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0. Introduction

The purpose of this paper is to investigate the acoustic correlates of the word-level prominence system of Korean. Before such an investigation can be embarked, the phonological nature of the prominence system should be first established. That is, we need to know the parameters of the metrical system before measuring the acoustic features of the prominence. We also would need to resolve other important issues regarding the status of stress [1].

It is, however, not always easy to determine the prominence system in a language. From the perspective of perception, determining the location of a prominence or a stress in a word is not always easy for speakers of the language. From the perspective of production, it is well-known that no one physical correlate can serve as a direct reflection of linguistic stress levels and that they are only indirectly related (Lehiste 1970, Berinstein 1979, Ladd 1980, Beckman 1986, etc.).

The prosodic prominence system in Korean has been analyzed from diverse perspectives, arguments coming both from studies based on impressionistic data and phonetic studies. However, the nature of the word-level prosodic system in Korean is far from being clearly established. Some have analyzed it as a weight-driven metrical system

[1] This paper is interested in discovering the nature of the prominence system of Korean rather than labeling it according to the unclearly defined typological classes of prominence system such as stress, pitch accent, tone, etc. For convenience's sake, however, I will use the term *accent* to refer to the underlying specification of the prominence and *stress* to refer to the surface level prominence of Korean.

(Lee H-B 1989, Kim 1997, *inter alia*) while others have treated it as a phrasal tonal system (Jun S-A 1993).

Proponents of the weight-driven metrical structure argue that Korean metrical foot is quantity-sensitive, right-headed, and unbound, i.e. stress falls on the initial syllable if it is heavy, otherwise it falls on the second syllable, where coda consonants and the vowel length contribute to the weight of a syllable (Lee H-B 1989, Jun J-H 1994). On the other hand, proponents of a tonal analysis of word level prosody argue that there is no word level prominence in Korean that is comparable to that of English or Japanese, but the tonal events which can be described as pitch accent delimit a prosodic grouping of words, functionally similar to the phrasal tones of Japanese (Jun S-A 1993).

Although previous analyses of the word level prosodic system propose a conflict with each other, most of the previous studies, whether phonological or phonetic, have agreed on the identity of the long vowel in Korean as a *phonemic* feature (Lee H-B 1987, Lee H-Y 1993, Jun S-A 1993, Jun J-H 1994, etc.). Most of the previous research on Korean prosody also have described the long vowel in Korean as being realized only in the *initial* syllable (Jun S-A 1993, Lee H-Y 1993) of a word[2].

At the same time, there have been relatively few phonetic studies which have investigated the acoustic correlates of stress in Korean. In a phonetic study of stress in Korean, Jun S-A (1995) suggests that there is no word-level stress in Korean but the prominence should be considered at a phrasal level. Her study does not, however, consider phonological factors in investigating the word-level prominence in Korean. Most of the other previous phonetic studies of Korean did not consider the metrical structure of Korean but, rather, focused on the intonational realization of pitch (De Jong 1989, Jun S-A 1993, Lee M 2000).

In this paper, I will first claim, based on phonological arguments, that what has been regarded as a phonemic long vowel in Korean should be seen as a manifestation of an accent. Then, I will show, through a phonetic experiment, that the accent in Korean is realized with longer duration, higher pitch, and greater amplitude, and that this effect is present in both the initial and non-initial positions. It will be argued that the presence of a longer duration in a non-initial stressed syllable supports the phonological claims made in earlier sections of this paper.

1. The Distribution of Vowel Length and Accent in Korean

Korean has a 7 vowel system whose members are /a, e, i, o, u, ɨ/ and /ə/[3]. Each of these vowels also has a long counterpart that brings about distinction in the meaning of a word.

(1) Minimal Pairs for Each Vowel

a.	[pam]	'night'	[pa:m]	'chestnut'
b.	[pe]	'ship'	[pe:]	'double'
c.	[sicaŋ]	'hunger'	[si:caŋ]	'market'

[2] This study uses data with a distinctive vowel length. The present study does not deal with the Modern Seoul dialect, which has recently lost the vowel length distinction (Magen & Blumstein 1993).

[3] In some dialects and older generation speakers, there is an additional vowel of /æ/ in the inventory. However, it is generally agreed that the vowel /æ/ has been merged into /e/ over the last few decades.

d.	[coŋ]	'bell'	[co:ŋ]	'servant'
e.	[nun]	'eye'	[nu:n]	'snow'
f.	[kɨn]	'a measuring unit'	[kɨ:n]	'near'
g.	[dʒəŋ]	'empathy'	[dʒə:ŋ]	'a family name'

Traditionally, the distinctive feature of a minimal pair such as *nun* 'eye' and *nu:n* 'snow' has been attributed to the distinctive length of the vowel in each word. However, an alternative analysis can attribute the distinction to the presence of an underlying accent vs. lack of one, the difference of vowel length being a consequence therefrom. That is, we can assume that *nu:n* 'snow' surfaces with a long vowel due to an underlying accent on the syllable whereas *nun* 'eye' surfaces with a short vowel because it does not have an underlying accent. Let us illustrate these two possible analyses further with the following data regarding the distribution of the long vowel and accent.

