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Nonlinear Bayesian cue integration explains the dynamics of vocal learning[1] BAOHUA ZHOU, SAMUEL SOBER, ILYA NEMENMAN, Emory University — The acoustics of vocal production in songbirds is tightly regulated during both development and adulthood as birds progressively refine their song using sensory feedback to match an acoustic target. Here, we perturb this sensory feedback using headphones to shift the pitch (fundamental frequency) of song. When the pitch is shifted upwards (downwards), birds eventually learn to compensate and sing lower (higher), bringing the experienced pitch closer to the target. Paradoxically, the speed and amplitude of this motor learning decrease with increases in the introduced error size, so that birds respond rapidly to a small sensory perturbation, while seemingly never correcting a much bigger one. Similar results are observed broadly across the animal kingdom, and they do not derive from a limited plasticity of the adult brain since birds can compensate for a large error as long as the error is imposed gradually. We develop a mathematical model based on nonlinear Bayesian integration of two sensory modalities (one perturbed and the other not) that quantitatively explains all of these observations. The model makes predictions about the structure of the probability distribution of the pitches sung by birds during the pitch shift experiments, which we confirm using experimental data.

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