What is special about prosodic strengthening in Korean: Evidence in lingual movement in V#V and V#CV

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ABSTRACT

The present study investigates effects of Boundary and Prominence (focus) on the /a/-to-/i/ tongue movement in Korean in two contexts: V#V and V#/m/V. Results show that the tongue movement at an IP boundary is larger, longer, and faster. Prominence effects show a relatively weaker but comparable pattern to the boundary effect, showing a larger, longer, and faster movement. The observed boundary-induced strengthening pattern in Korean is clearly different from that in English, implying that Korean, a language without constraints from the lexical stress system, has more freedom to strengthen articulation at prosodic junctures, creating strengthening patterns which are often encountered with prominence marking in English. Results also reveal that the presence of a consonant influences transboundary vocalic movement, and that the consonantal influence is further modulated by boundary strength. These results taken together are further discussed in terms of language-specificity of prosodic strengthening and its implications for the pi-gesture model.

Keywords: prosodic boundary, prominence, focus, Korean, kinematics, articulatory phonology, EMA

1. INTRODUCTION

One of the well-known linguistic factors that affect articulatory realization of segments is the prosodic structure. Speakers tend to produce segments strongly at prosodically important locations such as prosodic edges and prominence-lending units ([13, 16, 17]). As for the boundary-induced strengthening, for example, transboundary effects on articulatory kinematics have been observed, with slower and longer transboundary vocalic movement (with occasional spatial expansion) at a higher than a lower prosodic boundary ([5, 6, 9]). Prominence (e.g., pitch accent) also induces articulatory strengthening on similar articulatory measures. The nature of the strengthening, however, may differ depending on the source of prosodic strengthening.

For example, articulatory movement has often been found to be larger, longer and *faster* when accented than unaccented, while boundary-induced strengthening is often characterized by *slower* articulatory movement ([10, 11]). Research on prosodically-conditioned kinematic patterns thus far, however, has been limited mostly to Indo-European languages. Although certain patterns of prosodic strengthening are considered universal (e.g., phrase-final lengthening, prominence-induced lengthening), it is still not clear how languages may differ in the way prosodic strengthening is phonetically realized. To expand our understanding on how prosodic strengthening is kinematically realized, the present study investigates the transboundary vocalic movement in Korean and compare the results with those found in previous studies on other languages.

Korean was selected as our target language because its prosodic system is typologically different from that of English and many other Indo-European languages. Korean does not employ a lexical level stress and therefore there is no head in its prominence system. It has been claimed that the lack of head-prominence system allows Korean to exhibit robust domain-initial strengthening effect compared to other languages such as English ([15, 20]). Furthermore, prominence in Korean tends to be marked by prosodic phrasing ([19, 24]), and hence it is possible that prosodic boundary may be confounded with prosodic prominence. The current study therefore designed the speech material so that we could tease apart the kinematic patterns of boundary-induced versus prominence-induced strengthening in Korean.

In addition, the present study compares the vocalic movement in /a#i/ (without an intervening consonant during the transboundary vocalic movement) and /a#mi/ (with an intervening consonant) sequences, in order to examine whether or not prosody-induced modifications on the tongue movement are further affected by the presence of an intervening consonant. In the Articulatory Phonology, it is generally assumed that vocalic and consonantal gestures are independently realized on separate tiers and that the consonantal gesture is superimposed on

the vowel gesture ([3, 23]). Under this assumption, the tongue movement may not show any further temporal (or spatial) modification due to the intervening consonant. Alternatively, however, given that consonantal and vocalic gestures are realized with some vocal tract constraints, the results may show differential strengthening effects on the vocalic gesture depending on the presence or absence of /m/.

2. METHOD

Six native speakers of Seoul Korean in their 20s and 30s participated in the study. Lingual movement data were collected using the Electromagnetic Midsagittal Articulography (EMA, Cartens AG200). Eight sensors were used: three on the tip, the body, and the dorsum of the tongue; two on the upper and the lower lips; one on the lower gumline; two sensors on the nose and the upper gumline as reference points for head movement correction. The lingual movement data were obtained from a sensor on the tongue body.

The /a/-to-/i/ target sequence was placed across a prosodic boundary (IP vs.Wd) in the test sentences as in Table 1. The target bearing words were inserted in different syllable structures ([a#i] vs. [a#mi]) and prominence conditions (focused vs. neutral vs. unfocused). The test sentences were repeated 4 times in a random order. All the utterances were examined by the two trained ToBI transcribers to confirm their prosodic structure. A total of 288 tokens were collected (2 boundaries x 3 prominence conditions x 2 syllable structures x 4 repetitions x 6 speakers). Eighteen tokens that did not match the intended prosodic conditions were excluded, leaving 270 tokens for data analyses.

