

Segmental effects on Prosodic Domain–initial Strengthening

Mira Oh*

ABSTRACT

This study examines the effect of laryngeal consonants of Korean on prosodic domain–initial strengthening. Keating, Cho, Fougeron & Hsu (1999), Fougeron & Keating (1996), and Hsu & Jun (1998) found that consonants at the beginnings of larger phrases are more constricted than consonants at the beginnings of smaller phrases. Korean laryngeal consonants pose a counter–example to the general pattern of domain–initial strengthening since tense and aspirated consonants are longer word–medially than word–initially. Previous work on domain–initial strengthening focused on domain–initial consonants at different prosodic domains. This study shows that acoustic cues that are not domain–edge also function to demarcate prosodic structure when the domain–initial consonant is laryngeal: VOT for an aspirated consonant and duration of V2 for a tense consonant.

Keywords: Prosodic Domain, Laryngeal Consonants, Strengthening

1. Introduction

Consonants are articulatorily strengthened when they are initial in a prosodic domain. This domain–initial strengthening is generally cumulative as attested by Keating, Cho, Fougeron & Hsu (1999) for English, Fougeron & Keating (1996) for French, and Hsu & Jun (1998) for Taiwanese. That is to say, consonants at the beginnings of larger phrases are more constricted than consonants at the beginnings of smaller phrases. Cho & Keating (1999) suggest that “strengthening” and “lengthening” is a single effect in Korean. However, Korean laryngeal consonant lengthening pose a counter–example to the general pattern of domain–initial strengthening in that a word–internal intervocalic laryngeal consonant is longer than a word–initial one. Previous literature on prosodic domain–initial strengthening focused on domain–edge segments. This paper aims to

* Department of English, Chonnam National University

investigate whether domain-initial strengthening is confined to domain-edge segments and further to show that not only domain-initial consonants but also the acoustic cues next to the domain-initial segments can be strengthened to demarcate the prosodic domains in Korean.

In this work, I use the model of Korean prosodic structure of Jun (1993) where prosodic levels are defined by intonational correlates: Intonational Phrase (IP), Accentual Phrase (AP), and the prosodic Word plus any intra-Word domains as in Figure 1.

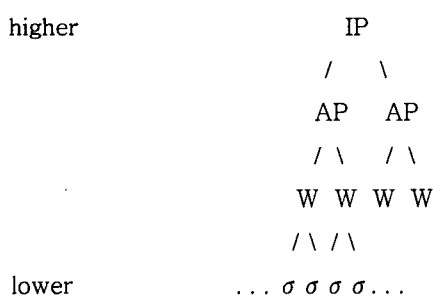


Figure 1. Prosodic structure of Korean

2. Experiment

Two male (S1 & S2) and two female (S3 & S4) Seoul speakers participated in the experiment. In total, 648 sentences (3 levels x 9 consonants x 4 speakers x 6 repetitions) varied in three prosodic levels and consonants were analyzed. 3 levels include AP-initial, AP-medial (word-initial), and Wd-medial (syllable-initial). 9 consonants consist of three types of consonants with different place of articulation; /p, ph, p', t, th, t', k, kh, k'/. Each test sentence was repeated 6 times. Sampling rate was 12.8 kHz.

Vowels and sonorants can stand alone with internal cues. However, obstruents are required to be adjacent to independent segments that can bear adequate external cues. Although external cues for obstruents are important for them to be perceived, the previous studies on domain-initial strengthening have focused on domain-edge consonants at different prosodic domains. They have not taken the vowels adjacent to laryngeal consonants which contain external cues into consideration. Not only closure duration of the intervocalic stop but also VC and CV transitions together strongly affect stop identification of place of articulation (Steriade 1999). By the same token, consonants with different manner of articulation may make use of different acoustic cues

and the acoustic cues adjacent to the domain-initial consonant may affect the perception of prosodic domain strength. In other words, intersegmental timing as well as intrasegmental timing should be considered. For those reasons, four measurements mentioned in (1)–(3) were conducted. Four acoustic measures were made from the audio signal.

