BMC Neuroscience

BioMed Central

Poster presentation

Open Access

Optimal odor intensity in olfactory neuronal models

Ondrej Pokora*[1,2] and Petr Lansky[1,2]

Address: [1]Department of Mathematics and Statistics, Masaryk University, Kotlarska 2, 61137 Brno, Czech Republic and [2]Institute of Physiology, Academy of Sciences of Czech Republic, Videnska 1083, 14220 Prague, Czech Republic

Email: Ondrej Pokora* - pokora@math.muni.cz

* Corresponding author

from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P118 doi:10.1186/1471-2202-10-S1-P118

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P118

Signal processing in olfactory systems is initiated by binding of odorant molecules to receptor molecules embedded in the membranes of sensory neurons. Different models of olfactory sensory neurons (concentration detectors, flux detectors) have been investigated [1]. Their behavior is described by stochastic processes of binding and activation [2]. The models assume that the response, concentration of activated receptors, is determined by the signal, the fixed log-concentration of odorant in perireceptor space. Dependency of the mean response on the signal is realized through the input-output function. How the concentration of activated receptors can code the intensity of odorant is analyzed using statistical properties of the steady-state responses. A deterministic approach to the problem of finding a suitable signal is based on the steepness of the input-output transfer function. The measure of optimality is the first derivative of the input-output function. For the usual sigmoidal shape, the best detectable signal is located at inflexion point of the curve.

An approach, which we use here, is based on stochastic variant of the law of mass action as a neuronal model. A model experiment is considered, in which a fixed odorant concentration is applied several times and realizations of steady-state characteristics are observed. The response is assumed to be a random variable with some probability density function belonging to a parametric family with the signal as a parameter. Different types of distributions of the response can be considered. As a measure how well the signal can be estimated from the response, the Fisher information and its lower bounds are used [3]. The Fisher information with respect to the signal is the inverse asymptotic variance of the best unbiased estimator of the signal, which means the higher the Fisher information is the better estimation of the corresponding signal can be achieved. These measures are computed and applied to locate the odorant concentration most suitable for identification. Another optimality measures are based on the theory of information, especially conditional and unconditional differential entropy [4]. Results for some models and probability distributions are compared. The point in which the first derivative of the input-output function is maximal coincides with the point of maxima of the Fisher information in the simple models. The obtained results differ in more complex models comprising the activation step(s). The study extends our previous results [5,6].

Acknowledgements

This work was supported by Grant 201/05/H007, by Center for Theoretical and Applied Statistics LC06024, Center for Neuroscience LC554 and by Research project AV0Z50110509.

References

1. Kaissling KE, Rospars JP: **Dose-response relationships in an olfactory flux detector model revisited.** *Chem Senses* 2004, **29:**529-531.
2. Lam HS, Lampard DG: **Modelling of drug receptor interaction with birth and death processes.** *J Math Biol* 1981, **12:**153-172.
3. Lansky P, Greenwood PE: **Optimal signal in sensory neurons under extended rate coding concept.** *Biosystems* 2007, **89:**10-15.
4. Bezzi M: **Quantifying the information transmitted in a single stimulus.** *Biosystems* 2007, **89:**4-9.
5. Lansky P, Pokora O, Rospars JP: **Classification of stimuli based on stimulus-response curves and their variability.** *Brain Res* 2008, **122:**57-66.

6. Pokora O, Lansky P: **Statistical approach in search for optimal signal in simple olfactory neuronal models.** *Math Biosci* 2008, **214:**100-108.