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The amount and scope of phrase-final lengthening in Seoul Korean

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Abstract

Phrase-final lengthening is a well-established phenomenon. However, what determines the amount and scope of the effect is still unclear. Previous studies have reported prominence as a key factor, but these findings rely on data from stress languages. Here, we use electromagnetic articulography to examine the amount and scope of phrase-final lengthening in Seoul Korean, a language with no lexical-level prominence, as a function of factors that are associated with prominence, i.e., focus position and accentual phrase (AP) length. Stimuli sentences included the test words either in phrase-final or phrase-medial positions with focus position (initial AP, final AP) and final AP's length (long, short) manipulated. Formation and release durations of the test words' consonant constrictions were calculated. Phrase-final lengthening affects the final syllable, with greater amount of lengthening found on its coda as opposed to its onset, suggesting that lengthening is progressive, i.e., decreasing with distance from the boundary. Neither focus position nor AP length affect the scope of lengthening, but AP length affects the amount of lengthening of the final coda. Finally, boundary-related shortening is detected prior to the lengthening effect, and is presumably anticipatory. The implications of these results for prosodic structure, prosodic typology and speech planning are discussed.

Index Terms: phrase-final lengthening, accentual phrase, focus, prosodic structure, Korean

1. Introduction

Phrase-final lengthening, also known as pre-boundary lengthening, refers to longer acoustic and articulatory durations at the end of phrases as opposed to phrase-medial positions (e.g., [1, 2]). Cumulated studies on this phenomenon with various structures of syllables in different languages have reported greatest and most reliable phrase-final lengthening on the rhyme of the phrase-final syllable (cf. [1-3]). The effect appears to be progressive, i.e., decreasing with distance from the boundary (e.g., [1, 2, 4]). These findings have been modeled by the means of π-gestures, i.e., clock-slowing gestures that modulate the temporal properties of the constriction gestures that are coactive with them ([5]). Although phrase-final lengthening is a well-established phenomenon, the scope of the effect, i.e., the stretch of speech affected, is unclear. The limited previous work on the matter has revealed intricate interactions among prosodic factors, namely between prominence and boundaries. For instance, in Greek, the position of lexical stress determines the timing of both phrase-final lengthening and boundary tones. In particular, the earlier the stress is within the phrase-final word, the earlier the onset of these boundary events occurs ([6, 7]). Similar effects of stress on pre-boundary lengthening were also found in English (e.g., [1, 2, 4]. In an articulatory study ([1]), phrase-final lengthening began earlier in the final word when lexical stress was non-final. An acoustic study ([2]) detected phrase-final lengthening on the final syllable as well as on the stressed syllable – which was also accented – leaving any intervening syllables unaffected. This latter finding suggests that pre-boundary lengthening might affect multiple domains. Nonetheless, this previous work has mainly focused on languages that employ lexical stress, leaving open questions as to the scope of phrase-final lengthening in languages with different lexical prosodic systems.

Here, we turn to Seoul Korean, a language without lexically marked prosody. Seoul Korean does not have lexical stress, lexical tone or lexical pitch accent. Although recent tonogenetic sound changes have been observed among younger speakers, these are limited to specific segments and phrasal positions (e.g., [8, 9]). In languages with lexical stress, phrasal prominence is marked by pitch accents associated with the stressed syllable of the prominent word (cf. [10]). Instead, in Seoul Korean, Accentual Phrases (APs) serve as the basic intonational unit. Jun ([11, 12]) proposed that AP's underlying tonal pattern is THLH, where the realization of the initial tone (T) tends to depend on the laryngeal configuration of the AP-initial segment (see [12-15]). Phrasal prominence in Korean is known to be marked by prosodic phrasing, with the focused word consistently starting, i.e., (left-) heading, an AP or a higher phrase ([11, 13]), and any following AP boundaries often undergoing elimination, or possibly attenuation, referred to as dephrasing, up to the end of the Intonational Phrase (IP). Thus, there is a relationship between prominence and phrasing in Korean instantiated at the AP level serving the function of prominence marking. The current study focuses on the IP level, and assesses the amount and scope of phrase-final lengthening in Seoul Korean via Electromagnetic Articulography (EMA). Motivated by the attested interactions between prominence and IP phrasing ([1, 2, 6, 7]) in stress languages, we specifically test the effects, if any, of the prosodic dimensions related to prominence in Korean, i.e., focus position and the left-edge of the AP, on the amount and scope of phrase-final lengthening. For this purpose, the final AP's length and the position of the focused linguistic unit are manipulated.

