

Language Specific Variations of Domain-initial Strengthening and its
Implications on the Phonology-Phonetics Interface: with Particular
Reference to English and Hamkyeong Korean*

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ABSTRACT

The present study aims to investigate domain-initial strengthening phenomenon, which refers to strengthening of articulatory gestures at the initial positions of prosodic domains. More specifically, this paper presents the result of an experimental study of initial syllables with onset consonants (initial-syllable vowels henceforth) of various prosodic domains in English and Hamkyeong Korean, a pitch accent dialect spoken in the northern part of North Korea. The durations of initial-syllable vowels are compared to those of second vowels in real-word tokens for both languages, controlling both stress and segmental environment. Hamkyeong Korean, like English, tuned out to strengthen the domain-initial consonants. With regard to vowel durations, no significant prosodic effect was found in English. On the other hand, Hamkyeong Korean showed significant differences between the durations of initial and non-initial vowels in the higher prosodic domains. The theoretical implications of the findings are as follows: The potentially universal phenomenon of initial strengthening is shown to be subject to language specific variations in its implementation. More importantly, the distinct phonetics-phonology model (Pierrehumbert & Beckman, 1998; Keating, 1990; Cohn, 1993) is better equipped to account for the facts in the present study.

Key words: domain-initial strengthening, phonetics-phonology interface, English, Hamkyeong Korean

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1. Introduction

There has been an increasing consensus that one of the most crucial elements in understanding spoken language on a segmental level lies in understanding how prosody affects the physical realization of individual segments. Equally, it is also important to study prosodically conditioned segmental variations because they are likely to serve as cues for higher-level linguistic structure. A large body of recent experimental work has shown that such prosodically conditioned segmental alternations come primarily from segment strengthening in domain-initial positions, an effect known as domain-initial strengthening. Fujimura (1990) proposed that more forceful articulatory gestures are used in syllable-initial positions as well as word and phrase initial position. Cooper (1991) showed that word-initial stops tend to have increased closure duration with greater glottal opening. Acoustic data in Pierrehumbert and Talkin (1992) suggested that the glottal articulation of /h/ in English is stronger at the beginning of an Intonation Phrase as compared to the beginning of a word. Similarly, Jun (1995) reported that VOT in Korean is longer phrase-initially than phrase-medially, and longer word-initially than word-medially. In a similar line, a series of electropalatographic studies showed that the consonants are produced in general with greater articulatory magnitude in domain-initial positions at each level than in domain-medial positions (Fougeron & Keating, 1996, 1997; Fougeron, 1999; Keating, Cho, Fougeron, & Hsu, 1999). There is also some evidence that the duration of word-initial vowels is longer than that of word-internal vowels in French and English (Fougeron, 1999; Turk & Shattuck-Hufnagel, 2000; Byrd, 2000).

A number of experiments cited above show that both consonants and onsetless word-initial vowels are regularly subject to this strengthening, but it is less clear whether initial-syllable vowels with onset consonants undergo it as well. Fougeron and Keating (1996) clearly demonstrating initial strengthening of consonants and onsetless word-initial vowels in English, found little evidence of lengthening of initial-syllable vowels with onsets. Byrd (2000) obtained similar results.

The results of these studies are furthermore puzzling in light of the typological frequency of vowel-quality neutralizations in non-initial syllables, suggesting that the initial position bears some type of positional prominence. Cross linguistically, vowels of initial syllables tend to retain contrasts even when they are not actually domain initial. Progressive vowel harmony is one of such an example. From a slightly different angle, domain-initial syllables are also known to be more important for lexical access, it is crucial that all contrasts be maintained there. If this is the case, why are only domain-initial consonants and onsetless vowels subject to domain-initial

strengthening?

This paper attempts to answer this question by presenting the result of an experimental study of initial syllables in Hamkyeong Korean, a pitch accent dialect spoken in the northern part of North Korea. The data were collected from two native speakers of Hamkyeong Korean who defected from North Korea.