- (1) V1 and V2 duration: Durations of the vowels adjacent to a tested consonant were measured in different prosodic positions.
- (2) Closure duration: Acoustic closure duration for all tested consonants was taken from spectrograms. This measure included both voiced and voiceless portions of closure, from the offset of F2 in V1 to the beginning of the stop burst.
- (3) Voice Onset Time: VOTs for /T, Th, T/'¹⁾ were taken from the point of the stop release to the voice onset of the following vowel as seen in F2 and above in spectrograms.

To test Wd-medial consonants which are syllable-initial, three kinds of consonants are placed within a made-up word as shown in (4)²⁾: Thus the subjects were asked to read them as one word without pause before the tested consonants. No instruction other than this was given to the speakers. In general, the subjects produced the intended intonational contours with an appropriate break. However, when some tokens were found not to have the intended contour, they were taken out from the tokens.

- | | |
|------------------------------------|---------------------------------|
| (4) a. [ajumenigapul]ul | ilgeyo |
| 'ajumenigapul'(nonsense word, obj) | 'read (indicative) |
| b. [ajumenigaphul]ul ilgeyo | 'ajumenigaphul' (nonsense word) |
| c. [ajumenigap'ul]ul ilgeyo | 'ajumenigap'ul'(nonsense word) |
| d. [ajumenigatal]ul ilgeyo | 'ajumenigatal' (nonsense word) |
| e. [ajumenigathal]ul ilgeyo | 'ajumenigathal' (nonsense word) |
| f. [ajumenigat'al]ul ilgeyo | 'ajumenigat'al' (nonsense word) |
| g. [ajumenigakal]ul ilgeyo | 'ajumenigakal' (nonsense word) |
| h. [ajumenigakhal]ul ilgeyo | 'ajumenigakhal'(nonsense word) |

1) T stands for /p, t, k/.

2) [] indicates that the tested words are placed within a word. Nonsense words are used to compare the tested consonants with the ones in different prosodic positions: AP-initial and Wd-initial positions. In Korean, most monomorphemes consist of less than 5 syllables.

- i. [ajumenigak'al]ul ilgeyo 'ajumenigak'al' (nonsense word)

To test AP–medial consonants which are Wd–initial, three kinds of consonants are preceded by a focused word so that they are put in the AP–medial position. In (5) only the answer part was taken for measurements³⁾:

(5) a. nuga	pulul	ilgeyo?
'Who'	'fire (obj)'	'read'
{Ajumeniga	pulul}	ilgeyo
'aunt (focus)'	'fire (obj)'	'read'
b. nuga	phulul	ilgeyo?
'Who'	'grass (obj)'	'read'
{Ajumeniga	phulul}	ilgeyo
'aunt (focus)'	'grass (obj)'	'read'
c. nuga	p'ulul	ilgeyo?
'Who'	'horn (obj)'	'read'
{Ajumeniga	p'ulul}	ilgeyo
'aunt (focus)'	'horn (obj)'	'read'
d. nuga	talul	ilgeyo?
'Who'	'moon (obj)'	'read'
{Ajumeniga	talul}	ilgeyo
'aunt (focus)'	'moon (obj)'	'read'
e. nuga	thalul	ilgeyo?
'Who'	'mask (obj)'	'read'
{Ajumeniga	thalul}	ilgeyo
'aunt (focus)'	'mask (obj)'	'read'
f. nuga	t'alul	ilgeyo?
'Who'	'daughter (obj)'	'read'
{Ajumeniga	t'alul}	ilgeyo
'aunt (focus)'	'daughter (obj)'	'read'
g. nuga	kalul	ilgeyo?
'Who'	'kal (obj)'	'read'
{Ajumeniga	kalul}	ilgeyo
'aunt (focus)'	'kal (obj)'	'read'

3) { } indicates AP boundary. The tested consonants in (5) are placed within the AP.

h. nuga	khalul	ilgeyo?
‘Who’	‘knife(obj)’	‘read’
{Ajumeniga	khalul}	ilgeyo
‘aunt(focus)’	‘knife(obj)’	‘read’
i. nuga	k’alul	ilgeyo?
‘Who’	‘k’al(obj)’	‘read’
{Ajumeniga	k’alul}	ilgeyo
‘aunt(focus)’	‘k’al(obj)’	‘read’

To test AP-initial consonants, three types of consonants are preceded by a long subject which tends to constitute an Accentual Phrase on its own as shown in (6)⁴.

