Effects of the auditory perception bias in F_0 imitation

In tone languages, fundamental frequency (F_0) is used to distinguish between lexical items and word categories and F_0 perception and imitation is thus, arguably, of high importance for native speakers of these languages. Interestingly, there appear to be large individual differences in speakers' ability to imitate F0. Using the shadowing task paradigm, originally introduced by Goldinger (1998), a recent study by Babel & Bulatov (2011) found a considerable amount of variation in F_0 accommodation. We hypothesized that the individual differences in speakers' ability to imitate F_0 may at least partly be due to their ability to extract information about pitch from the speech signal. In particular, due to neuroanatomical differences found in the lateral Heschl's gyrus (the 'pitch processing center'), some listeners show an auditory perception bias for the sound as a whole (*fundamental* listeners), while others (*spectral* listeners) focus on its harmonic constituents (Rousseau et al., 1996; Schneider & Wengenroth, 2009). The auditory perception bias has been almost exclusively analyzed in the context of musical training, but the results of individual studies indicate that it may also affect linguistic performance (Wong & Perrachione, 2007; Wong et al., 2008) and Ladd et al. (2012) suggest it to be a possible link between the geographical distribution of tone languages and genetic variation described in Dediu and Ladd (2007). In our experiment (N=88), we used a modification of the standard psychoacoustic perceptual test (Smoorenburg, 1970; Laguitton et al., 1998; Schneider et al., 2005) with missing fundamental frequencies to determine a speaker's auditory bias. For the perceptual test, we constructed 36 pairs of complex harmonic tones, all 160 ms long, that consisted of 2-4 harmonics, with the same harmonic composition as employed by Laguitton et al. (1998). Participants (all speakers of an intonational language) were asked to categorize 18 perceptually ambiguous stimuli consisting of two complex tones, A and B, that were composed of a number of upper harmonic tones with the same highest harmonic but different levels of virtual fundamental pitch (derived from the harmonics as the best fit) and spectral pitch (based on the lowest harmonic). The other 18 stimuli served as control trials in that their interpretation is unambiguous but helps to determine a participant's level of attention to the task. Listeners were instructed to categorize each experimental stimulus (tone pair) as either 'rising' or 'falling', depending on their perception of the sequence. We subsequently collected speech data in the classical shadowing task with two conditions, one with a full speech signal and one with high-pass filtered speech above 300 Hz. In both conditions, speakers with fundamental listener bias adapted more to the F0 of the model talker; as might be expected, the effect was more pronounced in the high-pass filtered condition. This result suggests advantages for fundamental listeners in communicative situations where F0 imitation is used as a behavioral cue. In two follow-up studies, we are currently exploring (1) what the impact is of excluding the effect of the otoacoustic emissions (Probst et al., 1986, a.o.) on the performance in the perceptual and shadowing task, and (2) the influence of feedback 'training' the listener to focus either on the lowest harmonic or on the missing fundamental derived from the harmonic distances, and a possible link with the global/local perception of prosodic contours (Ziegler et al., 2012).

References:

Babel, M., & Bulatov, D. (2011). The role of fundamental frequency in phonetic accommodation. *Language and Speech*, 1-17.

Dediu, D., & Ladd, R.D. (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.

Goldinger, S.D. (1998). Echoes of echoes? An episodic theory of lexical access. *Psychological Review*, **105**, 251-279.

Ladd, D.R., Turbull, R., Browne, C., Caldwell-Harris, C., Ganushchak, L., Swoboda, K., Woodfield, V., & Dedu, D. (2012). Patterns of individual differences in the perception of missing-fundamental tones, submitted.

Laguitton, V., Demany, L., Semal, C., & Liégeois-Chauvel, C. (1998). Pitch perception: A difference between right- and left-handed listeners. *Neuropsychologia*, *36*, 201-207.

Probst, R., Coats, A.C., Martin, G.K., & Lonsbury-Martin, B.L. (1986). Spontaneous, click-, and toneburst-evoked otoacoustic emissions from normal ears, *Hearing Research, 21*, 264-265, 267-275.

Rousseau, L., Peretz, I., Liégeois-Chauvel, C., Demany, L., Semal, C., & Larue, S. (1996). Spectral and virtual pitch perception of complex tones: An opposite hemispheric lateralization?, *Brain and Cognition*, *30*, 303-308.

Schneider, P., Sluming, V., Roberts, N., Bleeck, S., & Rupp, A. (2005) Structural, functional and perceptual differences in Heschl's gyrus and musical instrument preference. *Ann. N.Y. Acad. Sci*., *1060*, 387-394.

Schneider, P., & Wengenroth, M. (2009). The neural basis of individual holistic and spectral sound perception. *Contemporary music review, 28*, 315-328.

Smoorenburg, G.F. (1970). Pitch perception of two-frequency stimuli. *J. Acoust. Soc. Am*., *48*, 924-942.

Wong, P.C.M., & Perrachione, T.K. (2007). Learning pitch patterns in lexical identification by native English-speaking adults. *Applied Psycholinguistics*, *28*, 565-585.

Wong, P.C.M., Warrier, C.M., Penhune, V.B., Roy, A.K., Sadehh, A., Parrish, T.B., & Zatorre, R.J. (2008). Volume of left Heschl's gyrus and linguistic pitch learning. *Cerebral Cortex*, *18*, 828-836.

Ziegler, J.C., Pech-Georgel, C., George, F., & Foxton, J.M. (2012). Global and local pitch perception in children with developmental dyslexia, *Brain & Language*, in press.