DIALECTAL VARIATION IN THE ACOUSTIC CORRELATES OF KOREAN STOPS

Jeffrey J. Holliday[a] *& Eun Jong Kong*[b]

[a]Department of Linguistics, Ohio State University, USA;
[b]Waisman Center, University of Wisconsin-Madison, USA
jeffh@ling.ohio-state.edu; ekong@wisc.edu

ABSTRACT

Most acoustic analyses of Korean stops have focused on the Seoul dialect, and the few dialect surveys that have been done used participants from different age groups and cannot be easily compared to each other. In this study, word-initial stop productions were collected from speakers of three Korean dialects (Seoul, Daegu, and Jeju) born between 1980 and 1991. The acoustic correlates of the stop laryngeal contrast in Jeju pattern similar to the Seoul dialect, appearing to participate in the sound change currently underway, but male Daegu speakers seem to be more conservative and still use VOT to signal the lax-aspirated contrast.

Keywords: Korean, Jeju, Daegu, stops, dialectal variation

1. INTRODUCTION

Korean is well known for its three-way laryngeal contrast between tense (fortis), lax (lenis), and aspirated stops. Much work has been devoted to understanding which acoustic correlates cue the contrast for Seoul speakers [4, 9], and significant differences have been found in VOT, $f0$, and H1-H2 (the amplitude difference between the first and second harmonics) of the following vowel. In early studies [5, 7], the tense series was traditionally associated with a short lag VOT, high $f0$, and negative H1-H2; the lax series with intermediate lag VOT, low $f0$, and positive H1-H2; and the aspirated series with long lag VOT, high $f0$, and positive H1-H2. More recent studies [6, 8, 9] have provided evidence that Seoul Korean is undergoing a sound change in which the lax and aspirated categories are merging along the VOT dimension and are distinguished mainly by $f0$. Speakers born after around 1965 showed much smaller VOT differences between the lax and aspirated categories than speakers born before then, and speakers born after 1980 often had VOT values for aspirated and lax stops that did not differ significantly [8].

Because most acoustic investigations of the Korean stop laryngeal contrast focus on the Seoul dialect, it is not well understood how or whether these changes are realized in other Korean dialects. In one of the few studies on dialectal variation of stops, Cho [2] compared the acoustic correlates of stops in speakers in their mid-20s from both Seoul and Daegu (which is in the Gyeongsang dialect region) and found that Daegu speakers' lax stops had shorter VOT values than those of Seoul speakers and that for Daegu speakers all three phonation types were well differentiated by VOT alone. Cho, et al. [4] compared the acoustic correlates of stops of Seoul and Jeju dialect speakers in their mid-50s and mid-70s. They found that Jeju speakers tended to have slightly shorter VOTs for lax and aspirated stops than Seoul speakers did, and that Seoul speakers seemed to use H1-H2 to differentiate stop categories more consistently than Jeju speakers did.

While these two studies provided good accounts of the acoustic correlates of the stop laryngeal categories in both dialects, they cannot be compared to each other due to the speakers' generation differences. The 5 male and 5 female participants in Cho's [2] Daegu study had a mean age of 25.1 years. Assuming they were recorded around 2003, the participants' mean year of birth would have been around 1979. The 8 male participants in Cho, et al's [4] Jeju study were in their mid-50s and mid-70s, placing them well into an older generation of speakers.

Thus, our goal for the current study was to characterize the acoustic properties of the stop laryngeal contrast in three different Korean dialects in younger speakers who are close in age. This will provide a more accurate snapshot of how the sound change is progressing in the stop consonants of different dialects of Korean. Specifically, we investigated the dialectal variation of VOT values for the three-way laryngeal stop categories by

Seoul, Daegu and Jeju speakers. In addition, we compared the relative weights of the VOT, ƒ0 and H1-H2 parameters in differentiating the three categories in these three dialects of Korean.

2. METHODS

2.1. Participants

Data from 36 native speakers of Korean were collected for this study. Six males and six females were recruited from each of three Korean dialect regions: Seoul, Daegu, and Jeju. Participants were born between 1980 and 1991 and were recorded between September and December 2010.

The Seoul participants were recorded in either a home or a quiet room at a local church. The Daegu participants were recorded in a recording studio on the Yeungnam University campus. The Jeju participants were recorded in a quiet classroom on the Jeju National University campus.

