

VARIATION IN VOICE ONSET TIME FOR KOREAN STOPS

A Case for Recent Sound Change

David J. Silva

The University of Texas at Arlington

Abstract. Acoustic data elicited from 34 native speakers of Korean living in the United States provide evidence for diachronic change in the voice onset time (VOT) of phrase-initial aspirated and lax stop phonemes. While older speakers produce aspirated and lax stops with clearly differentiated average VOT values, many younger speakers appear to have neutralized this difference, producing VOTs for aspirated stops that are substantially shorter than those of older speakers, and comparable to those for corresponding lax stops. The data further indicate that, within each age group, older speakers manifest sex-based differences in VOT while younger speakers do not. Despite this apparent shift in VOT values, the acoustic evidence suggests that all speakers in this study, regardless of age, continue to mark underlying differences between aspirated and lax stops in terms of stop closure and the fundamental frequency of the following vowel. It is concluded that the data point to a recent phonetic shift in the language, whereby VOT no longer serves as the primary cue to differentiate between lax and aspirated stops. There is not, however, evidence of any reorganization of the language as the phonemic level: the language's underlying lax ~ aspirated ~ tense contrasts endure.

Keywords: Korean language, phonetics, phonology, variation, sound change, apparent time, voice onset time (VOT), aspiration.

1. INTRODUCTION

From the very earliest days of the “generative revolution” of the 1960s, Korean has held a special place in the literature on phonetics and phonology. Pioneering research on Korean phonetics by scholars such as Lisker and Abramson (1964),

Han and Weitzman (1965, 1967), and C.-W. Kim (1965) made important contributions to the development of phonological theory. Landmark treatises such as Chomsky and Halle's *The Sound Pattern of English* (1968), Halle and Stevens' "Note on Laryngeal Features" (1971), and Kim-Renaud's 1974 doctoral dissertation, *Korean Consonantal Phonology*, have acknowledged—and sought to explain—the putatively unique three-way distinction among Korean's non-continuant obstruents: lax (plain) /p t c k/, aspirated /ph th ch kh/ and tense (reinforced) /pp tt cc kk/.¹

While phonetic investigations of Korean conducted during the 1970s (e.g., Hardcastle 1973 and Kagaya 1974) confirmed the findings of the previous decade, acoustic research conducted since the early 1990's has suggested that there have been changes in Korean speech patterns. Silva's 2002 review of the data reported in these more recent phonetic analyses of the Korean obstruents (e.g. T.-H. Cho 1996, J.-I. Han 1996, S.-A. Jun 1993, Y.-H. Kim 1995, Yeni-Komshian et al. 2000) reveals that some of the acoustic characteristics associated with each of the language's oral stop types may have changed over the past 40 years. More specifically, this meta-analysis of the existing literature indicates that since the mid 1960's, the duration of post-release aspiration for lax stops appears to have increased, the duration of aspiration for aspirated stops seems to have decreased ever so slightly, and aspiration associated with tense stops has remained stable.

To examine these apparent changes more directly, Silva, Choi, and Kim (2004) analyzed the voice-onset time (VOT) values associated with the lax, aspirated, and tense stops as produced by 14 female native Korean speakers of various ages. Their findings not only corroborate those put forth by Silva (2002), but also reveal the remarkable degree to which the VOT patterns manifested by the speakers in their corpus varied. Moreover, it appeared that age might be a key factor in assessing the observed variation. Their initial analysis, however, found no clear correlation between a subject's age and the duration of aspiration associated with each stop type: Some speakers were "heavier aspirators" and others were "lighter aspirators." Yet, after factoring out individual differences among speakers, an age-based trend ultimately revealed itself: Younger speakers manifested a smaller VOT difference between aspirated and lax stops than did older speakers. Silva et al. interpreted these facts as tentative support for language shift in Korean, a change whereby the gap in VOT values between

¹ For a recent alternative perspective on the typological status of the Korean stop system, the reader is encouraged to read Kim and Duanmu's thought-provoking 2004 article. Their claim that the Korean system is not as typologically marked as has been claimed is certain to inspire lively discussion and, perhaps, lead to a serious rethinking of Korean phonology.

aspirated and lax stops (in phrase-initial position) has apparently decreased over time.