(6) a. Ajumeniga	{pulul	ilgeyo
‘aunt(subj)’	‘fire(obj)’	‘read’
b. Ajumeniga	{phulul	ilgeyo
‘aunt(subj)’	‘grass(obj)’	‘read’
c. ajumeniga	{p’ulul	ilgeyo
‘aunt(subj)’	‘horn(obj)’	‘read’
d. Ajumeniga	{talul	ilgeyo
‘aunt(subj)’	‘moon(obj)’	‘read’
e. Ajumeniga	{thalul	ilgeyo
‘aunt(subj)’	‘mask(obj)’	‘read’
f. Ajumeniga	{t’alul	ilgeyo
‘aunt(subj)’	‘daughter(obj)’	‘read’
g. Ajumeniga	{kalul	ilgeyo
‘aunt(subj)’	‘kal(obj)’	‘read’
h. Ajumeniga	{khalul	ilgeyo
‘aunt(subj)’	‘knife(obj)’	‘read’
i. Ajumeniga	{k’alul	ilgeyo
‘aunt(subj)’	‘k’al(obj)’	‘read’

4) The left boundary of the AP is only marked in (6) since it is crucial that the tested consonants are placed in the AP-initial position regardless of whether the following word belongs to the same AP.

3. Results and Discussion

Table 1 shows results of statistical comparisons for V1 duration, consonant closure, VOT and V2 duration of the sequence of V1CV2 in three different prosodic positions.

Table 1. Results of statistical comparisons for acoustic cues. Bonferroni pairwise comparison of acoustic measurements for 3 levels. (T stands for plain stops, Th, aspirated stops, T', tense stops. APi, Wdi, and Si refer to the data where the consonants in interest are in AP-initial position, word-initial position, and syllable-initial position, respectively.)

S1	V1 Dur.	C. closure	VOT	V2 Dur.
T	APi> Si> Wdi	APi> Wd= Si	APi> Wdi= Si	APi= Wdi= Si
Th	APi> Wdi= Si	Si> APi> Wdi	APi> Wdi= Si	APi> Wdi= Si
T'	APi> Wdi= Si	Si> APi> Wdi	APi= Wdi= Si	APi> Wdi= Si
S2	V1 Dur.	C. closure	VOT	V2 Dur.
T	APi> Si> Wdi	APi> Wdi= Si	APi> Wdi> Si	Si> Wdi> APi
Th	APi> Wdi= Si	APi> Wdi= Si	APi> Wdi> Si	Si> Wdi> APi
T'	APi> Wdi= Si	APi> Si> Wdi	APi= Wdi= Si	APi> Wdi= Si
S3	V1 Dur.	C. closure	VOT	V2 Dur.
T	APi> Si> Wdi	APi> Wdi= Si	APi> Wdi> Si	Si> Wdi> APi
Th	APi> Wdi> Si	APi> Si> Wdi	APi> Wdi> Si	Si> Wdi> APi
T'	APi> Wdi= Si	Si> APi> Wdi	APi= Wdi= Si	APi> Wdi= Si
S4	V1 Dur.	C. closure	VOT	V2 Dur.
T	APi> Wdi> Si	APi> Wdi> Si	APi> Wdi> Si	Si> Wdi> APi
Th	APi> Wdi> Si	Si> APi= Wdi	APi> Wdi> Si	Si> Wdi= APi
T'	APi> Wdi> Si	Si= APi> Wdi	APi= Wdi= Si	APi> Wdi= Si