The remainder of the paper is organized as follows: A brief sketch of the previous literature on the phonetics of initial positions will be presented in section 2. Basic facts of the sound patterns in Hamkyeong Korean will be introduced in section 3. The experimental method and the results will be addressed in sections 4 and 5, respectively. Comparisons with experimental results for English and implications of this study will be discussed in the conclusion.

2. Phonetic Studies on Domain-initial Strengthening

Many languages have recognized prosodically conditioned positional effects. One of such processes is domain-final lengthening which can be defined as more extreme lengthening at the end of higher prosodic domains as compared to lower prosodic domains (Klatt, 1975; Oller, 1973, Edwards, Beckman & Fletcher, 1991). Both vowels and consonants are equally subject to this lengthening effect.

Unlike the domain-final lengthening, the process known as domain-initial strengthening manifests an asymmetry between vowels and consonants. Across a variety of consonant types, it is relatively widely attested in a number of languages. Various consonants have been shown to acquire an increase in gestural magnitude (measured by linguopalatal contact or by VOT of aspirated stops) and closure duration in domain-initial positions (Fougeron, 1999; Fougeron & Keating, 1996; Keating, Cho, Fougeron, & Hsu 1999; Barnes, 2002, Oller, 1973 among others).

In comparison, domain-initial strengthening is less consistent in the case of vowels. Although there is some evidence that absolute word-initial vowels are realized somewhat longer than word-internal vowels in French and English (Byrd, 2000; Dilley, Shattuck-Hufnagel & Ostendorf, 1996, Fougeron 1999; Turk & Shattuck-Hufnagel, 2000), no clear evidence is found regarding whether initial-syllable vowels with onset consonants undergo it as well. A close look at the two phonetic studies of English will demonstrate this point. Fougeron and Keating (1996) found little evidence of lengthening of initial-syllable vowels with onsets. They demonstrated that vowel durations in English are strongly related with the degree of opening. Byrd (2000) found a lack

of domain-initial strengthening in English vowels as well. In a recent attempt to verify Byrd (2000), Barnes (2002) obtained the same results. These findings attesting to the absence of domain-initial-strengthening muddle our understanding of sound patterns because they can support the thesis that vowels with onsets (henceforth domain-initial vowels) are no more phonetically prominent than absolutely domain-initial vowels.

If this is the case, how can we explain the widely attested sound pattern of domain-initial syllables? Regardless of the presence of the onset, domain-initial vowels tend to be more resistant to neutralization than domain-medial ones. In many languages the vowels of initial syllables present a greater variety of contrast than those of non-initial syllables regardless of the presence of syllable onset. In the following sections, I present empirical counter-evidence to the thesis of weak initial-syllable vowels.

3. Behaviors of initial syllables in Hamkyeong Korean

Before proceeding to a discussion of the prosody and the behaviors of domain-initial syllables in Hamkyeong Korean, let us begin with a brief sketch of its tone patterns. Five basic observations should be noted. First, the pitch accent bearing unit in Hamkyeong Korean is a syllable rather than a mora. Second, it has two lexical tones and there is an asymmetry between high and low tones. It is always the high tone that undergoes any tone alternation. Nothing occurs if two low toned syllables are juxtaposed. The presence or absence of low tones does not make any contribution in defining tone classes. Third, three classes of verbal stems are recognized with regard to the distribution of high tones. They are not our concern and will not be discussed here (refer Kim, 1997; 1998a; 1998b; 1999 for more detailed descriptions along with Optimality theoretic analysis of tone patterns). What's of interest are the tonal alternations, which lead us to the fourth observation.

Fourth, Hamkyeong Korean observes Obligatory Contour Principle. In other words, one and only one syllable is high toned in a word in Hamkyeong Korean. Compounds and phonological phrases are also subject to the culminativity (Ramsey, 1978). Consider the tone pattern in (1).

- (1) pí 'rain' sóli 'sound' písolí 'sound of rain'
 múl 'water' kokí 'meat' mulkokí 'fish'
 pál 'foot' paták 'sole' palpaták 'the sole of the foot'

hamkyǽŋto	‘Hamkyeong Province’	mál	‘words’
hamkyǽŋto mál	‘Hamkyeong dialect’		
hamkyǽŋto mál	‘Hamkyeong dialect’	yónku	‘study’
hamkyǽŋtomal yánku	‘a study of Hamkyeong dialect’		

The generalizations born out of the data in (1) are summarized in (2).

