Visualizing Avian Vocal Diversity Through Chladni Resonances

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Birds generate calls and songs with distinct frequency patterns. Spectrograms have long been used to visualize those sound patterns by mapping changes in pitch and amplitude over time. While spectrograms are versatile for time-frequency analysis, they have inherent limitations: tradeoffs between temporal and frequency resolution, spatial/phase insensitivity, and difficulty resolving overlapping harmonics. For instance, short frames resolve rapid transitions in robin song shifts, but obscure harmonics. Conversely, long frames blur quick transitions, but enhance timbre of a warblers' trill. I present a novel approach using multi-material Chladni analysis to visualize avian vocalizations across 14 species (10 songbirds, 3 raptors, and a sentinel bird) as spatial sound energy distributions through standing wave patterns, inaccessible to spectrograms. These reveal tonal quality in a single image as nodal/antinodal geometries, governed by physical resonance, not algorithms. Selected species represent diverse phylogeny, habitats, social needs, and vocal structures. Dynamic aspects of American Robin songs were documented through sequential photographs of evolving patterns. Experiments revealed divergent resonant signatures in all but two species—the Louisiana Waterthrush and Magnolia Warbler, with the latter uniquely responsive to phosphor bronze. Results demonstrate that while materials set baseline resonances, species impose distinct acoustic signatures. Transposing Chladni figures, originally a physics tool, to bioacoustics fosters an innovative cross-disciplinary approach to visualize and understand animal sounds, providing key insights into spatial dynamics, resonance patterns, and biomechanical processes that complement traditional methods.

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