The research reported in the current paper builds on Silva et al. (2002) by extending the analysis of aspiration/VOT data in two ways. First, the subject pool is expanded to include male speakers. Second, renewed attention is paid to how each speaker's age and sex might be related to the observed variation in the VOT data. More specifically, this paper addresses the following questions:

Is there systematic variation in the voice-onset time (VOT) values for the three types of Korean stops: /p t k/ ~ /pp tt kk/ ~ /ph th kh/?

Do age and sex play a role in characterizing the observed variation?

Can we support the position that there has been a diachronic change in VOT values?

Can we support the position that there is corresponding phonemic shift in the language?

As we shall see, there is observable systematic variation in VOT values for the Korean stops, where age is a key predictor variable and sex-based differences obtain, but are age-constrained. Moreover, there is evidence of sound change in its latest stage, but only a phonetic change: There is no evidence of phonemic shift among Korean's lax, tense, and aspirated stops.

2. BACKGROUND

Among the first acoustic analyses of the Korean stop system (Han and Weitzman 1965, 1967; C.-W. Kim 1965; Lisker and Abramson 1964), one finds widespread agreement regarding the role played by VOT in the differentiation of the three stop types. As Kim 1965 reports, for example, phrase-initial tense stops were observed to manifest little to no aspiration (with VOT averaging 12 ms), phrase-initial lax stops manifested moderate degrees of aspiration (mean = 35 ms), and phrase-initial aspirated stops manifested long aspiration durations (mean = 93 ms). Furthermore, scholars observed significant overlap between the VOT durations associated with tense and lax stops, thereby leading researchers such as C.-W. Kim to remark that, on its own, VOT was not sufficient for distinguishing between these two underlying categories (i.e., tense vs. lax).²

² The apparently unique VOT values associated with the Korean lax stops—i.e., the fact that they were consistently “lightly aspirated”—led researchers such as Halle and Stevens (1971) to create a special category, “p_k,” where “k” represented “as in Korean.”

Approximately 25 years later, Silva reported (1992) a different set of VOT patterns: Korean-speaking subjects recorded in the early 1990s produced statistically significant differences among VOT values for all three phonation types, a pattern suggesting that VOT had become a more reliable marker of phonemic contrast—even between tense and lax stops (c.f. C.-W. Kim 1965). As Silva (2002) makes clear, this apparent diachronic shift in VOT behavior has subsequently been corroborated by the research of other phoneticians who completed similar research in the mid- and late 1990s. In addition, Silva's 2002 meta-analysis points to the possibility of yet another factor in accounting for VOT values: sex of the speaker. Generalizing over a range of studies from the 1960s to the early 2000s, Silva finds that male speakers appear to produce longer VOTs for lax and aspirated stops, while there were no comparable gender differences between VOT values for tense stops.

Critical to the meta-analytical assessments advanced in Silva (2002) is the notion of change in apparent time: short of conducting a large-scale longitudinal study of a representative sample of Seoul residents, what is lacking is a more direct apparent-time analysis of this suspected change, one that seeks to analyze speakers of various ages under a single, consistent methodology. Silva, Choi, and Kim (2004) was a first step in this direction, but was limited as it considered only the speech of 14 female speakers. The current paper expands upon their work and advances the position that there is, in fact, evidence of a recently completed sound change associated with the production of the Korean stops.

3. METHODOLOGY

The data for this study were collected from 34 native speakers of Korean residing in the Dallas–Fort Worth area of Texas. The subjects, all of whom were born and raised in the Seoul/Gyeonggi-do region of Korea and are self-reported native speakers of the Seoul dialect, ranged in age from 23 to 59; 15 were male and 19, female.³ All reported arriving in the United States on or after their 18th birthday. Subjects were interviewed by one of two native speakers of Korean, who were likewise responsible for soliciting participants by means of developing contacts via existing social networks.

Each subject in the study was first asked to complete a demographic questionnaire that solicited information about his/her age, sex, education, occupation, native dialect, hometown, family background, and attitudes toward language. After the subject completed the questionnaire, s/he was asked to read a series of

³ Of the 19 female subjects, 14 were subjects in Silva et al.'s (2004) preliminary study.

