ARTICULATORY CORRELATES OF STOP PHONATION IN L1 KOREAN AND L2 ENGLISH

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ABSTRACT

A growing body of research has identified and documented various acoustic cues for laryngeal contrasts, but it is still elusive what articulatory correlates various laryngeal contrasts are mapped onto, and whether such articulatory correlates emerge in a speaker's L1 and L2. Using ultrasound imaging of Korean-English late bilinguals, this study examines articulatory patterns of L1 Korean and L2 English alveolar stops. Results from eight speakers show that Korean fortis and aspirated stops and English voiced stops manifest as advanced tongue root when compared to Korean lenis stops and English voiceless stops respectively, along with some individualized patterns. Oral and nasal stops in both languages, albeit less robustly, also yielded some degree of articulatory distinction. These articulatory patterns offer new and exciting insights into abstract laryngeal categories and supralaryngeal articulatory gestures. Tongue root advancement serves as an articulatory correlate of Korean stop contrast, and also a cue to enhance voicing contrast in L2 English.

Keywords: stop phonation, tongue root advancement, ultrasound imaging, Korean, English

1. INTRODUCTION

Laryngeal stop contrast yields two major types: 'true-voice' and 'aspirating' types [1, 2]. Languages such as French, Spanish and Russian exhibit true-voice pattern where stops are classified as prevoiced and voiceless unaspirated stops. On the other hand, 'aspirating' languages such as English and German, word-initial stops appear as either plain, voiceless unaspirated and voiceless aspirated stops. It is widely acknowledged that various types of consonants are differentiated by a myriad of acoustic and perceptual cues, such as VOT for unaspirated vs. aspirated stops and f0 of the following vowel for fortis vs. non-fortis stops [3, 4]. Despite the numerous studies on acoustic and perceptual cues for laryngeal contrasts, it still calls for an investigation what articulatory correlates are mapped onto such cues. Focusing on tongue body/root movement, this study examines articulatory gestures that are associated with three laryngeal stops in Korean, and voiceless and voiced stops in English produced by Korean L2 learners of English.

As one of the aspirating languages, Korean exhibits a 3-way contrast of lax (/p, t, k/), fortis (/p', t', k'/), and aspirated (/p^h, t^h, k^h/) stops. Of our special interest are the fortis stops, which have traditionally been identified as 'tense'. Previous studies on tense consonants show that tense consonants are produced with more muscular "tension" in the pharyngeal region of the tongue than lax consonants [5], and result in longer duration than lax counterparts [6]. English, another aspirating language, shows voiceless (/p, t, k/) and voiced (/b, d, g/) stop distinction, which are also associated with various aerodynamic and acoustic correlates. Voiced stops are made with the increased supralaryngeal volume than voiceless stops, along with variation among different places and phonological contexts [7]. Recent ultrasound studies showed that tongue root is moved further front and tongue body is moved more downward during English voiced stop closure [8], and tongue root displacement is made for different stops and fricatives in Korean [9], albeit based on a small number of speakers.

While aerodynamic, acoustic and articulatory correlates provide complementary documentation of laryngeal contrast in two languages, an additional articulatory investigation with more speakers would further our understanding of how laryngeal contrast is made with articulatory gestures. Furthermore, this study also looks into articulatory correlates of stops produced by L2 speakers, represented by Korean leaners of English. In the present study, we address three research questions to examine the articulatory correlates of L1 Korean three-way stop contrast and L2 English voicing contrast, along with the gestural differences between oral and nasal stops in two languages. First, we examine if there is an intraoral articulatory correlate of L1 Korean stop

distinction. Second, we investigate whether the enlargement of oral cavity is associated with tongue root advancement for L2 English stop voicing. Lastly, we look for tongue body configuration to differentiate oral and nasal stops in L1 Korean and L2 English.

2. METHODS

2.1. Participants

Eight native speakers of Korean (4 females) participated in the production experiment. All participants were undergraduate students majoring in English, recruited from a university in South Korea, with the age range of 20 to 26 (mean age = 21). They learned English through the formal education system in South Korea for an average of 11 years. Their averaged English proficiency test score and self-rated proficiency score are 560 out of 990 on TOEIC® (Test Of English for International Communication) and 5.8 out of 10 point-scale, respectively, representing a group of upper-intermediate learners of English.

2.2. Materials

Various di- and trisyllabic words, where all target segments were word-initial, were employed in the production experiment. Given the potential V-to-C coarticulatory effects, all target segments were produced in three vowel contexts: /i, a, u/.

	lax /t/	fortis /t'/	aspirated /t^h/	nasal /n/
/i/	tita	t'ita	t^hita	nita
/a/	tata	t'ata	t^hata	nata
/u/	tuta	t'uta	t^huta	nuta

Table 1: Examples of Korean stimuli.

	voiceless /t/	voiced /d/	nasal /n/
/i/	teem	deep	need
/a/	tah-dah	darling	narcissism
/u/	too	doodle	noon

Table 2: Examples of English stimuli.