- (2) The generalizations of the tone pattern in Hamkyeong Korean
- One and only one syllable is high-toned in a compound.
 - If high tone-bearing syllables are adjacent, then the leftmost one is high toned.
 - If high tone-bearing syllables are not adjacent, the rightmost one is high toned.

Vowel durations in Hamkyeong Korean are positively correlated with degree of opening in isolation and thus low vowel /a/ is much longer than a high vowel /i/. In citation forms, the presence of pitch accent does not affect the vowel duration if all other conditions are equal. Put differently, pitch accent in Hamkyeong Korean is not cued by vowel duration and low-tone bearing vowels do not undergo reduction. It is cued by fundamental frequency. (Kim, 1999)

Some might ask why Hamkyeong Korean is an interesting language that calls for an investigation with regard to domain-initial strengthening. Researchers in previous studies provide an interesting and recurring description of the behavior in the utterance initial syllables in connection with the absence of vowel reduction of low-toned vowels and its duration in Hamkyeong Korean (Ramsey, 1978; Cheong, 1988; Cheon, 1993). One such description is shown in (3).

- (3) The first syllables in the utterances appear to be louder and more prominent than other syllables regardless of whether they are high pitched or not.

(Cheong Y-H 1988: 175)

Some scholars working on Hamkyeong Korean have a tendency to link this observation to the presence of intonational variations or speech style unique to Hamkyeong Korean speakers, which turns out to be misleading. A question that arises from the description is what the physical correlates of prominence mentioned in (3) are. It should be noted that pitch accent or high tone is not cued by vowel duration in citation forms and observations as in (3) are based on ones

in utterance level.

The experimental analysis in the following sections suggests a totally different understanding of facts previously described as an intonational variation. I argue that the phenomenon is in fact a consequence of domain-initial strengthening.

4. Experimental Method and Procedure

The first experiment in English was designed to verify the results of Fougeron and Keating (1996) and Byrd (2000) showing the lack of initial strengthening for initial-syllable vowels. As English vowel duration is strongly correlated with degree of opening, only the durations of initial-syllable vowels were measured.

The stimuli I chose were nonsense names in English such as '*Masha*,' '*Nana*,' and '*Mamma*.' All stimuli contained an open syllable with low vowel nucleus. Low vowels were chosen for their relatively long inherent duration on the assumption that any systematic temporal variation would be more readily detectable in a longer stimulus than in a shorter one. Since unstressed vowels in English are heavily reduced and durational variations, the location of the stress were varied. Out of 6 stimuli, half of the stimuli have the primary stress on the first syllable and the other half have it on the second syllable. For readers' convenience, they are listed in phonetic symbols in (4).

(4) Stimuli in English

Masha	[mʌʃə]	Masha	[məʃʌ]
Nana	[nʌnə]	Nana	[nənʌ]
Mama	[mʌmə]	Mama	[məmʌ]

Adjacent segments were also controlled to avoid perturbations of vowel duration because voiceless stops were avoided as preceding segments because of their long positive VOT in some environments in English. Each token was placed in three different frame sentences selected to place the target word in initial position in a variety of prosodic domains as in Fougeron and Keating (1996). The relevant domains were Utterance, Phonological Phrase, and Phonological Word. They are shown in (5).

(5) Prosodic Environments

- a. Utterance-initial: U [Phr [X is damaged a lot last summer.
- b. Phonological Phrase-initial: U [Phr [I think] Phr [X damaged a lot last summer.
- c. Word-initial: U [Phr [last summer's X] damaged a lot.