The occurrence of a long vowel has traditionally been believed to be limited to the word initial position in Korean. Also, an accent falls on either the initial or pen-initial syllable. When the initial syllable of a word has a long vowel, stress always falls on the initial position. This, however, can also be stated from the opposite perspective, i.e. when an accent falls on the initial syllable, the vowel of the initial syllable is always realized long. As such, it is not clear whether it is the stress that is responsible for the realization of the initial long vowel or it is the initial long vowel that is responsible for the realization of a stress on the initial syllable. The following data illustrate the distribution of the long vowel and accent:

(2)	a.	yə́:ŋsucɨŋ	'receipt'
	b.	kyó:doso	'prison'
	c.	samkákhyəŋ	'triangle'
	d.	tenámu	'bamboo'

If we assume that Korean has an iambic system where the long vowel counts heavy, we can explain the distribution of the vowel length in (2) by assuming that an underlying long vowel is assigned an accent by a regular metrical phonological foot formation as illustrated in (3).

(3)	UR		SR	
a.	[yə:ŋ]$_F$ sucɨŋ ∧ μμ	→	yə́:ŋsucɨŋ	'receipt'
b.	[kyo:]$_F$ doso ∧ μμ	→	kyó:doso	'prison'
c.	[samkak]$_F$ hyəŋ | | μ μ	→	samkákhyəŋ	'triangle'
d.	[tena]$_F$ mu | | μ μ	→	tenámu	'bamboo'

Alternatively, we can assume a lexical stress system where a stress is assigned on the second syllable by default but, for some lexical items, stress is realized on the initial

syllable if an underlying accent is specified for it. A stress induces a longer duration of a vowel, respecting the restriction on the occurrence of the long vowel only on the initial syllable. Thus, a syllable is realized with a long vowel iff it is initial and accented. This alternative analysis of the surface long vowel can be illustrated as follows. In the following examples, '*' means underlying accent, and '́' indicates stress on the SR.

(4)	UR		SR	
a.	yəŋsuciŋ[4]	→	yə́:ŋsuciŋ	'receipt'
	* *			
b.	kyodoso	→	kyó:doso	'prison'
	* *			
c.	samkakhyəŋ	→	samkákhyəŋ	'triangle'
d.	tenamu	→	tenámu	'bamboo'
	*			

As such, the relationship between the long vowel and an accent in Korean is not immediately clear; whether a long vowel attracts an accent, as hypothesized in (3), or an underlying accent causes vowel lengthening on surface, as analyzed in (4).

In this study, in proposing the latter view, I will make a claim, based on both phonological and phonetic grounds, that the status of vowel length in Korean is not phonemic and should be seen as an acoustic correlate of stress. Consequently, it will be also shown that the occurrence of a long vowel is not confined to the initial syllable but that lengthening of a vowel as a result of stress also occurs in a non-initial position.

2. Morphologically Triggered Accent Shift in Korean

Previous studies of Korean prosody, both phonological and phonetic, fall short of an account of several phonological phenomena which, according to the view presented in this study, can all be explained by assuming a metrical system with a lexical accent. Two of the phenomena will be examined in this paper: (1) accent shift in verb stem and compounds, (2) tune-text alignment. In this section, the first of these will be discussed and we will turn to the tune-text alignment in the next section.

Although some analyses such as Jun (1993) suggest that the prosodic organization of Korean can be best seen as a phrasal grouping of accentual phrases, there is independent need for a metrical system to explain some phonological phenomena which are also found in many other languages such as Vedic, Russian and Japanese. Such phonological rules include 'accent clash in verb stem' (or 'verb stem vowel shortening' in traditional terms) and a 'compound stress rule' (or 'compound vowel shortening' in other accounts). Each of these phenomena will be examined in the following subsections.