2.3. Procedures

Ultrasound imaging was employed to identify, extract and analyze the midsagittal tongue surface images. The production experiment with ultrasound imaging was proceeded in a quiet room at a university in South Korea. Articulatory and acoustic data were simultaneously collected using Articulate Assistant Advanced (AAA) software, connected to the EchoB ultrasound machine and 5-10 MHz convex-curved transducer. Participants were asked to wear a head-stabilizing headset, sit comfortably in front of a computer monitor and read out a list of stimuli at a normal speed. Following the data collection, midsagittal tongue images of interest were identified and extracted manually.

Extracted tongue contours were statistically analyzed using SSANOVA. As shown in Figure 1, when the averaged tongue curves and confidence intervals in different conditions do not overlap, tongue curves in different colors are considered statistically different, equivalent to $p<.05$.

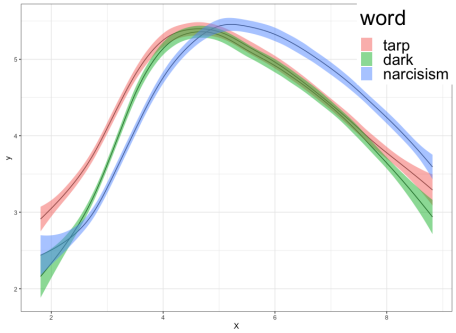

Figure 1: SSANOVA plot.

3. RESULTS

3.1. L1 Korean laryngeal contrast

Table 3 presents the percentages of speakers who showed 3-way and 2-way articulatory contrast for Korean lax, fortis and aspirated stops. Figure 2 illustrates 3-way comparisons of lax (/t/), fortis (/t'/), and aspirated (/t^h/) stops in Korean produced by Speakers #1 and #6, and Figure 3 shows 2-way comparisons of oral (/t/) and nasal (/n/) stops produced by the same speakers.

The results from Table 3 indicate that a vast majority of speakers make articulatory distinction for different laryngeal stops. Gestural patterns represented by two speakers in Figure 2 show a clear sign of tongue root advancement for the fortis stop (/t'/) when compared to non-fortis stops, and also for aspirated stop (/t^h) when compared to the lax counterpart. Tongue configuration is mediated by different vowel conditions, in which the /a/ environment yield more articulatory contrast

among three stops. As illustrated in Figure 3, the articulatory distinction between oral and nasal stops is not as robust as that among three laryngeal oral stops.

	lax vs. fortis vs. aspirated /t/ vs. /t'/ vs. /t^h/		oral vs. nasal /t/ vs. /n/
/i/	0%(3-way)	25%(2-way)	25%
/a/	50%(3-way)	37.5%(2-way)	37.5%
/u/	12.5%(3-way)	37.5%(2-way)	50%

Table 3: Summary of the Korean results.

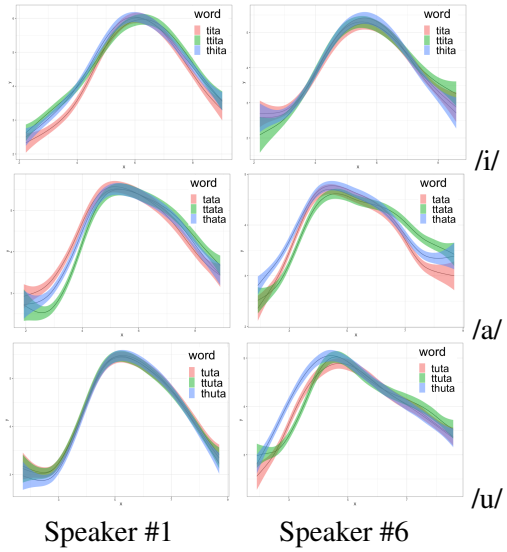

Figure 2: Korean lax (pink), fortis (green), and aspirated (blue) stops in three vowel conditions, produced by Speakers #1 and #6.

3.2. L2 English laryngeal contrast

Table 4 presents the percentages of speakers who showed 3-way articulatory contrast for English voiceless, voiced and nasal stops. Figure 4 shows 3-way comparisons of voiceless (/t/), voiced (/d/), and nasal (/n/) stops in English produced by Speakers #1 and #6. All 2-way articulatory contrasts in Table 4 were made for voiceless vs. voiced stops, with an exception of one instance by Speaker #5 who differentiated oral and nasal stops only in the /a/ context.