We expect that Seoul Korean will present phrase-final lengthening, with the rhyme of the phrase-final syllable being affected (see [1, 3, 6, 7]). Moreover, one possible hypothesis based on previous findings of the interaction between position of prominence and phrase-final lengthening in stress languages ([1, 2, 6, 7]) is that lengthening might extend beyond the final rhyme towards (the head of) the prominent

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unit. If this hypothesis holds, we should see constrictions gestures preceding the rhyme of the final syllable undergoing phrase-final lengthening 1) when focus in on the penultimate AP as opposed to the final one, and 2) in long final APs as opposed to short ones. Following the same logic, the stretch of speech affected by phrase-final lengthening should be the longest when both the penultimate AP is focused and the final AP is long, since the distance between the head of the prominent unit and the IP boundary is maximized due to dephrasing. On the other hand, it is possible that in order for prominence to interact with phrase-final lengthening, a minimum distance between the head of prominence and the IP boundary should be satisfied. Indeed, the relevant findings from stress languages involve at most a three-syllable distance between these two prosodic events. If this is the case, the stretch of speech affected by phrase-final lengthening might be longer 1) when focus in on the final AP as opposed to the penultimate one, and 2) in short final APs as opposed to long ones. Finally, since Korean does not have lexical stress, there might not be an interaction between prominence and phrase-final lengthening.

2. Method

2.1. Participants and experimental procedure

Five native Seoul Korean speakers (4F, 1M; Mean age = 24.6; Age range = 21-29) participated in the present experiment. They were all affiliated with the University of California, Santa Barbara as graduate or exchange students, or post-doctorate researchers at the time of the experiment. The speakers were naïve as to the purpose of the study and had no reported speech, hearing, or vision problems. They received financial compensation for their participation.

Before the experiment, the participants went through a short 15-minute training session in order to be familiarized with the speech materials and the experimental procedure. In the experimental session, ten receiver coils were attached to the tongue dorsum (two sensors), tongue tip, upper/lower incisors, upper/lower lips, left/right ears, and nose. Kinematic data were collected using the AG501 3D electromagnetic articulograph (Carstens Medizinelektronik) at the UCSB Phonetics Laboratory. Audio recordings were performed simultaneously to the kinematic recordings by the means of a Sennheiser shotgun microphone set at a sampling rate of 16 kHz. Speech materials were presented on a computer screen placed roughly one meter away from the participant. Participants were asked to read target sentences (see Section 2.2) as if they were asking questions to a friend. To help appropriate focus placement, each target sentence was preceded by a prompt sentence. The prompt sentence, shown in green font, appeared 1 second before the target sentence, which was shown in blue font. Both prompt and target sentences were presented in regular font, i.e., non-bolded and non-underlined. The participant read prompt sentences silently and target sentences aloud.

Stimuli

To examine the scope of phrase-final lengthening, the test word /nɛ.maŋ.mi.nam/ was placed either in IP-final or IP-medial positions (see Table 1). The test word was purposefully selected to include nasal consonants in order to yield a typical LHLH AP tonal pattern of Seoul Korean and to avoid any lexical tonal effects coming from the laryngeal configurations of the segments involved (e.g., [12, 14]).

To vary AP length, the target sentences consisted of two APs, referred to as AP1 and AP2, which were either 4 or 7 syllable long, yielding the following combinations: [4-syllable-AP1 + 7-syllable-AP2] vs. [7-syllable-AP1 + 4-syllable-AP2]. Focus location was also varied, with contrastive focus being either on AP1 or on AP2. Focus on AP1 led to dephrasing, presumably also increasing the distance of the right IP boundary from the left boundary of the final AP to 11 syllables. The combination of AP length and focus location gave eight conditions in total and each condition was repeated eight times. Note that for one speaker, five repetitions were collected due to interruption of the experimental session for technical reasons. In total, 296 tokens were included in the analyses reported here. The acquired data were checked for their prosodic rendition, i.e., focus placement and appropriate accentual and IP phrasing.