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[4] The examples with more than one underlying accents are sino-Korean vocabulary composed of more than one sino-Korean morphemes. We know a sino-Korean morpheme is accented when it has an alternating realization as a long vowel in the initial position:

ex.					
	a. /yəŋsuciŋ/	→	[yə́:ŋsuciŋ]	'receipt'	('ciŋ' realized short)
	* *				
	b. /ciŋmyəŋ/	→	[cí:ŋmyəŋ]	'proof'	('ciŋ' realized long)
	*				

2.1. Accent Shift in Verb Stem

In Korean, a verb is not an independent word but is in a stem form that should always be followed by some suffixes. Interestingly, for some verb stems, stress is realized on the verb stem when followed by certain kinds of suffixes, but on the suffix when used with other kinds of suffixes. Examples are given below:

(5) Accent Shift in Verb Stem

a.	**tá:m-ta**	'put in-infinitive'
b.	**tá:m-ko**	'put in-and'
c.	**tam-á**	'put in-connective'
d.	**tam-ásə**	'put in-because'

Explanations for the 'accent shift in verb stem' have been given from the perspective of weight-based account of the Korean metrical system (Jung 1995, Kim 1998, Lee 1999). In these approaches, the 'accent shift in verb stem' phenomenon has been analyzed as a 'stem vowel shortening' process where long vowels in verbal stems are *shortened* when followed by certain affixes.

However, these analyses have certain shortcomings. First, a class of verbal suffixes that share the grammatical function of passivization or causativization trigger accent shift. In addition, not all the triggering suffixes are vowel initial but consonant initial suffixes also trigger accent clash. This is illustrated in the following:

(6) Accent Shift in Passive/Causative Morphemes

a. passive/causative suffix **–í** (*causes* accent shift/vowel shortening)

k'ú:-ta	'borrow'	**k'ú-í-ta**	'be borrowed'
mək-tá	'eat'	**mək-í-ta**	'feed'

b. causative suffix **–ú** (*causes* accent shift/vowel shortening)

k'í:-ta	'put on'	**k'i-ú-ta**	'make put on'
cí:-ta	'carry'	**ci-ú-ta**	'make carry'

c. passive/causative suffix **–hí** (*causes* accent shift/vowel shortening)

tə́:p-ta	'be hot'	**təp-hí-ta**	'heat'
nú:p-ta	'lie'	**nup-hí-ta**	'lay'

d. passive/causative suffix **–lí** (*causes* accent shift/vowel shortening)

ú:l-ta	'cry'	**ul-lí-ta**	'cause to cry'
hə́:l-ta	'demolish'	**həl-lí-ta**	'be demolished'

e. passive/causative suffix **–kí** (*causes* accent shift/vowel shortening)

ú:s-ta	'laugh'	**us-kí-ta**	'cause to laugh'
á:n-ta	'hug'	**an-kí-ta**	'be hugged'

f. causative suffix **–kú** (*causes* accent shift/vowel shortening)

tá:l-ta	'become hot'	**tal-kú-ta**	'make hot'
t'ə́:l-ta	'fall'	**t'əl-kú-ta**	'cause to fall'

The following set of data further illustrate that the accent shift cannot be explained as a segmental process since homophonous suffixes, whether they begin with a vowel or a consonant, do not behave in the same way:

(7) a. nominalizing suffix **-í** (*causes* accent shift/vowel shortening)

kí:l-ta	'be long'	**kil-í**	'length'
nó:l-ta	'play'	**nol-i**	'playing'

b. adverbalizing suffix **-i** (*does not cause* accent shift/vowel shortening)

kó:p-ta	'be beautiful'	**kó:-i**	'beautifully'
má:nh-ta	'be a lot'	**má:n-i**	'a lot'

c. nominative case marker **-i** (*does not cause* accent shift/vowel shortening)

ká:m-to	'persimmon-also'	**ká:m-i**	'persimmon–NOM'
pyə́:ŋ-to	'disease-also'	**pyə́:ŋ-i**	'disease-NOM'

In the above examples, we can observe that among the homophonous suffixes in (7a)-(7c), only the nominalizing suffix *–i* in (7a) triggers accent shift. Another example of homophonous suffixes showing different behaviors can be found in the following examples:

(8) a. passive/causative suffix **–kí** (*causes* accent shift/vowel shortening)

tá:m-ta	'put in'	**tam-kí-ta**	'be put in'
á:n-ta	'hug'	**an-kí-ta**	'be hugged'

b. nominalizing suffix **–ki** (*does not cause* accent shift/vowel shortening)

kup-tá	'be bent'	**kup-kí**	'being bent'
kú:p-ta	'bake'	**kú:p-ki**	'baking'

We can see in the above examples that the nominalizing suffix *–ki* does not cause accent shift even though it is segmentally identical to the passive/causative suffix *–ki*.

