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Study of additional mechanism of short time delay detection in input signal by the homological neural network

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Sound source localization by the binaural hearing system occurs due to amplitude and time differences between signal arrivals into left and right ears [1]. To localize a sound source with a high resolution, the auditory system has to detect short time delays (STD) which are significantly less than any time constant of individual neural network elements. Thus, if short sound clicks are localized by human auditory systems with 5° resolution the value of interaural STD detected by the nervous system should be approximately 10 microseconds, while a time constant of a system individual element is not less than 700 microseconds [1,2]. The most known and investigated mechanism allowing detecting STD with such high accuracy is the mechanism based on the coincidence detectors [1-3]. But since such mechanism requires a continual periodical signal, this issue is still open. Here we present another STD detection mechanism based on the comparison of impulse activity of two symmetric populations of neurons accounted for in the auditory cortex, so called E-I neurons [4]. These cells are activated by contralateral ear stimulation and otherwise are inhibited when ipsilateral stimulation occurs. E-I neurons have slow reaction to a change of sound source location, and that is why such neurons are regarded as rough detectors of the sound source location.

However, the preliminary results which were obtained with the simplified model of the E-I cell population showed that the comparatively large population of such cells can detect STD with a high accuracy [2]. Similar to [2] the present research is based on the artificial neural network model which simulates the behavior of two E-I neuron populations under dichotic stimulation. To obtain more biologically adequate results we use a more complicated representation of synaptic transmission (a – synapse [1]) in the analytical study and a non-linear single element (neural model of E. Izhikevich [5]) activated by a synaptic reverse model [6] in the numerical simulations. The proposed model also shows a robust STD detection in the case when bi-polar white noise with different amplitude is present in the single networks element activity. Reducing noise influence by increasing population size is also illustrated. We show that the results obtained in simulations are well correlated with psychophysical test observations [7].

The obtained results allow us to suggest that the described mechanism contributes to the well-known system of sound source localization based on coincidence detectors.

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