Comments

Comment by Kollmeier:

Since you used the Greenwood-scale as frequency scale, a linear chirp in your definition is approximately a logarithmic chirp in physical units – this is a very unnatural stimulus. The difficulties your subjects have with discriminating such stimuli may therefore be plausible.

How would a natural formant transition (which is limited by the dynamics of the articulation apparatus) look like in the coordinates you are using?

Reply:

While it is true that formant transitions slow down as they approach their intended target frequency, to my knowledge there is nothing that would indicate that, at the onset, their trajectory is best described as being linear in Hz. Although tracing formants of natural speech is quite error-prone, models (see, e.g., Mrayati, Carré, and Guérin 1988) approximate the vocal tract with a series of resonators that act, within limits, similar to constant-Q filters. The most realistic simplification of formant trajectories, therefore, may be a chirp with a negatively accelerating frequency change. Of course, all this may not be relevant for first-formant or low second-formant transitions since, when individual components are resolved, the formant peak during transitions follows a step function and, therefore, its trajectory is neither linear, nor logarithmic.

Mrayati, M., Carré, R., and Guérin, B. (1988) Distinctive Region and Modes: a new theory of Speech Production. Speech Comm. 7, 257-286.

Comment by Moore:

You stated that your stimuli for experiment 1 were designed so that "the only valid cue for the discrimination was the velocity of the frequency change." However, for each glide, subjects could "compute" the velocity as the difference between the starting and ending frequencies divided by the duration. Thus, the subjects were not forced to judge velocity *per se*, although they may well have done this.

Dooley and Moore (1988) adopted a different approach to measuring sensitivity to differences in rate of change of frequency. They measured duration discrimination for tones that were either fixed in frequency and level, or that glided in frequency and/or level over a fixed extent. For the gliding stimuli, the rate of change of frequency and/or level co-varied with duration. Dooley and Moore found that duration discrimination was better for the gliding stimuli than for the steady stimuli, and argued that this indicated a sensitivity to the rate of change of frequency and/or level. It is noteworthy that the Weber fraction for "velocity" inferred from their results was about 0.06, which is much smaller than estimated by you. The discrepancy might partly be due to the fact that you used greater sweep extents than Dooley and Moore. However, a more likely explanation arises from the method that you used, which involved standard and variable stimuli falling in different frequency regions. It may be difficult for subjects to compare glide rates for such stimuli, in the same way that it is difficult to compare the fundamental frequencies of complex tones that are filtered into different frequency regions or have no harmonics in common (Moore and Glasberg 1990; Moore, Glasberg and Proctor 1992; Carlyon and Shackleton 1994; Moore and Moore 2003).

Carlyon, R. P. and Shackleton, T. M. (1994) Comparing the fundamental frequencies of resolved and unresolved harmonics: Evidence for two pitch mechanisms? J. Acoust. Soc. Am. 95, 3541-3554.

Dooley, G. J. and Moore, B. C. J. (1988) Duration discrimination of steady and gliding tones: a new method for estimating sensitivity to rate of change. J. Acoust. Soc. Am. 84, 1332-1337.

Moore, B. C. J. and Glasberg, B. R. (1990) Frequency discrimination of complex tones with overlapping and non-overlapping harmonics. J. Acoust. Soc. Am. 87, 2163-2177.

Moore, B. C. J., Glasberg, B. R. and Proctor, G. M. (1992) Accuracy of pitch matching for pure tones and for complex tones with overlapping or non-overlapping harmonics. J. Acoust. Soc. Am. 91, 3443-3450.

Moore, B. C. J. and Moore, G. A. (2003) 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).

Reply:

While it is true that the experiments do not permit distinction between perceiving velocity of frequency change or computing a duration-weighted extent of frequency change, no such distinction is possible in the results of any other study that attempted to evaluate sensitivity to the rate of frequency change using direct methods. Comparison between the Dooley and Moore (1988) velocity JND's estimated indirectly from duration discrimination and our data, indeed, appears to be difficult. Moore is probably correct when he assigns our large velocity JND estimates to the large stimulus uncertainty that we used, in order to serve as a guarantee that neither duration nor the extent of frequency change would co-vary, and thereby be confounded, with velocity. However, further (and presently yet unpublished) results from our laboratory in which the degree of frequency uncertainty was systematically reduced showed that, in the lowest uncertainty condition (in which the only uncertainty was associated with duration), our 79.4 percent correct thresholds decreased to about 0.1 – a figure comparable to Dooley's and Moore's 70.7 percent correct threshold of 0.061.