There have been previous analyses of this phenomenon from the perspective of rhythmic shortening (Kim 1998). However, it predicts a wrong footing for stems with clusters at UR. That is, a rhythmic analysis predicts an initial stress when the syllable is closed with a coda consonant. However, on the contrary, stress is realized on the second syllable when these stems are followed by certain suffixes. This is illustrated in the following examples:

(9)	a.	/sa:lm-ta/	→	[sá:m-ta][5]	'boil-infinitive'
		/sa:lm-a/	→	*[salmá]* *[sálma]	'boil-connective'
	b.	/ku:lm-ta/	→	[kú:m-ta]	'starve-infinitive'
		/ku:lm-ə/	→	*[kulmə́]* *[kúlmə]	'starve-connective'

These data suggest that a rhythmic approach to the accent shift, based on the weight of the syllable, has problems. Besides the arguments made above, the 'accent clash in verb stem' in Korean strongly resembles the phenomenon found other well-known lexical stress systems. Thus, I will give an analysis of this phenomenon from the perspective of 'accent clash' rather than 'vowel shortening' as illustrated in the following rule of accent clash:

(10) Accent Clash: (→ ϕ / __ x (x

[5] Consonant clusters are not allowed in onset or coda position in Korean.

The rule (10) suggests that a left foot boundary is erased when it is followed by another. In the above accent clash rule, a prespecified foot boundary is assumed following Halle & Idsardi (1995). An application of the above rule to an actual example is illustrated below:

(11) a. t a m - t a
UR (x x

b. t a m - a s ə
UR (x (x x
→ x (x x

In (11a), the verb stem *tam-* is pre-specified with a foot boundary. When it is followed by a suffix *-asə*, which is also pre-specified with a foot boundary on the initial syllable, two consecutive foot boundaries are put together. This situation is fixed by eliminating the foot boundary of the verb stem by applying the accent clash rule (10).

2.2. Compound Stress Rule

In this section, I will discuss an accent shift phenomenon in exocentric compounds of Korean, where the semantic head of the compound is not present within the constituents of a compound. When a lexically accented word is involved in exocentric compounding, it loses its lexical accent on surface as illustrated below:

(12) Compound Stress Rule

a.	**cá:k-ta** little-declarative	'be little'
b.	**cá:k-in cip** little-adnominal house	'little house'
c.	**cak-ín cip** little-adnominal house	'younger uncle's house'

In the above examples, (12a) is the base form of a lexically accented word, (12b) is a phrase whose meaning is compositional and maintains the lexical accent of the base form, and (12c) is an exocentric compound whose meaning is not compositional and the lexical accent on the base is not realized on the surface.

Most grammar books of Korean simply describe this phenomenon as a case of exception in pronouncing the originally long vowel as short. Few efforts, on the other hand, have been made to provide an analysis for this 'compound stress rule' in a generative framework. It is, however, a widely popular topic in the literature of generative phonology (Chomsky & Halle 1968, Prince 1983, Cinque 1993, etc.) and phonetics (Vogel, et al. 1995, Grabe et al. 1995, etc.) that compounds show different stress pattern from their phrasal counterparts, a fact which suggests an analysis of the Korean fact along these lines is needed.

An explanation for this phenomenon requires a morphosyntactic analysis of the internal structures of compounds, both of the exocentric as well as the phrasal ones, which is beyond the scope of this paper. Suffice to say for the purpose of this paper that these data suggest, together with the accent shift in verb stem discussed in the previous section, that it is better to analyze the phenomena from the perspective of the 'accent shift' instead of 'vowel shortening'.

3. Vocative Chant as a Window to the Metrical System

In this section, I will investigate vocative chant as an indirect way of diagnosing the metrical system of a language. I will show that the realization of the vocative chant in Korean supports the argument made in the previous section that Korean metrical system has properties of a lexical accent.

Before proceeding, it would be appropriate to provide a justification for the linguistic significance of investigating such phenomena. Since Liberman (1979)'s analysis of tune-text alignment in English vocative chant, where the association of tone patterns was suggested to be sensitive to the stress, subsequent research has further shown that the realization of the phrasal tones in vocative chant has a close relation to the metrical system of the language (Gussenhoven 1993, Inkelas & Zec 1993, Hayes 1995). This suggests that an analysis of such tune-text alignment can shed light on the analysis of the metrical system of a language.

No previous accounts of the Korean prominence system, however, have paid attention to this phenomenon, and none of the previous accounts of the Korean word prosody can account for the realization of tones in vocative chant[6].

There are several kinds of chants in Korean. Not all of them, however, are useful for the purpose of investigating the metrical system through the realization of their phrasal tones since, in many of them, the tonal melody is associated with each syllable one by one without making any reference to the metrical pattern of the words. That is, Korean allows relatively free association of tune and text, as can be demonstrated by numerous instances of an alignment of strong beats with function words such as case markers or postpositions in music. However, at least one exception is found with the vocative chant of Chonnam dialect of Korean.