3.1. V1 Duration

V1 preceding the three types of domain-initial consonants in Table 1 is in fact domain-final. For instance, V1 preceding APi consonants is AP-final. Cho & Keating (1999) found domain-final lengthening of a vowel: The higher the prosodic position, the longer the domain-final vowel. Their result is compatible with the result in Table 1 as far as AP-final and Wd-final vowels are concerned. Speaker 4 exhibits domain-final lengthening of a vowel even in the lower level. Table 1 shows that the durations of Wd-final and syllable-final vowels are not significantly different before a domain-initial tense consonant for three speakers and before a domain-initial aspirated consonant for two speakers. I suggest that the same length between Wd-final and syllable-final

vowels has to do with vowel shortening before laryngeal consonants whose domain is an Accentual Phrase (Oh 1998). In contrast, V1 preceding plain stops does not exhibit any consistent pattern. As for speaker 1, V1 is longest when it precedes a syllable-initial plain stop. On the other hand, it is shortest when it precedes a syllable-initial plain stop for speaker 4. Likewise, domain-initial laryngeal consonants affect domain-final lengthening of a preceding vowel.

3.2. Duration of consonant closure

Cho & Keating (1999) suggest that Korean illustrates two different strengthening effects. One is of general strengthening effect: Domain-initial consonants get stronger and longer as the prosodic domain gets larger. The other is specific to laryngeal consonants which are longer in word-medial position than in word-initial position. In other words, word-medial laryngeal consonants behave differently with respect to domain-initial strengthening. Domain-initial strengthening is attested for a plain stop in Table 1. However, Table 1 shows that Wd-medial laryngeal consonants are longer than or as long as Wd-initial ones for all 4 speakers. In particular, Wd-medial aspirated consonants are longer than even AP-initial ones for speakers 1 and 4 and Wd-medial tense consonants are longer than AP-initial ones for speakers 1 and 3. That suggests that different acoustic cues other than domain-edge segmental duration function to demarcate prosodic domain strength depending on the manner of articulation of domain-initial consonants

3.3. Voice onset time

Cho and Keating (1999) maintain that /th/ and /t/ show a four-way distinction with respect to VOT among prosodic positions (Ui> IPi> APi> Wdi). They observe that the tense stop /t'/ always has very short VOT and does not exhibit any systematic differences depending on the position in contrast to /t, th/. It suggests that consonants with different manner of articulation may employ a different mode for prosodic domain strengthening. The domain-initial /T, Th/ signal the prosodic domains by way of closure duration and VOT but /t'/ does not. That means that VOT which is not the domain-edge acoustic cue should also be taken into consideration to cue the prosodic domain strength.

3.4. Duration of V2

Kim (2001) and Cho (1996) notice that V2 duration is inversely related to the relative VOT durations of the preceding stops: V2 is longest following tense stops, shorter following plain stops, and shortest after aspirated stops. However Kim (2001)

did not consider stops in various prosodic positions. Figure 2 shows the results of V2 duration for 4 speakers.