3"-by-5" index cards, each containing a single carrier sentence of the form *iken* ___-*lako hacyo* ‘this (thing) is called ___’ (printed in *hankul*).⁴ Embedded in each carrier sentence was a three-syllable target word, each of which contained one of the nine Korean oral stops both in phrase-initial position (e.g., the /p/ in *panulcil* ‘sewing’) and in word-internal position (e.g., the /p/ in *capasem* ‘island of Java’), for a total of 18 test items.⁵ The subjects read the test sentences in random order five times each. Of these five rounds, the middle three were digitized and subjected to acoustic analysis.

For each token in the corpus, the temporal location of several acoustic landmarks was recorded: onset of the sonorant preceding the target segment; offset of the preceding segment’s F1, F2, and voicing; onset of the target segment’s burst; offset of the target segment’s burst; onset of the following vowel’s voicing, F1, and F2. From these data were derived a variety of acoustic measurements, central among these being the target segment’s VOT and its closure duration, both measured in milliseconds.

4. ANALYSIS

4.1 ANOVA Summary of the VOT Data

A preliminary analysis of variance (ANOVA) of VOT values was conducted by assessing the data in terms of four independent variables, each of which has proven relevant in previous research on Korean consonantal phonetics:

⁴ At the ICKL meeting in Turkey, the frame was mistakenly reported to begin with *ikey* ‘this thing-NOM’. Subjects in the field study, however, read frames beginning *iken* ‘this thing-TOP’, a fact that addresses one concern raised by a conference participant regarding the naturalness of the frame. I am solely to blame for this inadvertent error in my presentation and have my faithful research assistants to thank for reminding me that we had addressed this issue long ago. As is said in Korean, even monkeys fall from trees.

⁵ The carrier sentence was constructed by consulting previous work on Korean phonetics (e.g., C.-W. Kim 1965), in which there is frequent use of such frames. That said, I realize how labeling the position of the word-initial target segments as “phrase-initial” might be contentious, given the lack of agreement on how one can (or should) determine prosodic constituency in Korean. One ICKL conference participant, for example, questioned the validity of assuming that the frame included a phrasal boundary between first NP and the target form. While the concern is valid, previous research on the prosodic nature of Korean (e.g., Silva 2004), suggests that in a syntactic structure of this sort and length (10 syllables): (a) there will be a tendency to form multiple phrases; and (b) the most likely location for a phrasal boundary would be between the topic (*iken*) and the following predicate (beginning with the target word). All the same, there is no doubt that subsequent analyses of the sort undertaken here must take into fuller account the mechanisms by which prosodic structure is constituted in Korean, as has been eloquently discussed in the work of S.-A. Jun.

- speaker's sex;⁶
- place of articulation of the target segment (labial, alveolar, velar);
- phonation type of the target (lax, aspirated, tense); and
- prosodic position of the target (phrase-initial vs. word-internal).

These first ANOVAs indicated that only language-internal factors account for statistically significant differences in VOT values ($p \leq 0.05$): place of articulation, phonation type, and prosodic position. Post-hoc tests, however, contradict the between-subjects effects tests with regard to place of articulation: both Scheffé and Dunnett T3 multiple comparisons indicate no differences in mean VOT values for labial, alveolar, and velar segments (Table 1).

An analysis of interactions among the independent variables paints a more complex picture. As expected on the basis of similar previous work in Korean phonetics (e.g., Silva 1992, Jun 1993), there are interactions between phonation type and prosodic position. These interactions stem, in part, from the well-documented facts that in word-internal position: (a) lax stops typically become voiced, thereby yielding VOTs ≤ 0 ; (b) aspirated stops become less aspirated, approximating VOT values comparable to those for lax stops phrase-initially; and (c) VOT associated with tense stops are consistent, regardless of their prosodic position. In addition, the statistical significance of some of the factor interactions suggest that there may be systematic variation in VOT values attributable to the speaker's sex (see section 6 for further discussion).