Participants were two native speakers of North American English. They were in their twenties. Sentences were uncovered one at a time by the author to insert a short pause after each sentence. To induce a broad range of vowel duration, the speakers were asked to vary loudness and speech rate. There were two conditions with respect to loudness as used in Liberman et al. (1993): loud (as if shouting to a person in the hall), normal (as if speaking to a person next to you). With respect to speech rate, the conditions were normal and fast. In the normal condition, they were asked to speak at a normal conversation rate. In the fast condition they were asked to speak as quickly as possible while still speaking clearly. The utterances were all recorded on digital tape and they were digitized at a sampling rate of 22.5 KHz., and vowel durations were measured from spectrograms and waveforms display created using the PCquirer (Scicon). Each speaker repeated 6 stimuli 2 times per session. A total of 144 tokens were recorded per speaker (6 tokens X 3 prosodic conditions X 2 loudness conditions X 2 speech rate conditions x 2 repetitions).

In the second experiment for Hamkyeong Korean, two Hamkyeong Korean speakers, a female and one male in the fifties, participated. They read the test sentences from a randomized list as in the same manner as in the first experiment for English. Stimuli in Hamkyeong Korean are given in (6).

(6) Stimuli in Hamkyong Korean

kamaki	'a crow'	k'ek'ori	'a nightingale'
káməri	'a leech'	parámi	'wind+nominative'
kəmúnko	'Korean harp'	pisori	'sound of wind'
kəɾəŋbéŋi	'a beggar'	pəsáni	'socks+nominative'
sokómi	'salt+nominative'	p^hirika	'a flute'
sannamúl	'wild vegetables'	pəpóri	'a deaf person'
sók'ori	'ox tail'	t'əkaru	'rice flour'
sulcucəŋ	'drunken rowdiness'	tókaru	'the helve of an ax'
samakí	'a mole'	torík'ε	'a flail'
sont'opí	'nails+nominative'	nunmúli	'tears+nominative'
nurúki	'yeast+nominative'	patáka	'sea+nominative'

The stimuli given in (6) were composed of words with more than three syllables. No onsetless syllables were included in the stimuli. VOT of stops in the onsets of the first and second syllables were measured. Among the 22 words, 15 words have identical vowels in the first and second syllables and their durations were measured. The target vowels are indicated in boldface. Codas of the target vowels were controlled and they were all either nasals or liquids.

Each token was placed in three different frame sentences selected to place the target word in the initial position in a variety of prosodic domains as in Fougeron and Keating (1996) and Jun (1995). Although a comprehensive study remained to be done, I assumed accentual phrase in Hamkyeong Korean. For present purposes, it does not matter whether Hamkyeong Korean has accentual phrases or phonological phrases. What is crucial is that it has several domains organized hierarchically. The relevant domains were Utterance, Accentual Phrase, and Phonological Word, They are shown in (7).

(7) Frame sentences and prosodic environments

Utterance Initial: U[Phr[X is good for your health.

[ssannamulɪ mome cota]

‘Wild edible greens are good for your health.’

Accentual Phrase Initial: U[Phr[I think]Phr[X is good for your health.

neseŋkakenun[sannamulɪ mome cota]

‘I think that wild edible greens are good for your health.’

Prosodic Word Initial: U[Phr[.....X] is good for your health.

[hamkyəŋtoesənanun sannamulɪ] mome cota

‘Wild edible greens from Hamkyeong province are good for your health.’

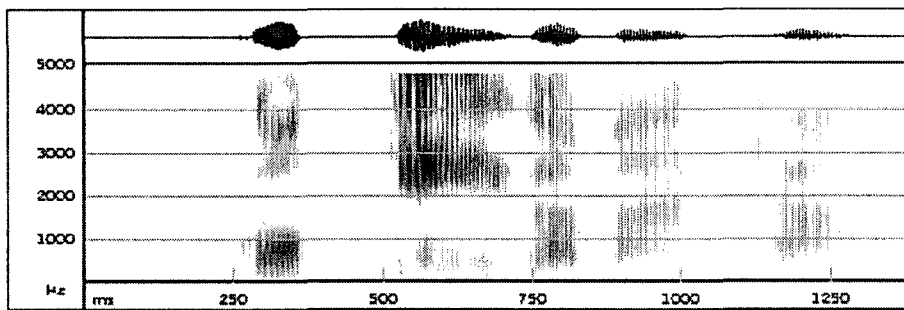
In the frame sentence, the word ‘mome’ referring to health was optionally deleted if it creates semantically odd utterances. For instance the word *kekorika* (nightingale) inserted in the frame sentences shown in (7) results in semantically odd sentences meaning Hamkyeong Koreans usually eat nightingales as a part of their diet. In such cases, the word ‘mome’ was deleted.

