Spike Train Statistics and Regularity for Consonant and Dissonant Musical Accords in a Simple Auditory Sensory Model

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The perception and processing of environmental complex signals resulting from the combination of two or more input periodical signals are still an open problem for physicists and physiologists. The phenomena of *consonance* and *dissonance* in a simple perception model system by a probabilistic approach are investigated. We try to answer the above question by showing which characteristic of the physical processes involved in brain functioning discriminates between consonance and dissonance. The auditory sensory model is composed of three neurons: two of them, here so-called *sensory neurons*, are driven by noise and subthreshold periodic signals with different ratio of frequencies, and its outputs plus noise are applied synaptically to a third neuron, so-called *interneuron*. We propose a theoretical analysis with a probabilistic approach to investigate the interspike intervals (ISI) statistics of the spike train generated by the interneuron. We show how a complex input composed of two harmonic signals is transformed by the proposed simple sensory system into different types of spike trains, depending on the ratio of input frequencies. We find that tones with frequency ratios that are considered *consonant* by musicians produce at the third neuron inter-firing intervals statistics densities that are very distinctive from densities obtained using tones with ratios that are known to be *dissonant*. In other words, at the output of the interneuron, inharmonious signals give rise to blurry spike trains, while the harmonious signals produce more regular, less noisy, spike trains. Specifically, we present the results of the consideration of spike train regularity at the output of the auditory systems neural model as a simple parameter of the neural signal showing the difference between the feeling of harmony and disharmony while listening to tone dyads. The regularity is introduced as the quantity linearly connected with informational entropy due to a natural framework for many problems in biological signal processing provided by information theory. We show that consonant chords influencing the auditory system produce regular spike trains (high regularity) at the systems output, in contrast to dissonant chords, which result in irregular spike trains (low regularity). Theoretical results are compared with numerical simulations.

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