Concerning the effect of prosodic position, we find (as we would expect) significant interactions with phonation type. For lax and aspirated stops, phrase-initial position is associated with substantially longer VOTs as compared to word-internal position. Consistent with Silva's 1992 account, lax stops present very short VOTs word-internally, an apparent reflex of Korean's oft-documented "phonological rule" of intervocalic voicing. Aspirated stops are likewise less aspirated word-internally. Tense stops, in contrast, do not exhibit observable VOT differences in each prosodic position: In either context, the mean VOT for tense stops falls in the 6 to 16 ms range. In light of the existing literature, these prosodically based patterns are wholly unsurprising.

⁶ In response to an issue raised in an earlier version of this text, I stand by my decision to label this variable "sex" (and not "gender") for three reasons. First, previous research in the field of Korean linguistics refers to the sex (and not the gender) of subjects. Second, I believe that the term "sex" is a more accurate translation of Korean *seng-pyel*, which appeared on the demographic questionnaire answered by each participant. Finally, given the social, psychological, biological, and emotional complexities that can accompany gender self-identification, I feel it unreasonable to label the subjects by gender based solely on their self-assignment to a given *seng-pyel*.

Table 1. Mean VOT values (ms) by place, phonation, prosody, and speaker's sex

Standard deviations in parentheses; $n = 1648$. ANOVA results indicate that between-subject factors of Place, Phonation, and Prosodic Position are statistically significant ($p \leq 0.05$). While separate values for female and male speakers are reported below, the ANOVA indicates no statistically significant differences based on sex. *Post hoc* tests reveal no statistically significant differences among the three places of articulation, summarized at bottom.

Place of Articulation	Phonation Type	Prosodic Position	Female		Male		
			Mean	SD	Mean	SD	
labial	lax	phrase-initial	62.5	(22.9)	59.6	(24.0)	
		word-internal	7.5	(11.8)	9.4	(8.2)	
	aspirated	phrase-initial	74.3	(28.9)	67.4	(27.0)	
		word-internal	34.7	(18.5)	46.0	(31.3)	
	tense	phrase-initial	6.2	(4.5)	7.7	(4.0)	
		word-internal	5.8	(3.5)	7.5	(8.3)	
	alveolar	lax	phrase-initial	65.2	(23.1)	62.9	(27.6)
			word-internal	8.7	(6.5)	8.5	(5.5)
aspirated		phrase-initial	72.0	(27.0)	73.2	(20.5)	
		word-internal	32.5	(13.5)	54.6	(15.8)	
tense		phrase-initial	9.8	(9.8)	8.9	(4.2)	
		word-internal	8.0	(7.6)	10.0	(4.5)	
velar		lax	phrase-initial	73.7	(22.5)	67.1	(21.4)
			word-internal	9.2	(8.2)	11.6	(8.0)
	aspirated	phrase-initial	81.8	(24.1)	73.4	(28.3)	
		word-internal	39.4	(16.4)	43.6	(15.2)	
	tense	phrase-initial	12.5	(8.6)	15.9	(9.0)	
		word-internal	10.4	(6.9)	13.7	(7.6)	
	total	lax	phrase-initial	67.1	(23.2)	63.2	(24.5)
			word-internal	8.6	(8.5)	9.6	(7.1)
aspirated		phrase-initial	76.0	(26.9)	71.3	(25.4)	
		word-internal	35.5	(16.4)	48.1	(22.4)	
tense		phrase-initial	9.6	(8.4)	10.9	(7.1)	
		word-internal	8.1	(6.6)	10.5	(7.4)	

Given these preliminary observations, it was deemed necessary that subsequent analysis of the stops must separately address target segments occurring phrase-initially from those appearing word-internally. To compare most directly the current study with the Korean acoustic research conducted in the 1960s and 1970s, let us confine our attention to the phrase-initial tokens.

4.2 VOT for Phrase-Initial Stops

ANOVAs run on the phrase-initial tokens ($n = 875$) indicate that only place of articulation and phonation type play statistically significant roles in the analysis. With respect to place of articulation, post-hoc comparisons reveal a distinction between non-velar stops and velars, with the latter manifesting a VOT 5 to 10 ms longer, regardless of phonation type. Regarding phonation type, *post hoc* comparisons indicate that tense segments manifest significantly shorter VOTs than do lax and aspirated stops. In addition, the difference in the mean VOT values for lax vs. aspirated stops is statistically significant. It is worth noting, however, that the actual difference in mean VOT values is a mere 8.5 ms (Figure 1), with substantial overlap in 2-standard deviation ranges for each of these two categories. This pattern represents a departure from those previously reported in the literature (see above), in which one finds either overlap in VOT for tense and lax stops (e.g., C.-W. Kim 1965) or negligible overlap among the stop types (e.g., Silva 1992).