Each speaker of Hamkyeong Korean repeated 22 stimuli 2 times per prosodic conditions for a total of 528 stimuli per subject (22 tokens X 3 prosodic conditions X 2 loudness conditions X 2 speech rate conditions x 2 repetitions). Before the recording procedure done in a quiet room,

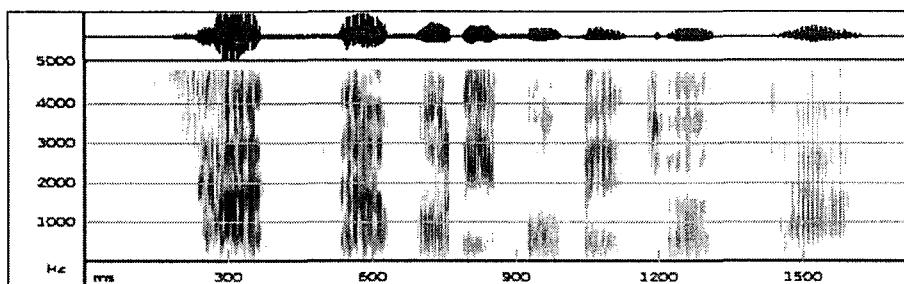
there was a short instruction session. Target words were provided in a random order and each repetition was done with a small pause.

The first measurement taken was of the VOT values of stops in the first and second syllables (Syllable 1 and Syllable 2 henceforth) in the spectrogram and waveform display shown in (8). From the zoomed in waveforms and spectrograms, VOTs were measured from the stop release to the onset of the onset of the second formant in the following vowel. For the intervocalic plain stops, some of which showed voicing during their closure, the stop release was clearly detected and VOTs were measured from that point. Another measurement was the durations of the two identical vowels in Syllable 1 and Syllable 2 as shown in (9).

(8) [kəkərɪka cóta] 'I like nightingales.'



(9) [sannamúli móme cóta] 'Wild edible greens are good for your health.'



5. Results and Discussion

Mean vowel durations for both classes of stimuli are shown for each speaker in Figure 1. T-test analyses revealed no significant differences between the vowels in initial and non-initial syllables tests ($p < 0.05$). Additionally, no lengthening of the target vowels was observed in

higher-level prosodic constituents either. In other words, the results of this experiment are in agreement with those of previous investigations: English vowels in initial syllables are not subject to domain-initial strengthening. Nothing new emerges from this experiment.

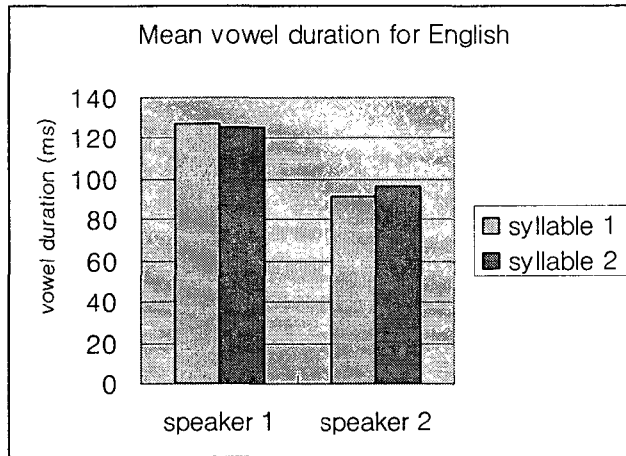


Figure 1. Mean vowel durations for English

Results of Hamkyeong Korean speakers are summarized in Figure 2 and Figure 3. First, the line chart in Figure 2 shows that VOT values of stops vary as a function of prosodic position (the higher the prosodic positions, the longer the VOT).