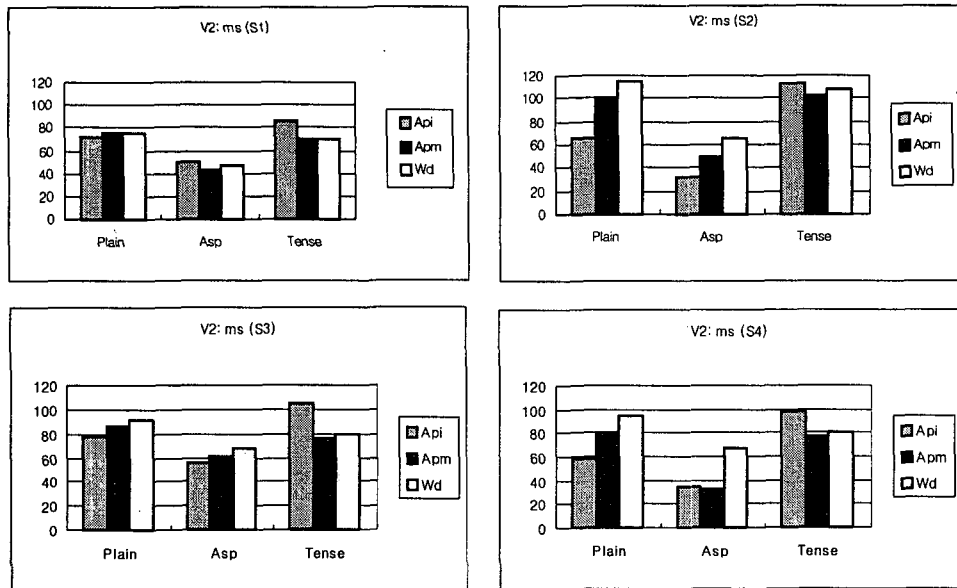


Figure 2. Results of V2 duration for 4 speakers (Apm and Wd stand for Wdi and Si, respectively)

Figure 2 shows that V2 duration is inversely related to VOTs when V2 follows /T, Th/ whose VOTs are categorically longer in a higher position for 3 speakers. However, when V2 follows /T/ which has the shortest VOT, V2 duration is longest in AP-initial position. Recall that 2 speakers have longer closure duration of /T/ in syllable-initial position than in AP-initial position. Closure duration of word-medial tense consonants is at odds with the overall cumulative pattern. In contrast to closure duration, V2 duration following a tense consonant is longest in AP-initial position. Then, it suggests that tense consonants affect the domain-initial strengthening by way of V2 duration. However, V2 duration following a tense consonant in word-medial and word-initial positions is not significantly different from each other. Their apparently same length in fact results from the durational difference of whole utterance as shown in Figure 3.

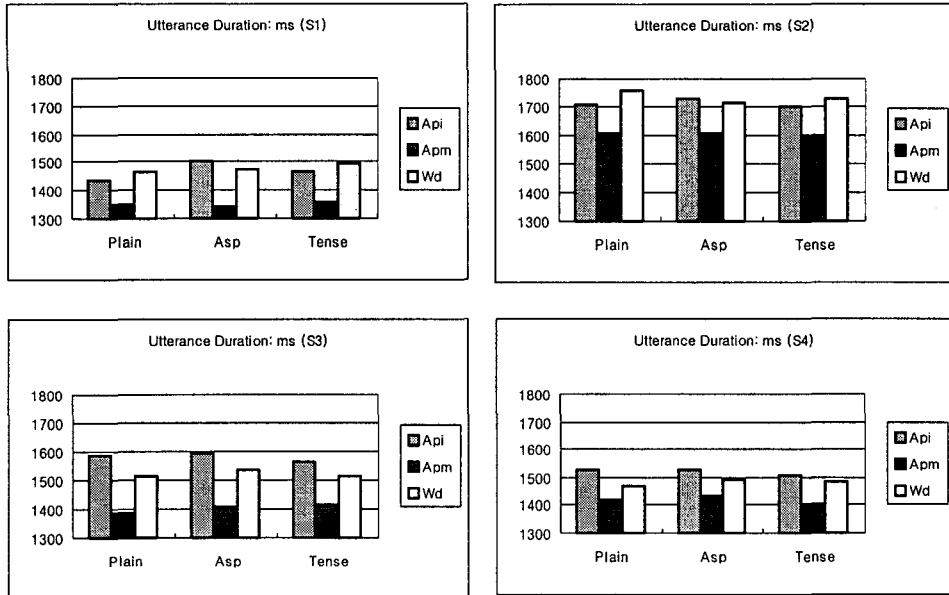


Figure 3. Duration of utterance

Figure 3 clearly shows that utterance duration is shortest when the tested consonants are read in AP-medial, Wd-initial, position, for all 4 speakers. It suggests that V2 duration after a tense consonant in Wd-initial position is longer than that in syllable-initial position compared to other segments in respective prosodic position. Then the insignificant difference between V2 durations after a tense consonant in Wd-initial and syllable-initial positions in fact respect prosodic domain-initial strengthening.