4.3 Evidence of Sound Change among Phrase-Initial Stops

To discern more clearly any evidence of sound change, the VOT data were subjected to a series of correlations in which the independent variable was each speaker's year of birth. As seen in Figure 2, speakers of all ages manifest similar VOT values for tense stops. Important differences, however, lie in the distance between VOT values for lax and aspirated stops. While older speakers maintain a separation (graphically represented by white space between the upper two lines), younger speakers do not so clearly distinguish VOT values for these two stop types; the two upper lines intertwine. Regression analysis reveals a statistically significant downward trend in VOT of aspirated stops ($p < 0.001$; $r^2 = 0.451$); there are no significant relationships between VOT and year of birth for either lax or tense stops. In short, younger speakers realize phrase-initial aspirated stop phonemes with less aspiration than might have been anticipated.

Figure 2 also reveals robust individual differences in absolute VOT: While some speakers are "heavy aspirators," others are "light aspirators." To factor out such idiosyncrasies, a regression was run on a derived dependent variable, the "VOT gap," defined as the difference (in ms) between the mean VOT for aspirated and lax stops (Figure 3). Regression of the phrase-initial VOT gap data yields a significant but modest negative relationship ($p < 0.001$, $r^2 = 0.364$). More specifically, the VOT gap is relatively smaller for many younger speakers,

ANOVAs run on the data for these subjects, however, reveal no statistically significant difference in the mean VOT for aspirated and lax stops; we conclude, then, that for these speakers the VOT gap most likely approximates zero.

5. PHONETIC CHANGE WITHOUT PHONEMIC SHIFT

If VOT no longer distinguishes between lax and aspirated stops, what does? Further investigation suggests that at least two other acoustic variables may come into play: closure duration and the fundamental frequency (F0) of the vowel immediately following the target consonant.

ANOVAs of the closure durations for the phrase-initial stops indicate that phonation type is a statistically significant factor; post-hoc comparisons further reveal that all three phonation types are differentiated (Figure 4). Lax stops manifest the shortest closure durations (mean = 47.79 ms; s.d. = 33.6), aspirated

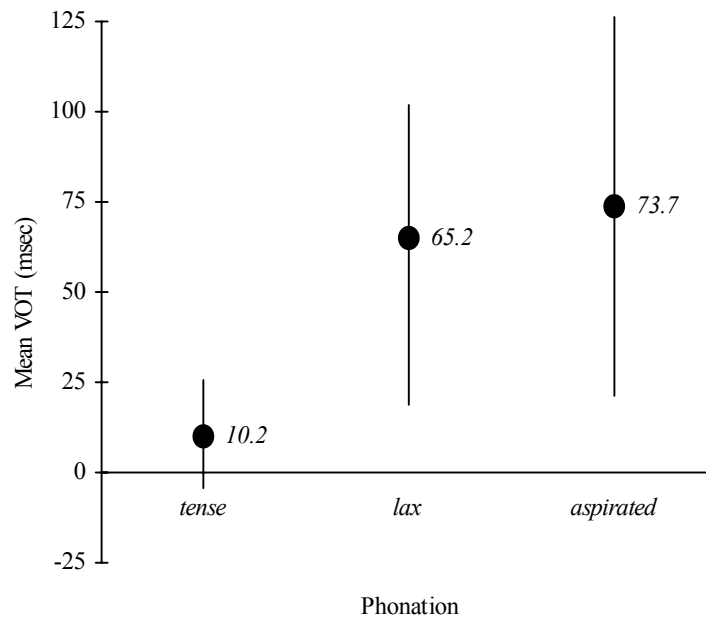


Figure 1. Mean VOT values for phrase-initial stops.