In vocative chant of Chonnam, some names are realized with a H* tone on the initial syllable but others on the second. This is illustrated in the following table:

(13) Tonal Pattern of Names in Vocative Chants

Location of the H* tone	Absence/Presence of a laryngeal consonant in the beginning of the name	Weight of the initial syllable	Names
H* on the initial σ	No laryngeal consonant	Heavy	a. Young-Sun [jə́ŋsən], Byung-Chul [bjə́ŋtʃəl]
		Light	b. Jae-Hun [dʒɛ́hun], Mi-na [mína]
	Laryngeal consonant	Heavy	c. Hyun-Cheol [hjə́ntʃəl], Seon-Suk [sə́nsuk]
		Light	d. Ho-Jun [hódʒun], Ha-Rim [hárim]
H* on the second σ	No laryngeal consonant	Heavy	e. Eon-Suk [ənsúk], Myung-Joon [mjəŋdʒún]
		Light	f. Eun-Ah [iná], Ki-man [kimán]
	Laryngeal consonant	Heavy	g. Sang-Won [saŋwə́n], P^{h}yung-Geun [pjəŋgín]
		Light	h. Hi-Myung [himjə́ŋ], Ha-Young [hajə́ŋ]

[6] One exception is my own work published as Ko (1999a, 1999b).

As a determinant of the location of the H* tone, one can think of constructing a foot structure based on a regular process of syllable weight, or consider the language specific phonetic effect of laryngeal consonantal effect which causes the F0 of the following vowel high.

It is shown in the above table, however, that the determination of the locus of the H* tone does not have to do with the segmental effect or weight of the syllable since examples can be found for all possible combinations of these features. These data support the arguments made in the previous section that the word-level prosodic system in Korean has properties of a lexical accent system.

So far, I have discussed the prominence system of Korean word level prosody from the perspective of phonology and I have argued that the long vowel in Korean is not phonemic, but is a consequence of expressing a stress, which is partially lexical. In the next section, we will examine this hypothesis through an acoustic experiment.

4. Acoustic Investigation of Stress

4.1. Methods and the Procedure of the Experiment

Three speakers of Chonnam dialect participated in this experiment, one male and two females. All of the subjects were in their late 20's and lived in Chonnam until they went to college in Seoul. Although they lived away from Chonnam for several years, they were able to distinguish the short from the long vowel both in terms of perception and production. Before recording, subjects were encouraged to read or make conversations in their own dialect.

The subjects were asked to read 30 minimal pairs of vowel length, composed of 14 monosyllable words and 16 disyllable words. Each of the data was positioned in a frame sentence, and the subjects read the data twice in a randomized order with filler examples.

(14) Frame Sentence Used in the Experiment

T'obak t'obak ____ kireboseyo.

'clearly' _____ 'pronounce please'

'Please pronounce _____ clearly.'

Each data in a frame sentence was automatically presented on a computer screen in five second's interval so that the subjects do not have to keep track of the list of the data while recording. The data were written in Korean, which does not reflect the vowel length difference in the writing system. Therefore, to indicate the intended length of the vowel for each data, a corresponding English word was put, in parenthesis, next to the target Korean data. Subjects were given explanation of the meaning of each word to make sure they pronounce the data with an intended vowel length, and they were given some time to read the data to familiarize themselves with them.

The recording was made in a sound insulated booth in the phonetics lab of the linguistics department of the University of Pennsylvania. The recorded data were digitized at a sampling rate of 16 KHz. Then, F0, amplitude and duration of the nucleus

vowels were measured using a spectrogram and a waveform generated by a speech analysis computer program.

Duration was measured from the onset of the voicing of a vowel to the offset of both the high energy frequencies and the glottal pulse. F0 was measured both at the mid point of the nucleus vowel and the average of the F0 over the duration of the nucleus vowel. Amplitude was measured from the arithmetic average of the RMS amplitude for the nucleus vowel. Measurement of the 'total amplitude' (Beckman 1986) was intentionally avoided to get around the phenomenon of temporal summation of loudness, i.e. the fact that when holding amplitude constant, a vowel nucleus of longer duration sounds 'louder' than one of a shorter duration.

