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The effects of mechanically gated ion channels of the inner ear on thermal sensitivity of spontaneous otoacoustic emissions

In quiet environments, the inner ear of vertebrates can produce low-intensity sounds that are detectable in the ear canal, termed spontaneous otoacoustic emissions (SOAEs). This production of acoustic energy has been regarded as an epiphenomenon of the active processes performed by hair cells –the sensory receptors of the auditory system. Experimental measurements of SOAEs emitted from the ears of ectothermic species, including frogs and lizards, reveal a linear increase of SOAE frequency with body temperature. Moreover, SOAEs at higher frequencies always display greater thermal sensitivity. In this work, we will elucidate the cellular mechanism underlying the sensitivity of SOAE frequency to temperature by investigating the transduction process of hair cells, mediated by mechanically gated ion channels. We employ the previously proposed gating-spring model which describes an individual ion channel by a two-state system, whose activation energy associated with channel gating depends on the level of temperature. The stability of the two states is further modulated by the tension of a molecular filament. Our results from numerical simulations reveal that the free energy difference between the open and closed states greatly dictates the magnitude of thermal sensitivity. Additionally, our findings suggest that SOAEs with higher frequencies are produced by hair cells whose ion channels are anchored by molecular filaments with greater stiffness.

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