4. Conclusion

Laryngeal consonants exhibit the different behavior with respect to tonal pattern of an Accentual Phrase and domain-initial strengthening. The standard tone pattern for an Accentual Phrase is LHLH but AP-initial laryngeal consonants trigger the first L to be realized as H (Jun 1993). This paper focused on apparently incompatible behavior of laryngeal consonants with respect to prosodic domain-initial strengthening: word-medial consonant closure of a laryngeal consonant is longer than AP-initial one (Cho & Keating 1999).

This study examined not only the domain-edge acoustic cues but also the acoustic cues adjacent to the domain-initial consonants. It turned out that acoustic cues that are not domain-edge indicate different prosodic structure when the domain-initial

consonant is laryngeal: VOT for an aspirated consonant and V2 duration for a tense consonant. Likewise, laryngeal consonants in Korean affect not only the pitch pattern of an AP but also prosodic domain-initial strengthening. However, we need to investigate further why laryngeal consonants behave differently from plain consonants with respect to tonal realization of an AP and prosodic domain-initial strengthening.

References

- Cho, T. 1996. *Vowel Correlates to Consonant Phonation: an Acoustic-Perceptual Study of Korean Obstruents*. MA thesis, University of Texas, Arlington.
- Cho, T. & P. Keating. 1999. "Articulatory and Acoustic Studies of Domain-initial Strengthening in Korean." *UCLA Working Papers in Phonetics*, 97, 100-138.
- Fougeron, C. and P. Keating. 1996. "Articulatory Strengthening in Prosodic Domain-initial Position." *UCLA Working Papers in Phonetics*, 92, 61-87.
- Han, J. 1996. *The Phonetics and Phonology of Tense and Plain Consonants in Korean*. PhD dissertation, Cornell University, Ithaca, New York.
- Hsu, C. & S. Jun. 1998. "Prosodic Strengthening in Taiwanese: A Follow-up Study." *UCLA Working Papers in Phonetics*, 96, 69-89.
- Johnson, K. & M. Oh. 1995. "Intervocalic Consonant Sequences in Korean." *Working Papers in Linguistics*, 45, The Ohio State University.
- Jun, S. 1993. *The Phonetics and Phonology of Korean*. PhD dissertation, The Ohio State University.
- Jun, S. 1995. "Asymmetrical Prosodic Effects on the Laryngeal Gesture in Korean." In B. Connel & Arvaniti, eds., In *Phonology and Phonetic Evidence: Papers in Laboratory Phonology*, 235-253, Cambridge, UK: Cambridge University Press.
- Jun, S., M. Beckman & H. Lee. 1998. "Fiberscopic Evidence for the Influence on Vowel Devoicing of the Glottal Configurations for Korean Obstruents." *UCLA Working Papers in Phonetics*, 96, 43-68.
- Jun, S. & H. Lee. 1998. "Phonetic and phonological markers of contrastive focus in Korean." *ICSLP98*.
- Keating, P., T. Cho, C. Fougeron & C. Hsu. 1999. "Domain-initial Articulatory Strengthening in Four Languages." *UCLA Working Papers in Phonetics*, 97, 139-156.
- Kim, M. 2001. "Consonantal and Vocalic Effects in Korean Stop Identification." *Speech Sciences*, 8(1), 93-111.

- Oh, M. 1998. "The Prosodic Domain of Intervocalic Tense Consonant Lengthening."
In David Silva, eds., *Japanese and Korean Linguistics*, 8, 317–330, CSLI.
- Steriade, D. 2001. "Directional Asymmetries in Place Assimilation: A Perceptual Account," In Elizabeth Hume & Keith Johnson, eds., *The Role of Speech Perception in Phonology*, 219–250, New York: Academic Press.

Received: April 25, 2002

Accepted: May 30, 2002

▲ Mira Oh
Department of English
Chonnam National University
300 Yongbongdong, Bukgu, Kwangju 500–757
Tel: +82–62–530–3165
E-mail: mroh@chonnam.ac.kr