Spectral pitch distance and microtonal melodies

Conference or Workshop Item

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1. Preliminary Definitions...

Spectral distance is a measure of the similarity of tones based on the frequencies and amplitudes of their partials; if two tones have many partials at similar pitches, their spectral distance is low. Setharian tones have their partials aligned to the tuning they are played in; e.g., if a melody is played in a 5-tone equal tuning (5-TET), a Setharian tone will have all its partials tuned to steps of 5-TET (see Box A, upper figure) [2]. Pseudo-Setharian tones have their partials aligned to a tuning different to the one they are played in; e.g., if a melody is played in 5-TET, a pseudo-Setharian tone may have all its partials tuned to steps of 7-TET, 12-TET, 17-TET, or any other non-5-TET tuning (see Box A, lower figure). The spectral distance between Setharian tones is typically lower than that between pseudo-Setharian tones.

2. Contribution

We demonstrate that the perceived affinity of tones in a melody is greater when using Setharian—rather than pseudo-Setharian—tones. This has two direct implications:
1) a microtonal melody can be made to sound more in-tune (have greater affinity) by using Setharian tones;
2) in Western music, the melodic affinity of tones separated by perfect fourths, perfect fifths and major seconds may be due, in part, to the harmonic partials that are produced by most Western instruments (including the human voice). This is because such intervals have relatively small spectral distances (see Box B).

3. The Experiment

Ten participants listened to 60 different randomly generated microtonal melodies. Each melody was randomly tuned to one of eleven different equal tunings with the following numbers of steps (per octave): 3, 4, 5, 7, 10, 11, 12, 13, 15, 16, or 17 (why these tunings?—see Box C). Each melody was played with two timbres: A Setharian timbre with partials tuned to the steps of the equal tuning used by the melody, or a pseudo-Setharian timbre with partials tuned to the steps of a different equal tuning (randomly chosen from the above). Participants were asked to choose which of the two timbres made the tones in the melody have the “greatest affinity”, “best fit”, and sound most “in tune”.

4. Results

A binomial test shows that, given a choice between Setharian and pseudo-Setharian tones, participants felt the former produced melodies with “greater affinity”, “better fit”, and sounded most “in tune”. Whether the results were consistent across all the different equal tunings tested has not yet been analyzed. The significance of this result is very high—there is a 1 in 47 million chance it is due only to a chance relationship; participants chose Setharian timbres on 63% of occasions and pseudo-Setharian on 37% (p difference = 26%).

References