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(U*) Whispers from the active inner ear

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The vertebrate inner ear achieves high sensitivity and selectivity via active sensors known as hair cells. Hair cells use metabolic energy to generate force to improve their functionality, resulting in self-induced vibrations that can manifest as faint sounds akin to whispers –otoacoustic emissions (OAEs). OAEs are detectable in the ear canal using a sensitive microphone and can arise spontaneously (SOAEs) or be evoked by external tones (eOAEs). Even though OAEs are used extensively for clinical purposes, the underlying mechanics and active dynamics that govern their production, particularly the collective interactions of hair cells, are not well understood. Here we focus on the green anole lizard (Anolis carolinensis) to study the biophysical processes associated with active hearing. Despite simpler morphology relative to the mammalian cochlea, anole lizards show sensitivity and selectivity comparable to many mammals. We present two sets of preliminary OAE results from anole lizards. First, we characterize how changing the level of an external tone at a fixed frequency affects SOAE activity. We observe a broadening frequency range of suppression of the SOAE with increasing tone level, suggesting an entrainment effect where activity effectively synchronizes to the stimulus. Based upon the assumptions of a simple model for tonotopy (i.e., how frequency maps to different spatial locations along the sensory epithelium of the inner ear), we attempt to characterize the spatial extent of the entrainment region. Such could have important constraints for hair cell coupling in theoretical models of the inner ear. Second, we examine intermodulation distortions arising from the presentation of two tones at nearby frequencies. Characterizing such reveals features of the underlying nonlinearities, a key facet in helping constrain mathematical models of the inner ear. Ultimately, these data combined with modeling will help elucidate how the collective behaviour emerges more generally from active spatially-distributed biomechanical systems.

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