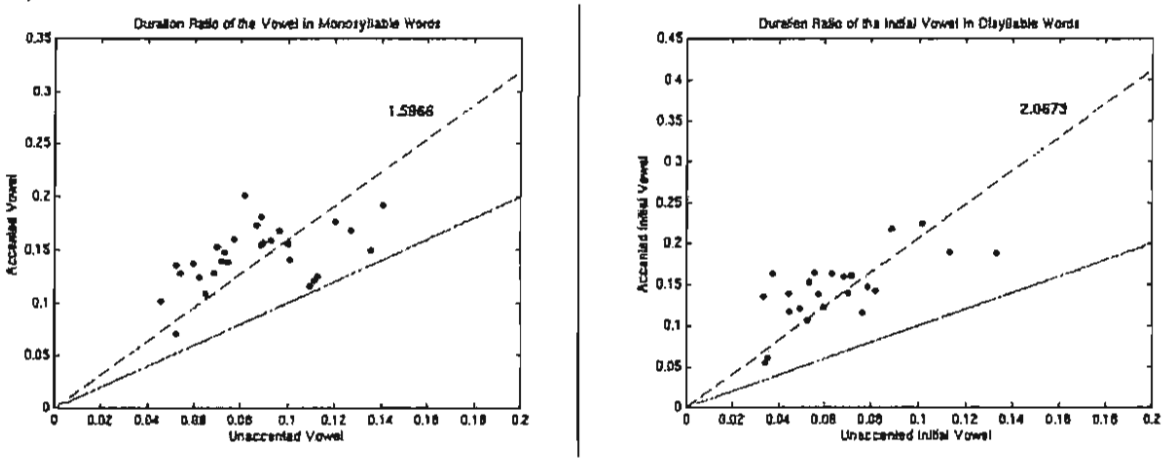
5. Results of the Experiment

5.1. Duration

The duration of the nucleus vowel of the accented syllable was longer than the counterpart of the unaccented syllable. This effect was found both in the monosyllable and disyllable minimal pairs, but was greater in the latter case. This result was found consistently regardless whether the offset of a vowel is taken from the cessation of high energy frequencies or the glottal pulses.

The effect is illustrated in the following graphs, where the dotted line represents a regression and the solid line a slope of 1. The values of an unaccented vowel is plotted on the X axis, and those of an accented vowel on the Y axis. These conventions apply in all the graphs hereafter.

(15) Duration Ratio of the Vowel in Chonnam



a. Duration Ratio in Monosyllable Words b. Duration Ratio in Disyllable Words

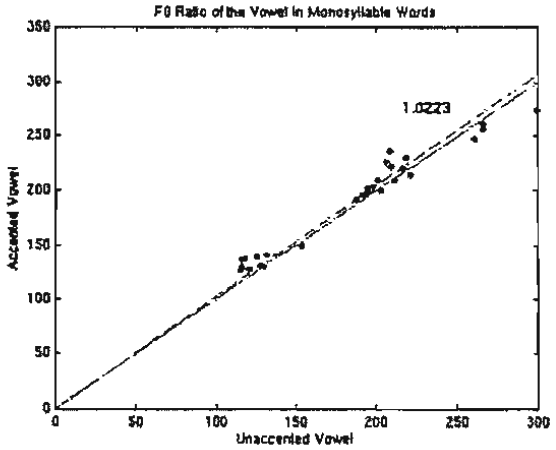
We can observe that the ratio between the duration of the long and short vowel is greater in the disyllable data than in the monosyllable ones. This difference is assumed to be due to the phrasal position of the target syllable in each case. In the frame sentence, the target word constitutes a phrase of its own in a carefully read speech. This causes the target syllable of the monosyllable words to be both in the initial and the final position of a phrase whereas the target syllable in the disyllable words always comes in the initial position of a phrase.

It is well-known that certain prosodic effects are sensitive to the position of a phrase, and it appears that the contrast of vowel length difference due to the effect of stress is more conspicuous in the initial position of a phrase but somewhat weakened in the phrase final position. This same tendency is also reported in other languages such as Telugu (Reddy 1999).

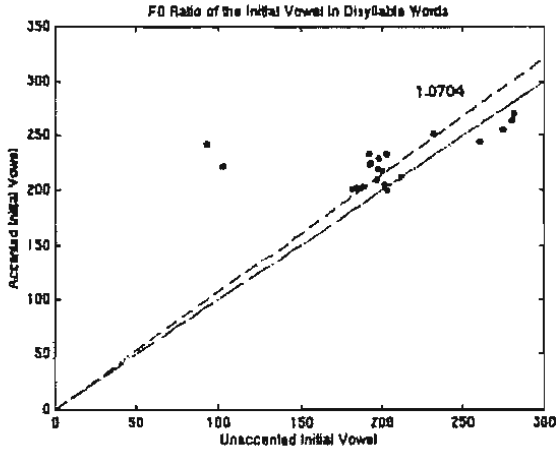
5.2. Pitch

It was found that the accented syllables have higher F0 values than their unaccented counterparts both in the monosyllable and disyllable cases. This tendency was found consistently regardless of whether the F0 values were taken from the middle of the vowel or the maximum F0 value within the target vowel. The following graphs illustrate the distribution of F0 values in monosyllable and disyllable data measured from the mid position of the target vowel.

