

HOW SENSORY NEURONS CODE WHAT ISN'T OUT THERE?

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ABSTRACT

An important unsolved problem in sensory systems are the cases of illusions, in which the coded input does not exist in linear terms. A classical example is how the brain estimates the pitch of a complex sound. Complex sounds are composed of more than one tone. When two tones occur together, a third lower pitched tone is often heard. This is referred to as the “missing fundamental illusion” because the perceived pitch is a frequency (fundamental) for which there is no actual source vibration. This phenomenon exemplifies a larger variety of problems related to how pitch is extracted from complex tones, music and speech, and thus has been extensively used to test theories of pitch perception. A noisy nonlinear process[1] is presented here as a candidate neural mechanism to explain the majority of reported phenomenology and provide specific quantitative predictions. The two basic premises of this model are as follows: (I) The individual tones composing the complex tones add linearly producing peaks of constructive interference whose amplitude is always insufficient to fire the neuron (II): The spike threshold is reached only with noise, that naturally selects the maximum constructive interferences. The spacing of these maxima, and consequently the spikes, occurs at a rate identical to the perceived pitch for the complex tone. Comparison with psychophysical and physiological data reveals a remarkable quantitative agreement not dependent on adjustable parameters[2]. In addition, results from numerical simulations across different models are consistent, suggesting relevance to other sensory modalities.

Keywords: pitch perception, stochastic resonance, missing fundamental.

References

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