The articulatory measures taken from /a/-to-/i/ vocalic movement included 1) peak velocity, 2) spatial displacement, 3) maximum tongue height for the vowels /a/ and /i/, 4) acceleration duration, 5) deceleration duration, and 6) total movement duration. Note that due to inherent noise in the velocity profile, the onset and the target were defined when the velocity value reached 20% of the peak velocity.

Table 1. A list of carrier sentences with [a#i] in different boundary (IP vs. Wd) and prominence (focused vs. unfocused) conditions. The target sequence [a#i] is underlined (#=an IP or a Wd boundary). Focused words are marked in bold and contrasting words in the preceding utterance are italicized. Speech materials with the target words that contain /a#mi/ (i.e., the target word [tʃʰa#minsa**)** are not shown in the table. Speech materials in the neutral condition (not shown in

Table 1) were the same as the sentences in this table, but they were produced without any indication of a specific focus.

a. IP, focused, [a#i]
[ja], [*minsa*hweiika anira],
[jəŋmani ilnjəntʃʰa]ɪₚ, # [insahweiie atʃik ankanni]?
→ 'Hey, I'm not talking about the civil affairs meeting, first-year, Youngman; didn't you go to the personnel meeting yet?'
b. IP, unfocused, [a#i]
[ja], [insa*tʃɛpʰan*i anira],
[jəŋmani ilnjəntʃʰa]ɪₚ, # [insahweiie atʃik ankanni]?
→ 'Hey, I'm not talking about the personnel's trial, first-year, Youngman; didn't you go to the personnel meeting yet?'
c. Wd, focused, [a#i]
[ilnjəntʃʰa*minsa*hweiika anira], [jəŋmana], [ilnjəntʃʰa # insahweiie atʃik ankanni]?
→ 'I'm not talking about the first-year civil affairs meeting; Youngman, didn't you go to the first-year personnel meeting yet?'
D . Wd, unfocused, [a#i]
[ilnjəntʃʰainsa*tʃɛpʰan*i   anira], [jəŋmana],
[ilnjəntʃʰa # insahweiie   atʃik ankanni]?
→ 'I'm not talking about the first-year personnel's trial; Youngman, didn't you go to the first-year personnel meeting yet?'

3. RESULTS

3.1. Boundary effects on the /a/-/i/ tongue movement

As summarized in Table 2, significant main effects of Boundary were found on almost all kinematic measures except for the maximum tongue height for /i/. The tongue movement was *faster* in peak velocity, *longer* in duration, and *larger* in displacement for IP than for Wd. The tongue height for /a/ was lower for IP than for Wd, indicating more lip opening along with the displacement data. A significant Boundary x Prominence interaction was found on peak velocity, which was in part due to the fact that the Boundary effect was not found in the focused condition, but it was significant (IP>Wd) in the neutral condition and revealed a trend effect (IP≥Wd) in the unfocused condition. An interaction between Boundary x Consonant was also significant on peak velocity. The interaction was attributable to a more robust boundary effect (IP>Wd) when there was no intervening consonant (/a#i/) than when /m/ was present (/a#mi/).

3.2. Prominence effect on the /a/-/i/ tongue movement

The Prominence effect could be generally characterized by larger (displacement, maximum height for /i/), longer (total movement duration), and slightly faster (peak velocity) tongue movement under focus (see Table 2). Note, however, that significant Boundary x Prominence interactions were observed for most of these measures (i.e., all but total movement duration), indicating that the Prominence effect is modulated by the prosodic

boundaries in Korean. The Boundary x Prominence interactions found for peak velocity and displacement were due to the fact that the Prominence effect was reliably found only at a Wd boundary: The tongue movement was faster and larger in the focused than in the neutral and unfocused conditions only for Wd. Similarly, the tongue maximum height for /i/ was significantly higher for the focused than for the unfocused condition only at a Wd boundary. A trend effect of Boundary x Prominence interaction found on the deceleration duration also revealed that the tongue movement tended to be longer in the focused than in the neutral condition, again only at a Wd boundary.

Post-hoc analyses on total movement duration showed that the tongue movement tended to be longer in the focused and unfocused conditions than in the neutral condition. No significant interaction was found between factors on total movement duration.