Data for all three places of articulation have been aggregated. Vertical lines represent 2 standard deviations both above and below each category mean.

stops manifest longer closures (mean = 63.94 ms; s.d. = 35.3) and tense stops manifest the longest (mean = 71.79 ms; s.d. = 35.7).

F0 patterns of the vowel following the target also appear to correlate with phonation (viz. Silva 1998). For vowels following a lax stop, the F0 trajectory from vowel onset to steady state tends to be level or slightly rising. In contrast, vowels following an aspirated stop always begin with a relatively higher F0, which then often manifests a drop into the steady state. Consider, for example, Figure 5, which includes two target words that have been extracted from their original frames—*tamocak* ‘multiple cropping’ and *thakocang* ‘alien place’—produced by subject Y01, a male speaker born in 1979. For the word-initial lax /t/ of *tamocak* (on the left), VOT is 77 ms; F0 of the following /a/ begins as 115 Hz and rises into the /m/ to a peak of 132 Hz. For the word-initial aspirated

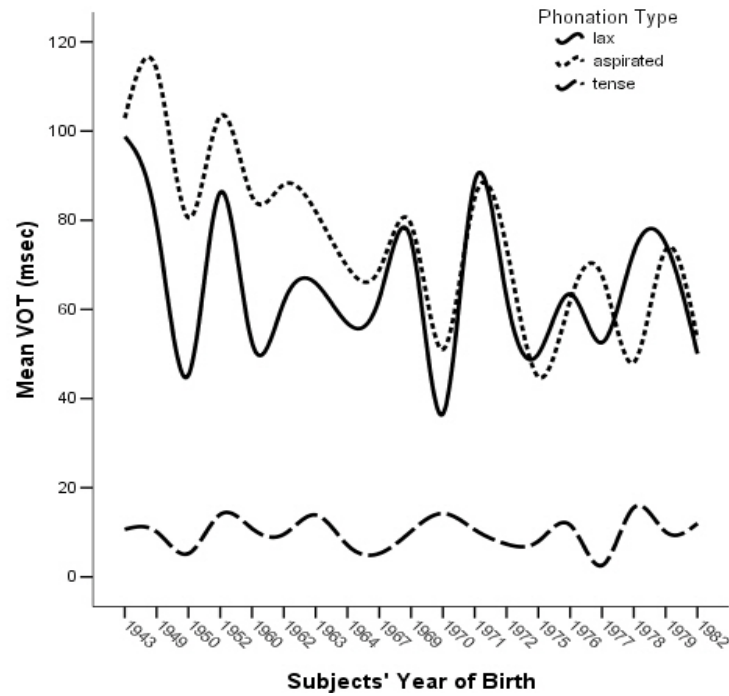


Figure 2. Mean VOT as a function of subjects' year of birth.

Lines have been splined for visual effect.

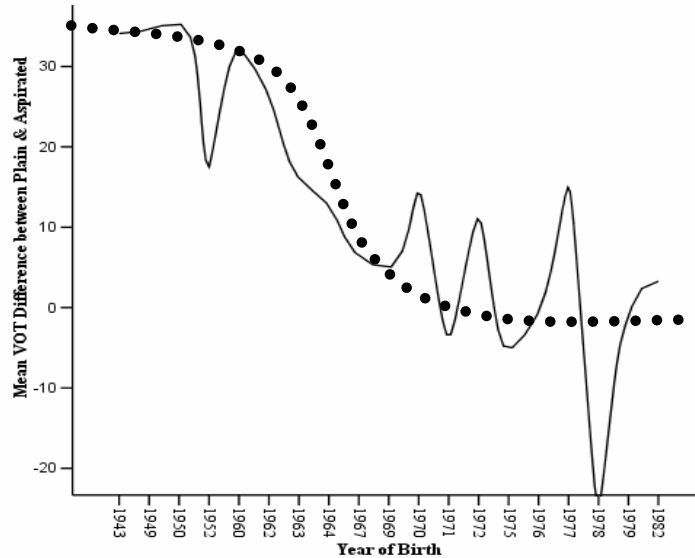


Figure 3. Age-related change for the VOT Gap (ms) ($mean VOT_{asp} - mean VOT_{lax}$).

The dotted line approximates an S-shaped curve, indicative of language change (see section 6).