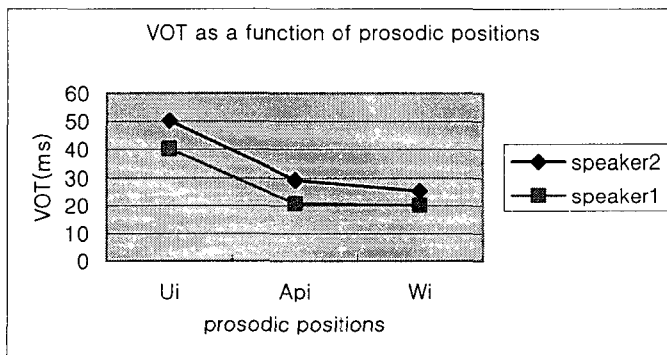


Figure 2. Variations of VOT values as a function of prosodic positions

Second, the bar charts in Figure 3 illustrate the VOT values pooled across the prosodic positions. The left bars indicate the VOT values of Syllable 1, while the right bars represent those of Syllable

2. In short, VOT of stops in Syllable 1 is significantly longer than that of Syllable 2. This finding was supported by the results of paired t-tests ($p < 0.05$).

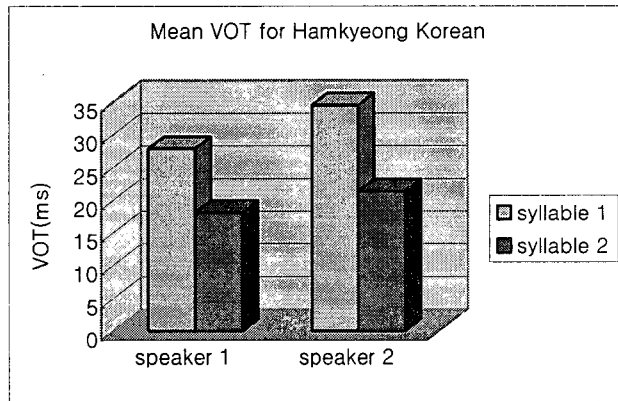


Figure 3. Mean VOT for Hamkyeong Korean

So far, we have shown that stops in the initial positions of prosodic domains are strengthened, which arguably serves as a significant cue marking different levels of prosodic boundaries in Hamkyeong Korean.

Now, let us move on the most important part of the experimental results: durations of the domain-initial vowels with onsets. It should be reminded that words with identical vowels in the first and second syllables were selected for this purpose in the experiment.

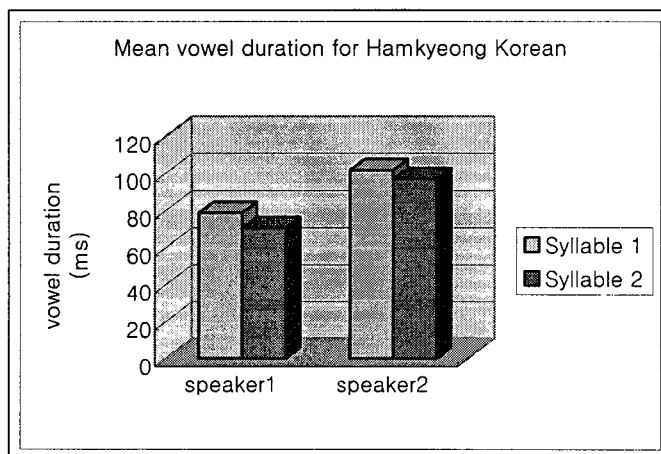


Figure 4. Mean vowel duration for Hamkyeong Korean

Figure 4 corresponds to mean vowel durations for Syllable 1 and 2 of the target vowels. Across all the speakers, mean durations of initial-syllable vowels are significantly longer than those of the vowels of second syllables as verified by paired t-test ($p < 0.01$).

In this section, we have shown that both English and Hamkyeong Korean show the strengthening of domain-initial consonants. On the other hand, only Hamkyeong Korean exhibits a pattern of initial-syllable vowel strengthening in the higher prosodic domains.

