Comments

Comment by Carlyon:

The results of your experiment 2 indicate that there is a substantial source of additional noise when making across-region comparisons. F0DLs for resolved-resolved comparisons seem barely smaller than those for unresolved-unresolved comparisons, suggesting that this "comparison noise" is sufficient to swamp even the substantial differences in encoding accuracy between resolved and unresolved harmonics. So I think that a substantial translation noise could still exist, yet not be observable in your study. A useful approach might be to try to reduce the comparison noise, either by (even more) extensive training, or by gating on a burst of noise in the complementary region with each complex (e.g. in a LOW-MID comparison, adding a mid-region noise to the LOW complex and a low-region noise to the MID complex). This latter manipulation could serve to reduce timbre differences between the two sounds to be discriminated.

Reply:

You are correct in stating that a putative translation noise must be sufficiently large relative to the other noise sources in order to be measured. In some ways this is precisely the point: if the noise is too small to be measured then it can be treated as negligible, but it is impossible to *prove* its nonexistence. Our subjects received over 30 hours of training each on these tasks, so we think it unlikely that further training would resuscitate the idea of a translation noise for our conditions. In addition, note that not only the comparison noise, but also the *encoding* noise for the unresolved harmonics, contributes to placing a lower limit on the measurable size of the translation noise. In our conditions both these noises have similar magnitudes, so that even a large reduction in one of these will not lead to a substantial reduction in the minimum measurable translation noise.

Comment by Plack:

In Experiment 2, did you randomize F0 between trials? If so, was the randomization sufficient to prevent listeners from performing the resolved vs. unresolved task by comparing the F0 of the resolved harmonics with a memory representation of the average F0 of the resolved harmonics? If the randomization was not sufficient, then it is possible that listeners performed this particular task without encoding the F0 of the unresolved harmonics, thereby avoiding any (hypothetical) translation noise.

Reply:

In the data described above, we randomized, or roved, the F0 between trials by 1 semitone, or about 6% (uniformly distributed on a log-frequency scale). Given the hypothesis that, in conditions involving across-region comparisons between a resolved and an unresolved complex, listeners attended only to one interval (i.e., the one with resolved harmonics) this predicts a lower limit of performance (assuming no internal noise) of: $\Delta F0 = R(2P - 1)$, where $\Delta F0$ is the ratio between the lower and upper F0s at threshold, R is the rove range, and P is the proportion of correct responses tracked (in this case about 75% - averaging the 70.7 and 79.4% values). For our conditions, therefore, the lower limit of performance based on a single interval would be about 3%. Thus for the data shown, we cannot rule out a single-interval analysis. However, as a follow-up, we also tested the same listeners using the same task, but with a larger (4-semitone) rove. In this case, all thresholds were somewhat elevated relative to those in the 1-semitone rove case, but they were below the lower limit (about 12%) predicted by the single-interval analysis provided above. This suggests that listeners were not basing their judgments on single intervals and instead were performing across-interval comparisons

Nevertheless, using this larger rove range, thresholds were still very similar in all the across-region conditions and no evidence for translation noise was found here either.

Comment by Kohlrausch:

In your first experiment, you test whether F0 difference limens differed for the cases that all harmonics of the stimuli were presented to both ears (diotic), and the dichotic case where even harmonics are presented to one ear and the odd harmonics to the other. By distributing the harmonics in the dichotic case, you increase the spacing between adjacent harmonics in both ears by a factor two. In the formulation of your experimental hypothesis, you assume implicitly that performance in the right and left channel of the dichotic stimulus is the same as for a diotic stimulus with twice the F0 value. While this is obvious for the side receiving all even harmonics, it is less clear for the side receiving the odd harmonics. I therefore suggest testing whether the decrease in performance of the odd-harmonic signal is indeed the same as for the even-harmonic one.

Reply:

We have not measured performance with the odd harmonics alone and in fact we think it likely that performance would be degraded in such conditions. However, our interpretation of the results does not depend on how the odd harmonics alone are perceived: if (as has been established many times) pitch information can be integrated across the ears then in principle the auditory system might have been able to combine the information from harmonics that are only resolved in the dichotic condition to form estimates of *consecutive* harmonic frequencies, resulting in a perceived pitch corresponding to the F0. The fact that this does not occur suggests firstly that normally unresolved harmonics do not contribute to the estimate of (resolved-harmonic) pitch and, secondly, that the presence of the odd harmonics in one ear somehow interferes with the ability of the even harmonics in the other ear to convey an otherwise clear pitch of 2F0. Neither of these interpretations requires the odd harmonics to deliver a salient pitch by themselves.

Comment by Moore:

You found in condition MID-HIGH for the 100-Hz F0 a tendency for the sound falling in the higher spectral region to be judged as having a higher F0. You describe this effect as a "bias". However, the effect may arise at least partly as a result of a pitch shift. When subjects match the pitch of two signals falling in different spectral regions, systematic shifts may be found (Walliser 1969; Ohgushi 1978; Moore and Moore 2003a,b). This occurs even for musically trained subjects, who are presumably familiar with the difference between pitch and timbre.

Moore, B. C. J. and Moore, G. A. (2003a) Discrimination of the fundamental frequency of complex tones with fixed and shifting spectral envelopes by normally hearing and hearing-impaired subjects. Hear. Res. (in press).

Moore, G. A. and Moore, B. C. J. (2003b) Perception of the low pitch of frequency-shifted complexes by normal-hearing listeners. J. Acoust. Soc. Am. 113, 977-985.

Ohgushi, K. (1978) On the role of spatial and temporal cues in the perception of the pitch of complex tones. J. Acoust. Soc. Am. 64, 764-771.

Walliser, K. (1969) Zusammenhänge zwischen dem Schallreiz und der Periodentonhöhe. Acustica 21, 319-328.

Reply:

We agree that a shift in spectral region may indeed lead to a change in the perceived pitch. In fact, our way of estimating what we term bias explicitly assumes this. So the bias we describe is not the same as a procedural bias or a shift in criterion, as defined in signal detection theory. However, one might still argue that if the listener's task is to judge F0, then any change in response (including changes in the sensory dimension of interest – i.e. pitch) caused by a variable other than F0 may be termed bias, as it is a shift in perception not directly related to the physical variable in question.

Comment by Moore:

You have taken up the suggestion that I made in 1982, namely that the range of time intervals that can be analysed accurately at a given CF is related to the CF and limited to about 15 times 1/CF. A possible reason why this may be the case is that the time interval information in a given neurone or small group of neurones is analysed with limited accuracy before information is combined across neurones. This limited accuracy would mean that, when the CF was high relative to F0, information about temporal fine structure would be lost, and only envelope information would remain; this would lead to relatively poor accuracy in the coding of the period corresponding to F0.