Relative cue weighting in perception and production of a sound change in progress

Jianjing Kuang and Aletheia Cui
University of Pennsylvania
kuangj@sas.upenn.edu

Multiple co-varying cues for a phonological contrast are often introduced by coarticulation, and sound change occurs when the relative weighting shifts (e.g., Ohala 1981, 1993, Beddor 2009, Harrington et al. 2008). The central issues for this kind of sound change include how cue weighting shifts over time in both production and perception and what the mapping is between production and perception during this process. This study aims to provide insights to these questions by examining an ongoing change in Southern Yi. The vowels in Southern Yi have a tense vs. lax register contrast, which is typically distinguished by consistent differences in phonation (Kuang and Keating 2014). The Yi languages also exhibit differences (varying from dialect to dialect and speaker to speaker) in F1, F2, and F0 between the two registers due to the coarticulation between glottal and supraglottal settings (Ladefoged and Maddieson 1985, Edmondson and Esling 2006). Kuang (2011) found that younger speakers tend to use vowel quality differences to distinguish the tense /e/ from the lax /e/ in Southern Yi, indicating that vowel quality may be overtaking phonation as the primary cue for the register contrast in this dialect. A specific goal of this study is to evaluate the relative importance of the coarticulated cues (i.e., vowel formants, f0, and phonation) in producing and perceiving the tense vs. lax contrast. The same 41 native speakers from three age groups (<40, 40-50, >50) participated in all the experiments. The minimal sets /be/ and /bu/ (low vs. high vowel conditions) with all possible tone and register combinations (21T, 21L, 33T, 33L, 55) were used in this study.

Methods: Two identification experiments were conducted to test perceptual cue weighting. Experiment 1 used natural stimuli (minimal sets /be/ and /bu/ from six speakers, 3F and 3M). Experiment 2 used stimuli resynthesized from naturally produced /be33, be33/ and /bu33, bu33/ (underscore = "tense") of two speakers (1F, 1M). Original phonation cues were maintained, and F1, F2, and F0 were modified in incremental steps (5 F1 × 3 F2 × 3 F0). In both perception experiments, each stimulus was presented in isolation in a forced choice identification task, administered through Praat in a quiet room. To evaluate cue weighting in production, the participants produced the minimal sets /be/ and /bu/ in Experiment 3. H1*-H2*, F1, F2 and F0 were measured using VoiceSauce (Shue et al. 2011).

Results: Experiment 1 showed that listeners reliably identified the phonological categories (mean ~60% > 20% chance level), and chi-square tests show that there were no age differences in accuracy rates. The percentages of responses along the resynthesized F1 x F2 x phonation continuum space for the >50 and <40 groups from Experiment 2 are shown in Figure 1. To evaluate the alignment between production and perception, mixed-effect logistic regression models (registers~H1-H2+F1+F2+F0, random factor=speaker) were used to estimate the relative importance of the cues (H1*-H2*, F1, F2 and F0) in perception (Experiment 2) and production (Experiment 3). Log10(p-values) are plotted in Figures 2 and 3. In general, /be/ contrasts more through formants, whereas /bu/ contrasts more through phonation. Strikingly, cue weights in production and perception are not aligned. For /be/, F1 is the dominant cue in perception for all age groups, but in production, the dominant cue is shifting from phonation to formants (>50 = phonation, 40-50 = both, <40 = formants). For /bu/, although phonation remains the most salient cue in both perception and production, the relative importance of F1 is increasing over time in perception.

Discussion: While the register contrast is maintained, formants are overtaking phonation as the primary cues, suggesting that sound change is indeed underway. Our results clearly indicate that perceptual innovation is ahead of production – formant cues have become more dominant in perception before a similar shift occurs in production. This is consistent with Ohala's (1993) hypothesis that change is initiated when listeners reanalyze coarticulatory effects (i.e., tongue root retraction) in the language input. This finding also supports more nuanced sound change models (e.g., Beddor 2009, 2012, Kleber et al. 2012) regarding the mapping between production and perception. In the stable stage either before or after a sound change, production and perception are aligned. However, when a sound change is in progress, production and perception become misaligned as the innovative cue first enters the perception domain before passing into the speaker's production. This misalignment does not interfere the

perceptibility of a phonological contrast because listeners establish perceptual equivalence between coarticulated cues (Beddor 2009). Our results show that /be/ and /bu/ are at the different stages of sound change: For /be/, cue shifts have completed in both production and perception for younger speakers, but the oldest speakers still rely on the conservative phonation cue in production. /bu/ shows an earlier stage of change: cue shifts have only entered the perception domain of the youngest speakers.