6. Conclusion

So far we have found that the phenomenon of domain-initial strengthening has language specific variations: In English, initial-syllable vowels did not show significant lengthening effect, while Hamkyeong Korean did. We should discuss the implications of the experimental results in the present study.

Before proceeding to the discussion, let us have a brief sketch of the place of phonetics in relation to a phonological model. As speech is both discrete and continuous, the relationship between phonetics and phonology has long been the subject of debate. By and large, there have been two different positions regarding phonetics and phonology. The first is the traditional view that was adopted in the generative phonology since *The Sound Pattern of English* (SPE henceforth). The SPE view assumed that the binary features of the phonology were translated into numeric scales, and this procedure was called 'the phonetic implementation.' Everything beyond this numeric specification of features, for example coarticulation, was thought to be universal and therefore outside the scope of the linguistic grammar. Thus the distinction between phonological rule and phonetics appears to be clear cut: phonology is equal to the language specific rules whereas phonetics consists of universal mechanical realization of the phonology. As a consequence, phonetic implementation was little help from a linguistic point of view. Phonology serves as a substantial part of grammar and there is only an arbitrary relation between phonetics and phonology across languages.

Since 1980s, much evidence of the language-specific nature of coarticulation and other aspects of phonetic implementation has been widely noted. Recent works on phonetic implementation have led to a view that linguistic aspects of the phonetics are a system parallel to the phonology: phonetics is distinct from phonology. The core idea is that phonology manipulates discrete abstract unit (target interpretation) and phonetics manipulates gradient quantitative values which are

context-sensitive. This distinction has been underscored by the discovery that a number of patterns that had previously been analyzed in terms of phonological rules are better analyzed as gradient phonetic implementation: Japanese tone 'spread', lateral velarization in English, and English vowel nasalization.

Clarifying this distinction is of fundamental significance to both phonetics and phonology. If we cannot reliably distinguish phonological pattern from phonetic pattern, we do not know what facts our theories of these domains should be held accountable for. Not enough work has been devoted to distinguishing the two sorts of patterns. About twenty years after Pierrehumbert (1980) established the need for a phonetic implementation component, we still have no more than a vague idea of the properties that distinguish phonetic implementation from phonology. The distinct phonetics- phonology model, however, has been called into question in some work (Kirchiner, 1997; Steriade, 1997 among others) in which researchers challenge the presence of language- specific phonetics.

Given these two views on the relationship between phonetics and phonology, the absence and presence of durational asymmetry between initial and non-initial vowels in English and Hamkyeong Korean is important since it provides evidence that domain-initial strengthening varies depending on its language-specific phonetic implementation rules. The potentially universal phenomenon of initial strengthening is shown to be subject to language specific variations in its implementation. The present results show that at least part of the phonetic component is not universal and belongs to a language-specific grammar. Hence, they suggest the traditional model of distinct phonetics and phonology is better equipped to account for the English and Hamkyeong Korean facts.

Any close reader may ask why Hamkyeong Korean displays domain-initial vowel lengthening making it different from English. The answer to this question can be found in Keating, Cho, Fougeron and Hsu (1999) where the different boundary signals were revealed in English, as opposed to French and Korean. One of the primary cues for stress placement in English is vowel duration. It is no wonder that English avoids simultaneous implementation of other prosody-determined vowel-lengthening patterns. Otherwise, it would seriously confuse the accurate perception of the placement of stress. Hamkyeong Korean pitch accent is cued only by fundamental frequency (Kim, 1999). It is not related to vowel durations, which may allow prosodically determined vowel durations to serve as a source of phonetic cue.

In short, English stress is cued in large by vowel durations and additional positional complication of the feature could interfere with the perception of stress thus leaving no room

for positional perturbations of vowel duration. The pitch accent in Hamkyeong Korean, however, is cued only by fundamental frequency and thus vowel duration is free to vary as a boundary signal if necessary. More extensive work will be necessary for us to make any further claims concerning this matter.

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