Table 2. Summary of statistical analyses. '*' = $p<0.05$, '**' = $p≤0.01$, 'tr.' = $0.05<p≤0.09$.

Measures	Boundary (IP vs. Wd)	Prominence (N vs. F vs. U)	Consonant (/a#i/ vs. /a#mi/)
Peak Velocity	$F[1,5]=8.40$* IP>Wd	$F[1.5,7.4]=4.35$tr. F>U*	$F[1,5]=5.12$tr. /a#i/≥/a#mi/
	Boundary x Prominence: $F[2,10]=15.34$** IP>Wd** in N; IP≥Wdtr. in U; F>(N=U)* only at Wd		
	Boundary x Consonant: $F[1,5]=11.89$* IP>Wd* in /a#i/; IP≥Wdtr. in/a#mi/; /a#i/>/a#mi/**only at IP		
	Boundary x Prominence x Consonant: $F[1.8,9]=4.10$tr. (IP>Wd in N & U but more for /a#i/)		
/a/ Max Height	$F[1,5]=50.50$** IP<Wd	n.s.	n.s.
	No interaction		
/i/ Max Height	n.s.	n.s.	$F[1,5]=4.67$tr. /a#i/≤/a#mi/
	Boundary x Prominence: $F[1,5]=10.07$** IP≥Wdtr. In F; IP>Wd* in N; F>U* only at Wd		
Dis-placement	$F[1,5]=30.24$** IP>Wd	$F[1.1,5.7]=9.65$* F>Ntr., F>U**	n.s.
	Boundary x Prominence: $F[1.4,6.9]=12.40$** F>(N=U)** only at Wd		
	Boundary x Consonant: $F[1,5]=10.06$* /a#mi/>/a#i/* only at Wd		
Accel. Duration	$F[1,5]=52.48$** IP>Wd	$F[1.7,8.4]=5.06$* F>Ntr.	n.s.
	No interaction		
Decel. Duration	$F[1,5]=49.35$** IP>Wd	n.s.	$F[1,5]=10.27$* /a#mi/>/a#i/
	Boundary x Prominence: $F[2,10]=3.76$tr. F≥Ntr. only at Wd		
Total Movement Duration	$F[1,5]=140.47$** IP>Wd	$F[2,10]=5.66$* (F=U) ≥ Ntr.	$F[1,5]=164$** /a#mi/>/a#i/
	No interaction		

3.3. Consonant effect on the /a/-/i/ tongue movement

Peak velocity of the tongue movement showed a trend effect of Consonant, showing faster movement when there was no intervening consonant (/a#i/) than when there was (/a#mi/). This effect, however, was significant only at an IP boundary. Significant main effects of Consonant were found on deceleration duration and total movement duration such that the duration was longer for /a#mi/ than for /a#i/. As for the displacement, there was no main effect of consonant, but the Boundary x Consonant interaction was significant, showing larger displacement for /a#mi/ than for /a#i/ only at a Wd boundary.

4. DISCUSSION

One of the important questions of this study was how the boundary effects are manifested on the transboundary V-to-V movement in Korean and how the effects are comparable to those in other languages. The results showed that the /a/-to-/i/ tongue movement is bigger in all directions: it is *larger* in displacement, *longer* in movement duration (including acceleration and deceleration durations), and *faster* in peak velocity. The spatial and temporal expansion of the transboundary vocalic movement, which has been observed in other languages such as English and French ([5, 11, 26]), seems to be universally observed pattern of prosodic strengthening. Crucially, however, the boundary effects on the transboundary V-to-V movement in Korean was found to be different from those in English which showed a larger, longer, and *slower* transboundary tongue movement at a strong boundary ([3, 11]). The present result is more similar to the case of French ([26]) which also exhibited faster peak velocity in the opening movement into the pre-boundary vowel /Ca#/ (C = consonant). This can be interpreted as implying that the articulatory slowing down at the prosodic juncture found in English may not be a universal characteristic of boundary-induced strengthening, but it is determined in a language specific way. We propose that the language-specificity found in terms of movement speed is attributed to language-specific prosodic systems. In English, lexical stress and phrase-level pitch accent are important aspects of prosodic structure, especially in terms of prominence marking, and its phonetic manifestation has often been found to be differentiated from that of boundary marking (e.g., [1, 2, 11]), showing larger, longer and *faster* movement. Korean and French, on the other hand, do not employ lexical stress and pitch accent in its prosodic system. Given that there is no articulatory constraint coming from stress marking, Korean appears to allow more degree of freedom to express the prosodic boundary marking.