2.2. Materials

The target consonants were word-initial /t/, /t*/, /t^h/, /k/, /k*/, and /k^h/ in various vowel contexts. They were elicited in 51 Korean words that were very familiar to the participants, as the list was designed to elicit productions from novice L2 learners of Korean as well. The consonant-vowel makeup of the target CVs is presented in Table 2. The list also contained words with word-initial affricates and fricatives that were not analyzed in this paper.

Table 1: The number of stimuli for each consonant-vowel combination.

	Vowel			
Consonant	/a/	/i/	/u/	/ɨ/
/t/, /t*/, /t^h/	3	0	3	1
/k/, /k*/, /k^h/	3	3	3	1

2.3. Procedure

Participants read a list of 132 Korean words presented in Korean orthography in size 13.5 font on four sides of laminated A4 paper. They were seated a desk or table in front of a University Sounds US658H microphone mounted on a table-top mic stand approximately 15 to 20 cm from the participant's mouth. Participants were instructed to read the list at a comfortable pace, inserting at least 1 second between words, and to avoid using list intonation. Half of the Seoul participants were recorded in Praat, with the microphone connected to a laptop computer through a Roland UA-30 USB interface. The remaining participants were recorded with the same microphone connected directly to a Roland Edirol digital recorder. All recordings were sampled at 44,100 Hz.

2.4. Analysis

2.4.1. Acoustic measures

Three acoustic correlates were measured in each target word-initial CV token: VOT, ƒ0, and H1-H2. VOT was measured as the time from the peak energy of the burst until the onset of voicing, as signaled by the appearance of a voicing bar in the spectrogram. ƒ0 was measured 20 ms after vowel onset by calculating the inverse of the duration between two adjacent pulses. H1-H2 was measured at vowel onset by calculating the difference in amplitude between the first and second harmonics.

2.4.2. Statistical analysis

We combined the acoustic measures for each token into a single data frame along with information about talker dialect and gender. Each token was tagged as lax, tense, or aspirated. We then built mixed effects logistic regression models, using the lme4 package [1] in R, to assess the relative weight of the three acoustic parameters in differentiating tense, lax and aspirated stops.

Because a logistic regression requires a dependent variable of only two discrete categories, we made two sets of regression models to account for the three categories. The first set of models predicted tense/non-tense (i.e. lax and aspirated) based on the acoustic measures. VOT, ƒ0, and H1-H2 were included both as fixed effects and as random effects nested within subject, the grouping factor.

The second set of models excluded the tense tokens and only predicted lax/aspirated based on the acoustic measures. Separate models were built for males and females of each dialect, resulting in 12 models in total.

3. RESULTS

3.1. Raw patterns of VOT, ƒ0 and H1-H2

First, the distributions of VOT are presented in Fig. 1. Tense stops were highly similar across dialects in having shorter VOT than lax and aspirated stops. However, the VOT values of lax stops varied across both dialect and gender. Females exhibited more category overlap between lax and aspirated stops than males did, and Seoul and Jeju speakers showed more overlap than Daegu speakers did.

Figure 1: VOT values across dialect and gender. Vertical lines are the median VOT values for each category. Results of two-tailed t-tests between the lax and aspirated categories are shown in each plot.

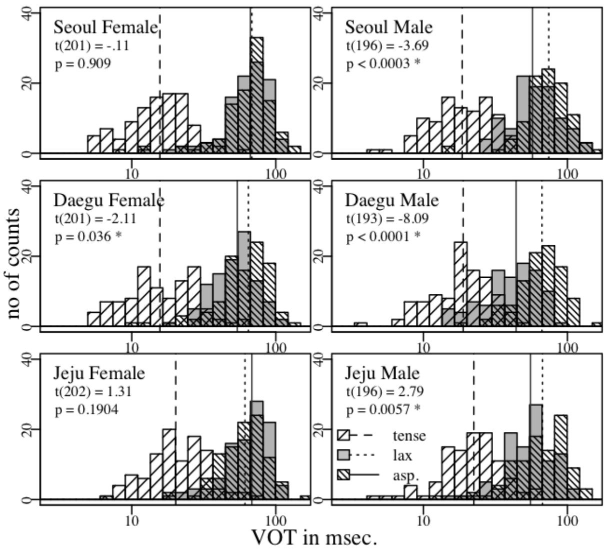
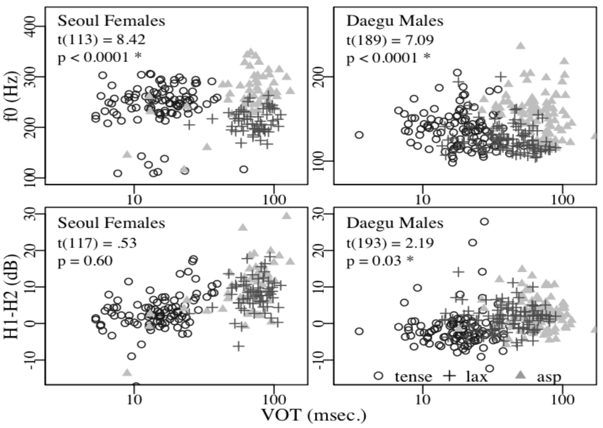


