Title	初期聴覚中枢系の神経細胞レベルでの時間情報処理機構に関する研究
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Citation	
Issue Date	2003-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/934
Rights	
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In order to understand the brain's strategy for neural information processing using neural signals with temporal fluctuation and temporal redundancy, we have mathematically studied the mechanisms of temporal information processing in the primary stage of the auditory system which is one of the sensory organs. These mechanisms are on the pathway to the interaural time difference (ITD) detection related to the sound localization and include improvement, utilization, and loss of temporal information, i.e. the interspike interval (ISI). This study was done through simulations using computational models based on the recent physiological and anatomical knowledge, and from a novel viewpoint of psychoacoustic experiment.

For the improvement of temporal information in the auditory system, we have studied a mechanism that enhances the phase-locking of a neuron in the anteroventral cochlear nucleus (AVCN). Simulations focusing on synchronization, especially on entrainment showed a relation between the number of the input terminals connected to a cell model and the number of the input events allowing the cell model to fire. This relation is quantitatively derived to keep its ISI more regular against the primary-like behavior of inputs from the auditory nerve fibers. Then the cell model displays enhanced synchronization and precise entrainment at low frequencies with multiple-input configurations. These suggest the possibility of the existence of a firing mechanism with multiple inputs on a single neuron in AVCN.

For the utilization of temporal information, we have studied a mechanism for detecting ITD performed in the medial superior olive (MSO). Nerve impulses and synaptic transmission in the nervous system were computationally modeled and these models were applied to a common coincidence detector circuit model to detect ITDs. Impulse trains with fluctuation in time were used as input data and the effects of the impulse fluctuation on the detection of ITDs were investigated. Simulation results showed that the peak of output spikes indicating the ITD in azimuth sharpens when impulses fluctuating in time are used as input. The results also indicated that using impulse trains with fluctuation in time as input data improves the output of the model compared with using those having no fluctuation. This suggested that impulse fluctuation cannot be considered as noise but it can contribute to the detection of the ITD in the temporally redundant process and the nonlinear output mechanism.

For the loss of temporal information, the relation between the characteristic frequency (CF) and synchronization index of neurons was computationally reviewed. The model generates impulses in time according to the physiological data of synchronization of cats. It was shown that impulses at any CF were distributed in a similar time length at any CF. Therefore, we can hypothesize that the distributions of impulses are similar at any CF pathway and the loss of temporal information is caused by overlapping impulses between adjacent periods of stimulation at higher CF pathways, which can be a factor causing the decline of ability of localization based on ITD to tones reported by psychoacoustic studies.

We have investigated the mechanism of temporal information transmission in the human auditory system from the viewpoint of psychoacoustic experiment of lateralization based on the interaural phase difference (IPD) to tones. Differences in lateralization in various stimulations under the condition of similar phase ambiguity can imply that there is a factor, which is different from phase ambiguity, in the decline of localizing ability of human. We suggest the possibility that the factor is the loss of temporal information.

The results mentioned above indicated that the auditory system constructs clever mechanisms to process temporal information using neural signals with fluctuation and redundancy; e.g., it eases the influence of both jitters and pauses of impulses with multiple-input configurations and extracts necessary information from a variety of information using jitters positively. This study on the auditory system showed a part of the brain's strategy for temporal information processing. It can give suggestions to people working on engneering applications to construct noise-robust signal processing systems.