(17) F0 Ratio of the Vowel in Chonnam



a. F0 Ratio in Monosyllable Data



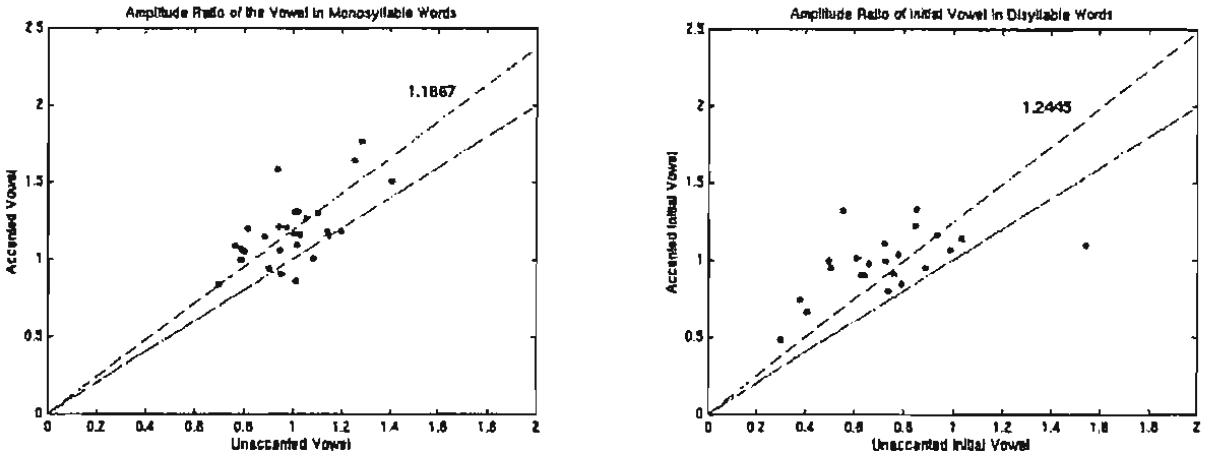
b. F0 Ratio in Disyllable Data

As in the case of the duration, the difference of the F0 values between an accented syllable and an unaccented syllable was more conspicuous in the disyllable data than in the monosyllable case. This could be explained again from the difference of phrasal positions of each data combined with phrasal final lowering effect. That is, the F0 value of a monosyllable words is lower than the initial target syllable of the disyllable words because the F0 tends to get lowered near the end of a phrase.

5.3. Amplitude

For measuring the amplitude of the target vowel, RMS amplitude values automatically generated by the speech analysis program were used. When averages of the RMS amplitude values of each data were compared, it was found that an accented syllable has greater amplitude values than its unaccented counterpart both in the monosyllable and disyllable data. This is shown in the graphs presented below:

(18) Amplitude Ratio of the Vowel in Chonnam



a. Amplitude Ratio in Monosyllable Data b. Amplitude Ratio in Disyllable Data

As in the other acoustic correlates of stress discussed above, this difference of amplitude values between the accented and unaccented pairs was greater in disyllable data where the target is in a phrase initial position than in monosyllable data where the target is located in a phrase final position.

5.4. Acoustic Effects of Stress in Non-initial Position

As discussed in the introduction of this paper, there have been two propositions that have been traditionally assumed in the phonology and phonetics of Korean regarding the status of the long vowel: First, that the long vowel is phonemic and, second, that it is confined to the phrase initial position in its distribution.

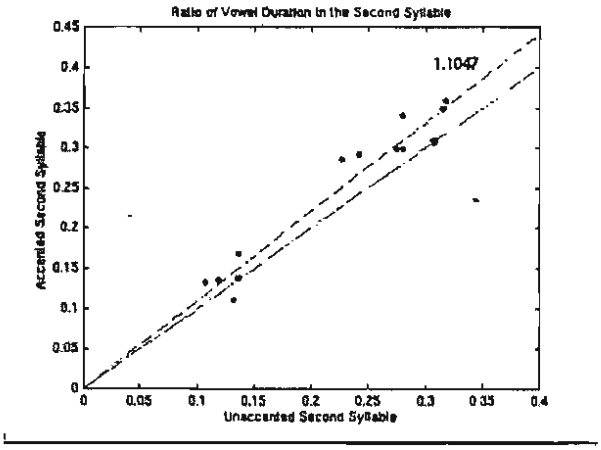
In earlier part of this paper, however, I have argued on phonological grounds that the long vowel in Korean should be seen as a reflex of stress, whether underlying or derived, instead of a phonemic feature.