Figure 4 indicates that Korean learners of English do produce the articulatory distinction between voiceless and voiced stops, manifested as tongue root advancement for the voiced stop, in line with the findings from L1 English speakers [7, 8]. As for oral and nasal stops, only one speaker (Speaker #5) makes articulatory distinction between nasal

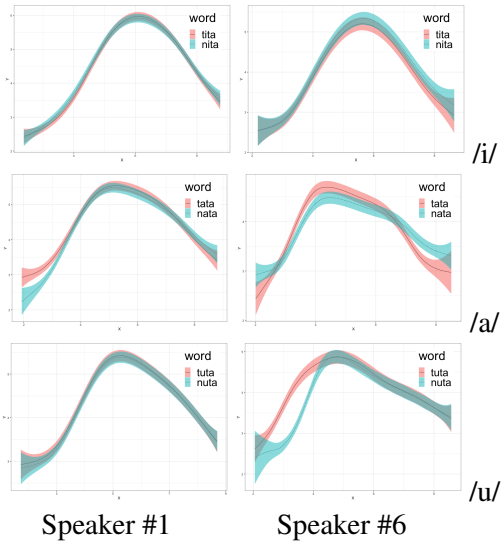

Figure 3: Korean oral (pink) and nasal (blue) stops in three vowel conditions, produced by Speakers #1 and #6.

	voiceless vs. voiced vs. nasal /t/ vs. /d/ vs. /n/	
/i/	0%(3-way)	25%(2-way)
/a/	37.5%(3-way)	50%(2-way)
/u/	25%(3-way)	12.5%(2-way)

Table 4: Summary of the English results.

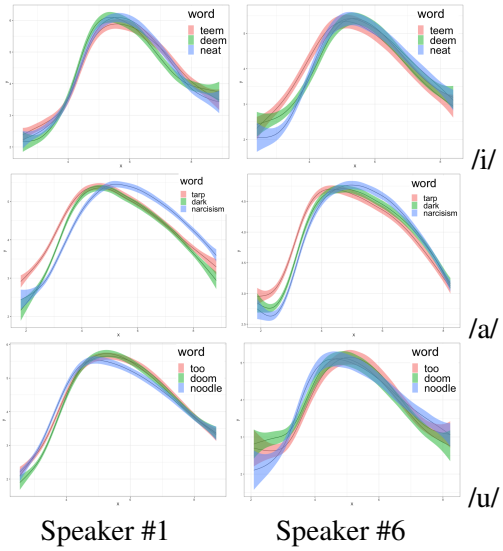

Figure 4: English voiceless (pink), voiced (green), and nasal (blue) stops in three vowel conditions, produced by Speakers #1 and #6.

and non-nasal stops. The gestural patterns of English voiceless and voiced stops produced by L2

learners suggest that Korean learners of English make articulatory efforts to produce voiced stops, even when voiceless and voiced stops are markedly different in the acoustic dimension, as illustrated in Figure 5. Voiceless and voiced stops produced by Speakers #1 and #3 show that they are clearly different in VOT and closure voicing. Tongue configuration for voiceless and voiced stops in this study suggests that tongue root advancement acts as L2 learners' cue that enhances the voicing contrast in L2.

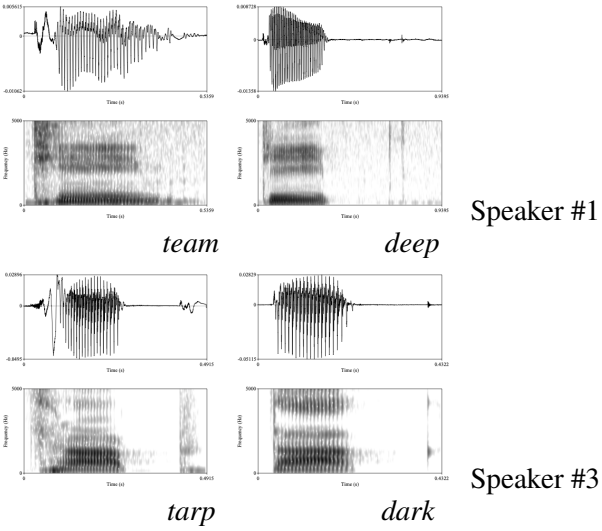

Figure 5: Waveforms and spectrograms of *team*, *deep*, *tarp*, and *dark* produced by Speakers #1 and #3.

In sum, our findings from Korean-English late bilinguals provide empirical evidence for the articulatory cue [ATR] at play both native and non-native stop contrast.

4. DISCUSSION AND CONCLUSIONS

The gestural patterns from our study indicate that the tongue root is advanced further front for Korean fortis stops than lenis or aspirated ones, and for English voiced stops than voiceless ones. In addition, compared to the contrast among oral stops, oral and nasal stops in both L1 and L2 do not differ markedly in the magnitude of tongue root displacement. The findings from this study offer new insight into tongue configuration for Korean and English stops. Tongue root advancement, or [ATR] serves as an articulatory cue to laryngeal contrast in L1 Korean and L2 English, accompanied or enhanced by the adjustment of supralaryngeal oral tract volume in conjunction with tongue root displacement. Less marked distinction between oral and nasal stops can be explained as the lowering of larynx, which obviates the need to advance the tongue root for nasal stops and expand the supralaryngeal volume.

Our findings can be further supported by future investigation with a wider variety of phonological and extralinguistic factors. Of our interest is whether different places of articulation and prosodic positions, e.g., utterance-medial vs. -final, result in different articulatory configuration. Furthermore, examining L2 speakers with various proficiency levels will lead to a more comprehensive understanding of tongue configurations for L1 and L2 stops.

5. REFERENCES

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