/th/ of *thakocang*, VOT is 82 ms—a mere 5 ms longer than that of /t/. The F0 of the following /a/, however, is significantly higher: it begins at 167 Hz, falls to 156 Hz into the /m/ (which, as a nasal, may contribute to this drop), and then rises to 162 Hz for the /o/, before continuing a downward trajectory toward the right edge of the word. These sorts of patterns, in which F0 movements are associated with the phonation of the word-initial stop, manifest themselves throughout the corpus, and as such, merit closer quantitative investigation.

Such patterns are not new. Researchers from as far back as the 1960s (e.g. Han and Weitzman) have observed that the phonation type of Korean stops often correlated with F0 discursions in the following vowel: lax stops with low rising F0, aspirated stops with high falling F0, etc.⁷ What is noteworthy about the current study is the tantalizing notion that as VOT loses status as the primary differentiator between lax and aspirated stops, this secondary marker—F0 patterns—may be assuming prominence.

⁷ For general insights regarding relationships between phonation and corresponding prosodic reflexes, see Halle and Stevens 1971; Hombert, Ohala and Ewan 1979; and Kingston and Diehl 1994.

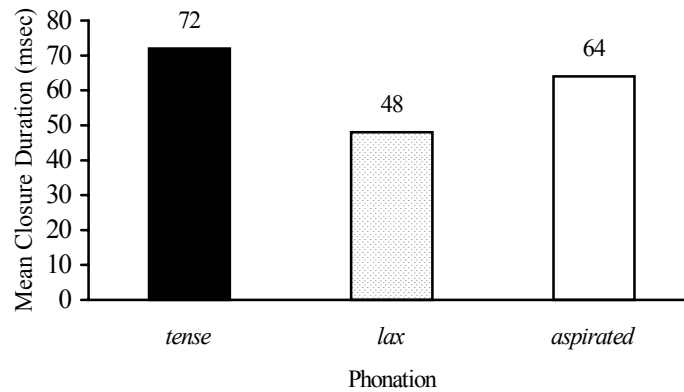


Figure 4. Mean closure values for phrase-initial stops.

Taken together, systematic differences in closure durations and F0 help to distinguish lax stops from their aspirated counterparts, thereby mitigating any neutralizing effects precipitated by the observed realignments of VOT. The extent to which Korean may be moving toward a system wherein one attribute (VOT) is being traded for another (e.g., F0) in the service of marking traditionally-conceived phonation distinctions (lax vs. aspirated) merits further acoustic research, as well as corroborating perception experiments (along the lines of those reported in Kim, Beddor, and Horrocks 2002).

6. CONCLUSIONS

To the extent that data for this study are representative of Seoul speech, one can conclude that this variety of Korean has recently changed. Until the late 1970s, VOT differences corresponded consistently with the categorical difference between aspirated stop phonemes and their lax and tense counterparts, while the latter two categories manifested overlapping VOT ranges. More recent data, however, suggest that differences in VOT for lax and aspirated stops have been neutralized, and may be being supplanted by differences in F0. Are we, then, witnessing tonogenesis in contemporary Seoul Korean? This question, which remains open, will be best assessed through a more systematic account of the relationships between phonation type and corresponding F0, of the sort documented for Jeonnam Korean by Jun (1989, 1990, 1993). Discerning the extent to

