BMC Neuroscience

BioMed Central

Poster presentation

Interaural time difference detection by the auditory system model in the presence of phase noise

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

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P314 doi:10.1186/1471-2202-10-S1-P314

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P314

Interaural time differences (ITDs) in arrival of sound at the two ears are a major cue for sound source localization in the horizontal plane. It is known that to localize a sound, the auditory system must to detect ITDs which are significantly less than any time constant of single neurons [1]. The most prevalent approach that allows ITD detection with such remarkable temporal accuracy is the mechanism based on the coincidence detectors [2,3]. However, there are a few facts that are not consistent with such a mechanism, thereby principles providing ITD processing are still open issues.

We continue to consider another biologically inspired mechanism underlying the ITD detection with microsecond precision [4]. Proposed mechanism is based on impulse activity comparison of two symmetric populations of auditory neurons, called EI neurons [5]. Single EI cells show relative insensitivity to the variation of ITD, therefore, EI neurons are considered as rough detectors of sound location. Despite this evidence, results of our recent investigation have revealed that relatively large population of EI neurons can detect ITD with exquisite temporal precision [6].

The goal of this study is to examine the behavior of suggested mechanism in the presence of phase noise in input signal. Phase noise reflects travel time differences of ipsi- and contralateral auditory signals. Similar to our previous works [6,7], the present study is based on the neural network model that simulates the behavior of two EI neuron populations under dichotic stimulation. The model contains two groups, each of them consists of no less than one hundred single neuron models. Every neuron model has excitatory synapse with contralateral input element and inhibitory with ipsilateral. However, in present work the parameters of neuron model and conductivity of synaptic transmission are homogeneous through both populations. Additionally, in order to investigate suggested mechanism in the presence of noise, network model was slightly modified and the generator modules of bipolar white noise were incorporated.

The results of modeling reveal the ability of proposed neural network to detect time delays with high temporal precision in the case of presence of phase noise in the input signal. Even if magnitude of phase noise is comparable with ITD value, the stable work of considered mechanism is showed. Robust ITD detection in the presence of both (i) amplitude noise [6] in the single neuron activity and (ii) phase noise in the input signal is also illustrated.

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