LETTER

REPLY TO GOFFINET:

In consonance, old ideas die hard

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Goffinet's complaints (1) about our vocal similarity hypothesis (2) are unwarranted on both practical and theoretical grounds.

First, the issue of tuning is a red herring. We used standard just intonation intervals to evaluate the consonance of chords because their role in music across historical and cultural boundaries is foundational (3). We limited the chords tested to combinations of the 12 intervals of the chromatic scale for practical reasons: additional ratios and/or tuning systems would have increased the chords that had to be evaluated to an unreasonable number.

More generally, our results are unlikely to depend on a particular tuning system. The popular chords in our study correspond to those frequently used in popular (equally tempered) music, reflecting the fact that people tolerate substantial tuning variation in practice (4). Furthermore, the harmonic similarity metric we use can be adapted to accommodate tuning variation by introducing a tolerance window for judgments of harmonic overlap (2).

Regarding the tritone, we selected the simplest possible ratio (7:5). Had we chosen a more complex ratio, our predictions would likely have improved. Because the 7:5 ratio has a relatively high harmonic similarity score (31.4%), chords containing tritones were often predicted to be more consonant than actually perceived. Mistakes of this kind accounted for 46% of the errors in our study [see supporting information of our report (2)].

Second, limiting the analysis to pairs of chords exhibiting significant differences in consonance does not inflate the accuracy of vocal similarity; it excludes noise due to differences that people do not reliably perceive. Because consonance is a perceptual phenomenon, what people hear must be the basis for any analysis.

Third, roughness models do not explain consonance (5). The idea that the human attraction to tone combinations in melody and harmony is determined by the absence of neural "irritation" is nonsensical. Roughness is inversely correlated with harmonic similarity, and thus with consonance. However, when roughness and harmonic similarity are dissociated, only the latter accords with consonance (6, 7).

Fourth, the assertion that our metrics do not assess vocal similarity because they do not consider formants is incorrect. Harmonic spectra are a universal property of laryngeal vocalization, and their biological relevance principally derives from conspecific communication. Thus, any metric that captures harmonic structure over the range of biological vocalization measures vocal similarity. We have previously investigated formant information, with results that are less predictive of consonance than harmonic relationships (8). Similarly, differences in timbre have little effect on consonance, provided that spectra are harmonic.

The vocal similarity hypothesis is motivated by the recognition that music is a biological phenomenon, perceived by neural circuitry that has been shaped by the requirements of vocal communication. Although the basis of consonance remains controversial (9, 10), our study (2) adds to empirical evidence that its central importance in music is founded on the biology of auditory–vocal communication, as are many other musical phenomena [see refs. 24–31 in our report (2)]. The criticisms Goffinet (1) offers refute neither the accuracy of our results, nor the importance of the biological framework on which they depend.

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