Figure 2: Scatter plots of $f0$ (top panels) and H1-H2 (bottom panels) as a function of VOT in Seoul female (left panels) and Daegu male (right panels) speakers. The t-test results (two-tailed) are for either $f0$ or H1-H2 in the lax-aspirated contrast.

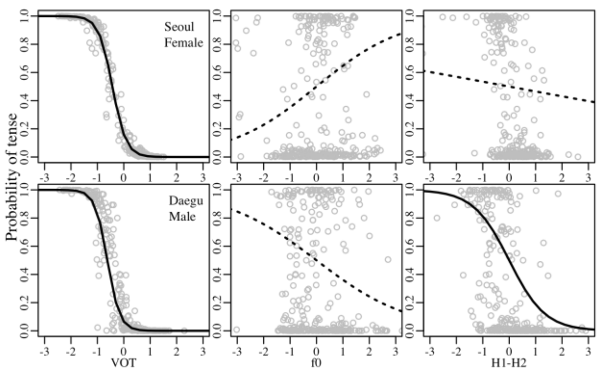


Thus, although VOT seems to differentiate tense stops in all gender-dialect groups, $f0$ and H1-H2 may be needed to separate the lax aspirated stops from each other. Because the Seoul females and Daegu males were the groups with most and least VOT overlap, respectively, we will look at them more closely in the figures below. In the left panels of Fig. 2, we can see almost total overlap of lax and aspirated stops in H1-H2 but clear separation in $f0$ by Seoul female speakers. The Daegu males, in the panels on the right, seem to exhibit less overlap in H1-H2 but not less separation in $f0$. These patterns suggest that Seoul females may be relying almost entirely on $f0$ to make the lax-aspirated contrast, whereas Daegu males are using multiple cues of VOT, $f0$, and H1-H2. More detailed patterns will be described in the results of the regression models in the next section.

3.2. Mixed effects logistic regression models

In the tense/non-tense models of all dialects, VOT was the only significant variable for females, whereas VOT and H1-H2 were both significant in the male model. As an example, Fig. 3 shows the probability curves of tense/non-tense as a function of each acoustic parameter estimated from the regression models for Seoul females and Daegu males. The shorter VOT values were more likely to be tense stops than non-tense stops by both speaker groups. Unlike in the female model, however, both shorter VOT and smaller H1-H2 values tended to be tense stops in the male model.

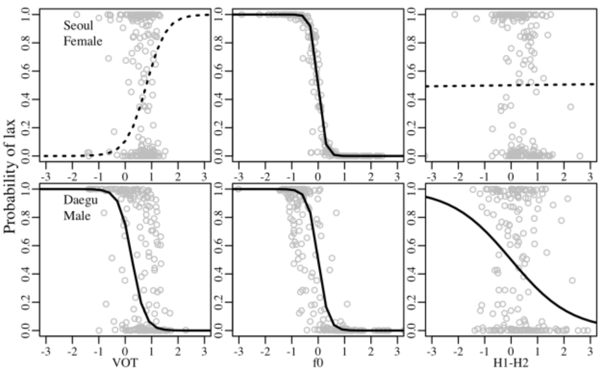
Figure 3: Probability curves of tense stops against VOT, $f0$ and H1-H2 parameters estimated from mixed effects logistic regression model: tense/non-tense stops (top panels for Seoul females and bottom panels for Daegu males). Data points indicate a model-predicted probability of tense for each token. Solid/dashed lines indicate significant/not significant variables based on the models.