The results have further implications for the π-gesture theory ([7]). Longer and *faster* vocalic

movement at a prosodic juncture found in Korean challenges the current π-gesture theory, which predicts longer and slower movement due to the (putative) universal clock slowing effect at the prosodic juncture. Our data suggest that, as the kinematic characteristics of prosodic strengthening differ depending on language-specific prosodic systems, the modulation of the clock slowing rate at the prosodic boundary might also differ from language to language, which implies that the theory of π-gesture should be augmented, reflecting how cross-linguistically different prosodic systems influence the operation of π-gesture.

The boundary-induced strengthening in Korean is quite comparable to the prominence-induced articulatory pattern in English not only in terms of movement speed, but also in terms of how the tongue gesture contributes to enhance vocalic features. The maximum tongue height values for /a/ and /i/ showed that the tongue height was lower for /a/ and higher for /i/ at an IP than at a Wd context, suggesting the enhancement of features [+low] (for /a/) and [+high] (for /i/). The featural enhancement due to local hyperarticulation ([16]) is known to be related to the prominence-induced strengthening in other languages such as English (e.g., [9, 10, 25]). The results are also in line with [12] which showed that the boundary effect in Korean induced the local phonetic contrast enhancement for consonantal articulation. The current results therefore add more evidence to the assumption that the boundary effect in Korean can be characterized by the local hyperarticulation. The results, along with the fact that the boundary- and the prominence-induced articulatory strengthening patterned alike in Korean, further lend support to the claim that prosodic boundary is confounded with prosodic prominence in Korean, such that it serves not only the function of marking prosodic phrases, but also that of signaling prominence in the language ([19, 24]).

Another important question that the present study explored was how prominence-induced strengthening patterns are articulatorily manifested in Korean. The tongue movement was found to be larger, longer, and it tended to be faster, which is similar to the articulatory characteristics found for the tongue and the lip gestures under prominence in languages such as English ([5, 11]) and German ([18]). One more interesting finding in this study is that the prominence effect was observed only when the boundary strength was weak (i.e., at a Wd boundary) in most kinematic measures. The result thus shows boundary-sensitive prominence effects for the transboundary vocalic movement. But it should be noted here that some previous findings showed that the interaction was more clearly reflected in prominence-sensitive boundary effects rather than in boundary-sensitive prominence effects both in English ([14]) and in Korean ([15])). The boundary-prominence interaction therefore does not appear to be as simple as the current results indicate, requiring more systematic studies within and across languages.

The comparison between V#V versus V#CV sequence in the current study has an implication for general assumptions in Articulatory Phonology. It has been assumed that C and V gestures independently operate on different tiers ([3, 23]), and start almost simultaneously in producing #CV sequence, showing in-phase intergestural coupling relationship ([4, 21, 22]). Results of the present study, however, showed that the transboundary vocalic gesture is affected by the presence of the consonant in terms of its spatio-temporal realization, suggesting that kinematic realization of the vocalic gesture is constrained by the consonantal gesture. The results also illustrated that the transboundary vocalic gesture is further influenced by the boundary-induced consonantal strengthening, not just by its presence. The peak velocity difference between /a#i/ vs. /a#mi/ (i.e., faster for /a#i/) was found only for IP and not for Wd, suggesting that the consonant produced strongly at the initial position of a higher prosodic domain (i.e., IP-initial /#m/) somehow impedes, and hence slows down the vocalic gesture. Finally, the fact that spatial displacement differed in the Wd context (i.e., larger for /a#mi/ than for /a#i/) but not in the IP context, may be due to differential coarticulatory propensities associated with boundary strength—i.e., CV coarticulatory propensity (or vulnerability) increases with a Wd boundary (presumably through the jaw linkage with the lips and the tongue), whereas CV coarticulatory resistance arises with an IP boundary (cf. [8]).

To conclude, the present study showed that boundary-induced strengthening patterns in Korean were remarkably similar to prominence-induced ones. They were at the same time remarkably different from prosodic strengthening patterns previously observed with English. With no functional demands that may come from the lexical stress system, Korean appears to mark boundary in a way that is comparable to prominence marking. This provides a challenge for dynamical theories of speech production, calling for modulation of detailed dynamical mechanisms that account for the extent to which prosodically-conditioned articulatory variation is cross-linguistically applicable versus language-specifically attuned.

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