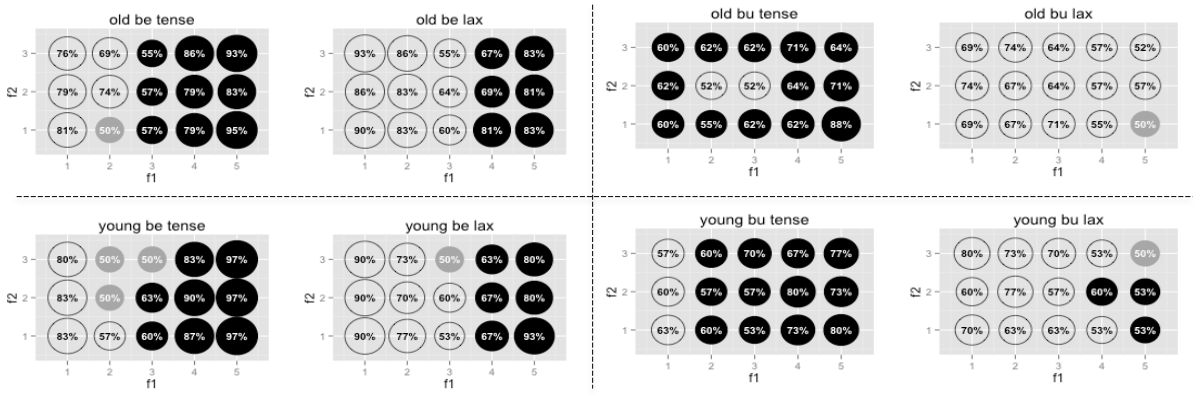

Figure 1. Percentages of responses along the resynthesized F1 x F2 x phonation continuum space for the >50 and <40 groups. Black circles indicate a majority of tense responses, and white circles a majority of lax responses. The 40-50 group is not shown due to space limitation.

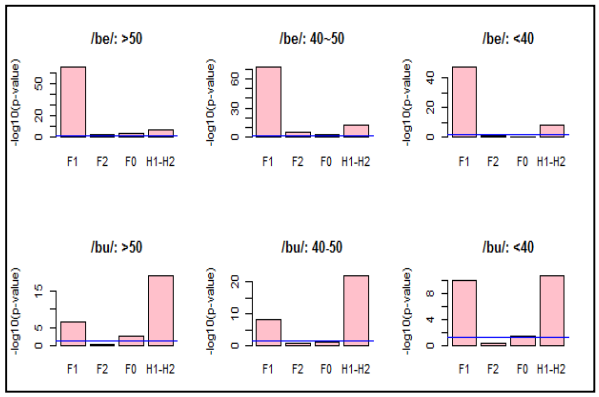

Figure 2. Cue weighting in perception. Horizontal line=-log10(0.05)

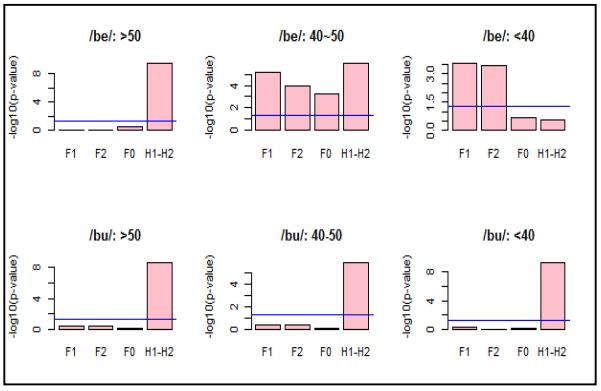

Figure 3, Cue weighting in production. Horizontal line=-log10(0.05)

References:

Beddor, P.S., 2009, A coarticulatory path to sound change. Language 85, 785-821.

Beddor, P.S. 2012. Perception grammars and sound change. *The initiation of sound change*, 37-55.

Edmondson, J.A., and J. H. Esling, 2006. The valves of the throat and their functioning in tone, vocal register, and stress: laryngoscopic case studies. Phonology 23,157-191.

Harrington, J., Kleber, F., & Reubold, U. 2008. Compensation for coarticulation, /u/-fronting, and sound change in standard southern British: An acoustic and perceptual study. JASA, 123(5), 2825-2835.

Kleber, F., Harrington, J., Reubold, U. 2012. The relation between perception and production of coarticulation during a sound change in progress. Language and Speech 55, 383-405

Kuang, J. & P. Keating, 2014, Glottal articulations in tense vs. lax phonation contrasts. JASA, 136(5):2784-2797

Kuang, J., 2011, Phonation contrast in two register contrast languages and its influence on vowel and tone, in Proc. ICPhS 17, 1146-1149

Maddieson, I., Ladefoged, P. 1985. "Tense" and "lax" in four minority languages of China. J. Phon. 13, 433-454.

Ohala, J. 1981. The listener as a source of sound change. In C. S. Masek, R. A. Hendrick, and M. F. Miller (Eds.) Papers from the Parasession on Language and Behavior. Chicago Linguistic Society: Chicago. (p. 178–203).

Ohala, J. J. 1993. The phonetics of sound change. In: Jones, C. (ed), Historical Linguistics: Problems and Perspectives . London: Longman, 237–278.

Shue Y.-L., Keating P. A., Vicenik C., and Yu K. 2011. "VoiceSauce: A program for voice analysis," in Proc. ICPhS 17, 1846–1849.