Are individual differences in pitch perception relevant for language typology?

D. R. Ladd, University of Edinburgh (bob.ladd@ed.ac.uk)

Although it is usual to equate 'pitch' and 'fundamental frequency (F0)', it is known that stimuli without F0 in the physical sense may nevertheless give rise to a pitch percept. 'Missing fundamental' (MF) stimuli can be artificially constructed from frequencies that are integer multiples of a frequency not physically present in the stimulus, and many listeners ('F0 listeners') perceive the pitch of such a stimulus to be that absent frequency. (For example, a stimulus consisting of energy at 800, 1000, and 1200 Hz has a MF – and for some listeners a pitch – of 200 Hz). However, two recent papers (Schneider et al. 2005 and Seither-Preisler et al. 2007), using an experimental task devised by Smoorenburg (1970), report the existence of significant individual differences in pitch perception in MF stimuli. Specifically, some listeners ('spectral listeners') appear to hear pitch not as the MF but as the lowest frequency actually present. Schneider et al. suggest that there are roughly equal numbers of the two types of listeners and present evidence that the difference is related to brain neuroanatomy (specifically, a difference in the relative volume of left and right Heschl's Gyrus). Seither-Preisler et al. find more F0 listeners than spectral listeners, but also note that roughly a quarter of listeners appear not to respond consistently. In a series of experiments involving altogether over 400 listeners, we have

- confirmed that many listeners consistently adopt one of these two modes of perception, and that roughly a quarter do not respond consistently;
- shown that there are other less common response patterns influenced by overall frequency level;
- found high test-retest reliability for all listeners; and
- shown that monaural presentation does not affect individual response patterns.

This paper has two goals: first, to present these studies more fully, and second, to suggest that these individual differences are plausibly related to the different role of pitch in typologically diverse languages. Dediu and Ladd (2007) reported a correlation between population genetics (the distribution of derived alleles of *ASPM* and *Microcephalin*, which are known to affect brain development) and language typology (the geographically very uneven distribution of tone languages). They speculated that this might be due to a 'cognitive bias' conditioned by the genetic differences. The existence of different responses to MF stimuli suggests an obvious hypothesis about the nature this cognitive bias, namely that it involves different cognitive or perceptual treatments of the relation between spectral and fundamental frequency. This relation is arguably the key to the difference between treating speaking pitch as an integral part of lexical identity (as in tone languages) and treating it as a kind of accompaniment that is independent of the words (as in non-tone languages). The recent finding by Wong (2012) that performance on a linguistic pitch task is correlated with whether individuals have 0, 1 or 2 copies of the derived *ASPM* gene makes it worthwhile to see whether there is any direct connection between *ASPM* and more basic tasks such as MF perception. Finding such a link would strengthen Dediu and Ladd's central thesis that population genetics may influence language typology, and more specifically would shed light on the relation between segmental phonology (which is universal) and tone (which is not).

References

Dediu, Dan; Ladd, D. Robert (2007). Linguistic tone is related to the population frequency of the adaptive haplogroups of two brain size genes, *ASPM* and *Microcephalin*. *PNAS* 104: 10944-10949.

Schneider, Peter; Sluming, Vanessa; Roberts, Neil; Scherg, Michael; Goebel, Rainer; Specht, Hans J.; Dosch, H. Günter; Bleeck, Stefan; Stippich, Christoph; Rupp, André (2005). Structural and functional asymmetry of lateral Heschl's gyrus reflects pitch perception preference. *Nature Neuroscience* 8: 1241-1247.

Seither-Preisler, Annemarie; Johnson, Linda; Krumbholz, Katrin; Nobbe, Andrea; Patterson, Roy; Seither, Stefan; Lütkenhöner, Bernd (2007). Tone sequences with conflicting fundamental pitch and timbre changes are heard differently by musicians and nonmusicians. *JEP: Human perception and performance* 33: 743-751.

Smoorenburg, Guido (1970). Pitch perception of two-frequency stimuli. *J. Acoust. Soc. America* 48: 924-942.

Wong, P. C. M.; Chandrasekaran, B.; Zheng, J. (2012). The derived allele of *ASPM* is associated with lexical tone perception. *PLoS ONE 7* (4): e34243. doi: 10.1371/journal.pone.0034243.