Table 1: *Example sentences with the [7-syllable-AP1 + 4-syllable-AP2] construction presented by focus position (AP1 vs. AP2) and boundary type (IP-final vs. IP medial). Measured intervals are shown in bold and focused words are underlined.*

Focus	Boundary	Target sentence (#=IP)
AP1	IP-final	[minamigomobuga **nɛmaŋminam**]? # [sʌntækhangʌja]? Uncle Minam (as opposed to Junseok) is the handsome guy from Nemang? Is it decided?
	IP-medial	[minamigomobuga **nɛmaŋminam** sʌntækhangʌja]? Uncle Minam (as opposed to Junseok) chose the handsome guy from Nemang?
AP2	IP-final	[minamigomobuga **nɛmaŋminam**]? # [sʌntækhangʌja]? Uncle Minam is the handsome guy from Nemang (as opposed to Nowon)? Is it decided?
	IP-medial	[minamigomobuga **nɛmaŋminam** sʌntækhangʌja]? Uncle Minam chose the handsome guy from Nemang (as opposed to Nowon)?

2.2. Data analysis

All consonant (C) gestures comprising the word /nɛ.maŋ.mi.nam/ were analyzed, except the coda of the second syllable. Coda /ŋ/ was excluded from the analysis because of its degree of blending with the neighboring vowels. These test C gestures were semi-automatically using custom software (Mark Tiede, Haskins Laboratories). For the first (C1) and the fourth (C4) test consonant of /nɛ.maŋ.mi.nam/, both of which are /n/, the tongue tip vertical displacement trajectory was used for labeling. For the second, third and fifth consonants (referred to as C2, C3, and C5 respectively), which are all /m/, the lip aperture trajectory was used. The labeling

procedure detected the following kinematic timepoints in each C gesture on the basis of velocity criteria: onset, time of peak velocity, target, constriction maximum, release, and offset (Figure 1). Based on these timepoints, several measures were calculated. The analysis reported here uses the following measures: duration of formation (F) and duration of release (R) of each test C gesture. Formation corresponds to the interval between the onset and release timepoints, and release to the interval between the release and offset timepoints.

The retrieved data were analyzed by linear mixed effects analysis using *lmerTest* ([16]) package in R (R Statistics, 2019). The dependent variables were formation duration and release duration for each C gesture. Fixed effects of boundary (IP-final, IP-medial), AP length ([4-syllable-AP1 + 7-syllable-AP2], [7-syllable-AP1 + 4-syllable-AP2]), and focus location (AP1, AP2) were included. Random effects of speaker and repetition were added in the model. In case of significant effects, pair-wise comparisons were assessed by the relevel function. Any additional evaluation of the model was compensated for using a Bonferroni correction.

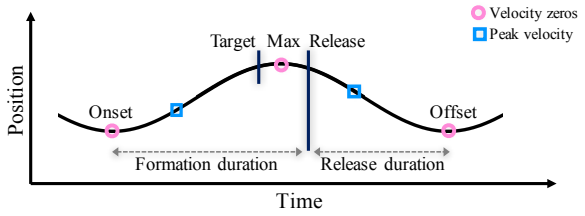

Figure 1: *Kinematic timepoints of constriction gestures.*

3. Results

For the purpose of the present study, we will only report results that are directly related to the research questions: i.e., main effects of boundary and its interaction with AP length and focus location.

3.1. Amount and scope of phrase-final lengthening

Statistical results are summarized in Table 2 and the main effect of boundary is visually represented in Figure 2.