Next, in the lax/aspirated models, $f0$ was the only significant variable for Seoul and Jeju female and male models. The models for Daegu speakers patterned differently in that the Daegu female model returned significant H1-H2 (although marginal, $p< 0.1$), as well as $f0$ and the Daegu male model showed all the three parameters significant in differentiating lax stops from aspirated stops. As in Fig. 4, lower $f0$ values were likely to be aspirated stops indicated by negative direction of the curve in both speaker groups. In the Daegu males' productions (bottom panels of

Fig. 4), shorter VOT and lower H1-H2 values also meaningfully predicted lax stops.

Figure 4: Probability curves of lax stops against VOT, *f0* and H1-H2 parameters estimated from mixed effects logistic regression model: lax vs. asp stops (top panels for Seoul females and bottom panels for Daegu males). Data points indicate a model-predicted probability of tense for each token.



4. DISCUSSION

We explored dialectal variation in the acoustic correlates for stop laryngeal categories produced by Seoul, Daegu and Jeju speakers. Our analysis revealed several trends. First, the Daegu lax and aspirated stops did not show as complete a merger along the VOT dimension as seen in Seoul and even in Jeju, as indicated by greater differences of VOT between the lax and aspirated categories in the Daegu dialect than in the Seoul and Jeju dialects. The VOT overlaps between lax and aspirated stops were least clear in Daegu males' productions evidenced by the significant role of VOT in differentiating lax stops from aspirated stops in the mixed effects logistic regression model. This suggests that Daegu males are perhaps the most conservative among the gender-dialect groups surveyed here. These results agree with Cho [2], whose results also suggested that the main difference between Seoul and Daegu stops is found in the VOT values of the lax stops.

Second, although older Jeju speakers' speech exhibits some conservative features in vowel production [3] and possibly also consonant production [4], our results provide evidence that young Jeju speakers' stop production is quite progressive, and fully participating in the sound change taking place in the Seoul dialect. Young Jeju males' and females' stops exhibited VOT distributions of the three stop categories indistinguishable from Seoul speakers, and in the mixed effects logistic regression model, *f*0 was the only significant parameter in distinguishing lax from aspirated stops. We interpret this result to mean that *f*0 is the only acoustic cue that Jeju speakers manipulate to signal the lax/aspirated distinction in stops.

On the contrary, it is the Daegu speakers who appear to be the most conservative in terms of sound change. Although we cannot discuss sound change within the Daegu dialect because we do not have recordings of older Daegu speakers, we can compare the patterns of the Seoul and Daegu speakers to determine whether Daegu speakers are following the merger pattern taking place in both Seoul and Jeju. It seems that they might be, but are advancing more slowly.

5. ACKNOWLEDGEMENTS

We would like to thank the participants and also Kyuchul Yoon, Yeonkyeong Lee, and Jay Seo for assistance in Daegu and Jeju. We would also like to thank Mary Beckman for her helpful comments. This work was supported by NSF grant #1024286 to Mary Beckman and the first author.

6. REFERENCES

[1] Bates, D., Maechler, M. 2009. lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-32. *http://CRAN.R-project.org/package=lme4*

[2] Cho, M. 2004. *An Acoustic Study of the Stops of the Seoul and Daegu Dialects.* MA thesis, Korea University, Seoul. [in Korean]

[3] Cho, T., Jun, S., Jung, S., Ladefoged, P. 2001. Vowels of Cheju. *Korean Journal of Linguistics* 26(4), 801-819.

[4] Cho, T., Jun, S., Ladefoged, P. 2002. Acoustic and aerodynamic correlates of Korean stops and fricatives. *J. Phon.* 30, 193-228.

[5] Han, M., Weitzman, R. 1970. Acoustic features of Korean /p',t',k'/, /p,t,k/ and /p^h,t^h,k^h/. *Phonetica* 22, 112-128.

[6] Kang, K., Guion, S. 2008. Clear speech production of Korean stops: Changing phonetic targets and enhancement strategies. *J. Acoust. Soc. Am.* 124(6), 3909-3917.

[7] Kim, C.W. 1965. On the autonomy of the tensity feature in stop classification (with special reference to Korean stops). *Word* 21, 339-359.

[8] Silva, D. 2006. Acoustic evidence for the emergence of tonal contrast in contemporary Korean. *Phonology* 23, 287-308.

[9] Wright, J. 2007. *Laryngeal Contrast in Seoul Korean*. Ph.D. dissertation, University of Pennsylvania.