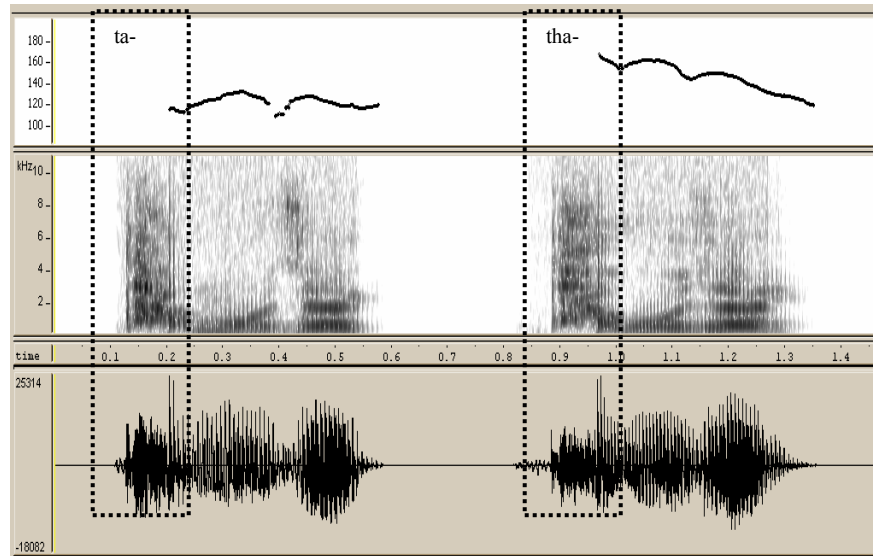


Figure 5. Acoustic displays for tamocak and thakocang (/ta-/ vs. /tha-/).

The fundamental frequency of the vowel following lax /t/ (left) rises slightly; F0 for the vowel following aspirated /th/ begins much higher and drops. VOT for each is similar: 77 vs. 82 ms.

which the standard language may be developing patterns typically associated with regional dialects (e.g., phonemic use of F0 as in Gyeongsang province) requires further investigation by sociolinguists, dialectologists, and phoneticians working in tandem.

As regards the extra-linguistic nature of this putative sound change, we find some evidence of an age-correlated S-shape (Figure 3), which suggests a completed sound change (Guy 2003). We do not, however, find clear effects on the basis of the speakers' sex—that is, until we account for age (Figure 6). For subjects born before 1970, female speakers produce VOT values for phrase-initial aspirated stops that are, on average, 29 ms longer than those for lax stops (s.d. = 13), while males present a mean VOT gap of 12 ms (s.d. = 11), a difference that proves statistically significant ($p = 0.029$). For subjects born in 1970 and after, however, there is no significant difference in the VOT gap across the sexes ($p=0.354$): the mean gap for females is -0.5 ms (s.d. = 12) while that of males is 5 ms (s.d. = 13). For this variable, VOT gap, sex-related behaviors have been

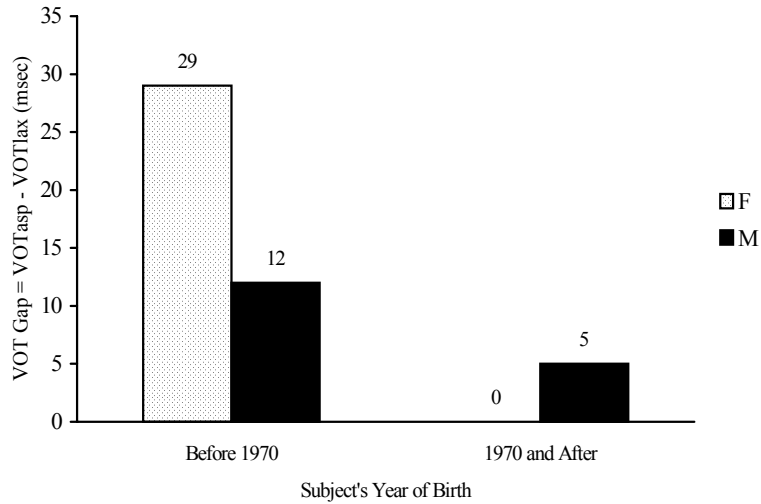


Figure 6. VOT gap by age group (older vs. younger) and sex.

neutralized for the younger generation. Whether this sex-by-age pattern represents a more generalizable trend remains to be explored.

In the end, these patterns of variation, coupled with the fact that we have no evidence of an irrecoverable phonemic merger, suggest the effects of a linguistic change from below. Whether the variation serves any discernible role as a sociolinguistic variable—for example, as a sociolinguistic indicator of socioeconomic status (Labov 1972:178)—remains to be explored. More comprehensive sociolinguistic fieldwork, including data collected from an appropriately socially stratified sample of speakers currently resident in Korea, as well as data from multiple speech styles, may reveal more about the status of the suspected language change documented here.

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David J. Silva <david@uta.edu>
The University of Texas at Arlington
Department of Linguistics and TESOL
UTA Box 19559—Hammond Hall 403
Arlington, TX 76019-0559, USA

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