Boundary had a significant main effect for the C gestures of the final two syllables, as shown in Figure 2. In particular, both the formation and the release phases of the C gestures in the onset and the coda of the final syllable (C4 and C5 respectively) were longer IP-finally than IP-medially. Among the C gestures that were lengthened by the IP boundary, the durational effect was the greatest in the C gesture adjacent to the boundary, meaning the coda of the final rhyme. The formation and release durations of the final coda consonant (C5-F and C5-R) were each 63% and 62% longer in phrase-final positions as opposed to phrase-medial positions. In parallel, the C gesture in the onset of the final syllable (C4), showed an increase in its formation and release durations by 8% and 19% respectively. Taken together, these findings suggest progressive phrase-final lengthening, with the effect decreasing with distance from the IP boundary.

The boundary-related effect on the onset of the penultimate syllable (C3), on the other hand, was of the shortening type, since C3 release was shorter in IP-final positions as compared to their IP-medial counterparts by 9.1 ms on average. A shortening effect is frequently observed in the phrase-final lengthening literature, and may be attributable to the global speech planning process (cf. [17, 18]). No further effect of boundary was found for the consonants that were further away from the boundary than C3.

Table 2: *Summary of the lmer results for the main effect of boundary and its interaction with AP length for each test C gesture (C1 to C5). F stands for formation and R for release. No significant interaction was detected for boundary*focus location.*

Measurement	Boundary	Boundary*AP length
C1-F	n.s.	n.s.
C1-R	n.s.	n.s.
C2-F	n.s.	n.s.
C2-R	n.s.	n.s.
C3-F	n.s.	n.s.
C3-R	$\chi2(1)=14.9$, $p<0.001$, $\Delta=-9.2$ms	n.s.
C4-F	$\chi2(1)=13.2$, $p<0.001$, $\Delta=5.2$ms	n.s.
C4-R	$\chi2(1)=38.0$, $p<0.001$, $\Delta=10.7$ms	n.s.
C5-F	$\chi2(1)=300.9$, $p<0.001$, $\Delta=51.8$ms	$\chi2(1)=11.1$, $p<0.001$
C5-R	$\chi2(1)=69.7$, $p<0.001$, $\Delta=41.8$ms	n.s.

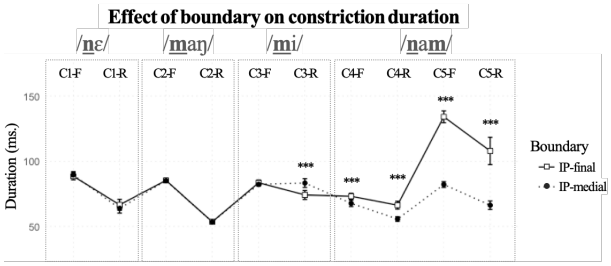

Figure 2: *Main effect of boundary on formation (F) and release (R) duration for each test consonant (C) gesture (C1 to C5). *** refers to p<0.001.*

3.2. Interaction with accentual phrasing and focus

Among the C gestures that showed phrase-final lengthening, the formation duration of the final coda consonant (C5-F) had an interaction effect with AP length that reached the level of significance (Table 2).

As shown in Figure 3, both [4-syllable-AP1 + 7-syllable-AP2] and [7-syllable-AP1 + 4-syllable-AP2] have the same direction of the phrase-final lengthening effect, i.e., longer duration IP-finally as opposed to IP-medially. The interaction arises from greater dispersion between the two boundary types in the [7-syllable-AP1 + 4-syllable-AP2] condition, where the formation duration of C5 underwent phrase-final lengthening by 75% (adjusted-$R^2 = 0.71$) as opposed to a 52% lengthening in the [4-syllable-AP1 + 7-syllable-AP2] condition (adjusted-$R^2 = 0.65$).

No other interaction was detected, indicating that the boundary effect had a consistent effect regardless of AP length or location of focus.

