) the random nature of stimuli obtained by PN from ORNs, (ii) the threshold-type response of PN on those stimuli, (iii) the leakage in the PN's membrane. Similar mechanism is also possible in individual ORNs, as well as in "electronic nose" sensors based on adsorption-desorption of odors.

Here, as a PN model the neuronal model is used, which has been proposed before, [1]. Activity of single ORN is described as a Poisson process. As a result of detailed mathematical analysis it is concluded that PN's selectivity can be several tens times better than that of ORN due to the mechanism proposed.

References

[1] V. S. Korolyuk, P. G. Kostyuk, B. Ya. Pjatigorskii, and E. P. Tkachenko. Mathematical model of spontaneous activity of some neurons in the CNS. *Biofizika*, 12(5):895–899, 1967.