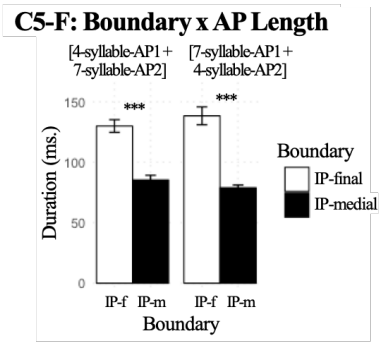

Figure 3*: The interaction effect between boundary and AP length on the formation duration of the word-final coda (C5-F). *** refers to p<0.001.*

4. Discussion

One of the main findings of the present study is that the phrase-final lengthening effect in Seoul Korean is largely restricted to the boundary-adjacent syllable, i.e., the phrase-final syllable. This is in line with previous literature that reports phrase-final rhyme as the most reliable domain of the effect (e.g., [1, 3, 6]). However, lengthening in Seoul Korean extends to a slightly larger domain, including, in addition to the final rhyme, the onset of the final syllable as well. The effect appears to be progressive, in accordance with previous studies (cf. [4, 6, 7]); lengthening is greater in the coda consonant as opposed to the onset consonant of the final syllable. These results conform to our hypothesis that the greatest lengthening would be detected on the rhyme of the final syllable, and can be captured by a π-gesture coordinated with that syllable, although further research is needed in order to specify the type of this coordination ([5]).

Our analyses also detected boundary-related shortening in the onset of the second to the last syllable. Boundary-related shortening effects have previously been reported in the literature on either side of the boundary (e.g., [1, 6]). Post-boundary, the shortening effect has been shown to be systematic and has been characterized as compensatory in nature. Pre-boundary, shortening has been found to be less systematic and speaker-specific, with its location being affected by the position of stress in the phrase-final word. Our data present systematic pre-boundary shortening. Combined with the post-boundary shortening effects reported elsewhere, the phenomenon could be attributed to processes regulating global speech timing – pre-boundary shortening being anticipatory and post-boundary shortening being compensatory (cf. [19]).

An important question for the current study was to assess which, if any, prosodic factors associated with prominence interact with the phrase-final lengthening in Seoul Korean. We examined factors that are related to the higher-order prominence system of Seoul Korean, namely focus location and AP boundaries. Our results suggest that there is no interaction effect between prominence position and the scope of phrase-final lengthening in Seoul Korean, unlike Greek or English (e.g., [6, 7]). A possible interpretation of these findings could be that the interactions between prominence position and phrase-final lengthening found in Greek and English is ascribable to lexical-level prominence rather than the higher-order prominence system. On the other hand, no effect of focus on the initiation of phrase-final lengthening raises the possibility that dephrasing in Seoul Korean is partial, exhibiting pitch compression post-focally but not involving any accompanying temporal adjustments in articulatory movements. Finally, final coda consonants presented an effect of final AP length on the amount of phrase-final lengthening. The formation of these gestures lengthened more when the final AP was short as opposed to long (Section 3.2). This indicates that prominence in Seoul Korean affects the amount of lengthening but not the scope of the effect. This pattern adheres better to our alternative hypothesis that there might be a minimum distance to be satisfied between the head of prominence and the IP boundary in order for the two prosodic factors to interact. Future research will examine shorter APs to confirm the hypothesis.

The work presented here provided critical information on the intricate relationship between boundary and prominence marking systems. Analyses that include more data and address a fuller set of boundary-related dimensions are underway, and will shed more light on the interface between prosodic structure and articulation.

5. Conclusions

In conclusion, phrase-final lengthening in Seoul Korean extends over the phrase-final syllable, i.e., a single continuous interval. The effect is progressive, being greater in the rhyme than in in the onset of that syllable. Prominence does not further modify the scope of the effect, but it does modify its amount: lengthening in phrase-final syllables is greater when the final AP is short as opposed to long. The effect of prominence on the amount of phrase-final lengthening suggests that prominence and boundary marking systems interact in Seoul Korean, a language that does not employ lexical-stress. The lack of an effect of prominence on the scope of phrase-final lengthening, on the other hand, combined with the presence of such effects in English and Greek (e.g., [1, 6, 7]), may indicate that scope-related effects in languages with lexical prominence are licensed by lexical-level prominence in general or lexical stress specifically. Future research will assess this hypothesis by directly drawing cross-linguistic comparisons. Boundary-related shortening detected in the penultimate syllable of the phrase adds to an anticipatory speech planning account.

6. Acknowledgements

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7. References

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