In this section, I test the second proposition that the long vowel is confined in the initial syllable of a word. For this purpose, I measured the acoustic features of the second syllable of the disyllable word pairs. For example, in the minimal pair of *sákwa* 'apology' and *sakwá* 'apple', it was traditionally believed that the two words are distinguished by the length of the initial vowel. That is, *sákwa* 'apology' has a long initial vowel and *sakwá* 'apple' a short initial one. In an alternative analysis proposed in this paper, the two words *sákwa* 'apology' and *sakwá* 'apple' are distinguished by the presence of an underlying accent on the initial syllable of *sákwa* 'apology' and the lack of one in *sakwá* 'apple'. In the proposed analysis, *sakwá* 'apple' is realized with a stress on the second syllable by default since it does not have an underlying initial accent.

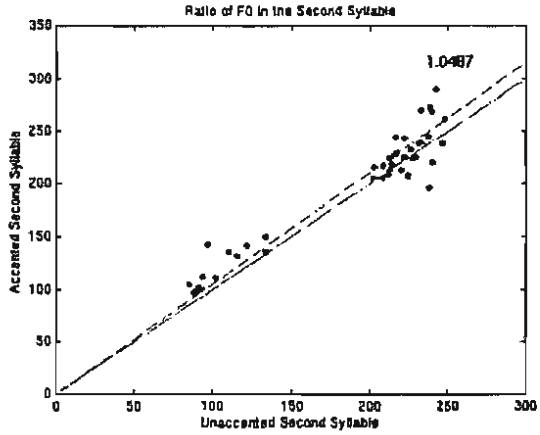
Thus, the question to be explored in this section is whether the stress on the second syllable of *sakwá* 'apple' derived as a default stress has any special acoustic features compared with the second syllable of *sákwa* 'apology'.

The results of the acoustic measurements reveal that the effects of stress are present in the second position as well as in the initial position of a word. It was found that a stressed syllable in the second position of a disyllable word has longer duration and higher F0 values than their counterpart as illustrated in the following graphs:

(19) Effects of Stress in the Second Syllable



a. Ratio of Vowel Duration



b. Ratio of F0

These results are remarkable since the difference is conspicuous despite the fact that the position of the target syllable is the phrase final position, where the salience of the differences of acoustic features are often weakened as observed in previous sections in examining the effects of stress on the duration, F0, and amplitude of monosyllable and disyllable words. The only acoustic factor that was not as clearly demonstrated as other features in measurements of this section was amplitude. There can be various reasons for this, including flaws in the experiment or measurement. However, it is well known that amplitude plays the least important role in perception of stress (Fry 1955, 1958) and, therefore, it won't undermine the discovery made in this section that the acoustic effects of stress is present in the non-initial syllable as well as in the initial syllable.

5.5. Discussion and Theoretical Implication of the Experiment

The experiment made in this section reveals that the longer duration of a vowel in Korean is associated with the higher F0 and greater amplitude at the same time. This supports the phonological claims made in section 2 and 3 that the long vowel in Korean is a reflex of stress, not just a stand-alone phonemic feature as has been previously believed.

The measurements made on the second syllable in section 5.4 further confirm the proposed argument regarding the status of the long vowel being a phonetic feature by showing that it is not confined to the initial position of a word but is also present in non-initial syllable as long as the syllable is stressed.

Interestingly, the degree of ratio between the long and short vowel in minimal pairs indicates that the lengthening effect is greater in the initial syllable than in the second syllable. This perhaps explains the long-held misconception that a long vowel exists only in the initial syllable in Korean. However, this is none other than the well-known *positional effect* (Ko 2000, Keating et al. (to appear), cf. Beckman 1997) that certain phonetic features are demonstrated stronger in specific positions, in this case in the initial position, than in others. Nevertheless, the effect of stress on the second syllable was found to be significant and this suggests that the duration of a vowel is a phonetic effect accompanying stress, and that, therefore, a theory which analyzes the vowel length as phonemic is problematic.

It is also interesting to note that the F0 in Korean seems to play a less important role in expressing prominence than in other languages. I speculate that this is because of

the abundant segmental effect found in Korean. Obstruents in Korean are classified into three categories of lenis, aspirate, and fortis, according to the laryngeal manner of articulation, and aspirate and tense consonants are subject to a strong segmental effect that raises the F0 of the following vowel. Moreover, there is a very common phonological rule called 'Post-obstruent Tensing' which turns a lenis consonant into a fortis after an obstruent, and the fortis consonant thus generated also exhibits a strong segmental effect. It may be due to this abundant F0 perturbation that the F0 does not play as the most important acoustic factor in expressing stress in Korean.

The findings made in this section are solely based on a production experiment. Therefore, it would be desirable if they can be supported with a perception experiment, which I leave as a future research project.

6. Conclusion

The main contributions of this paper can be summarized as follows: First, I have shown that the phonological phenomena that have been analyzed to involve long vowels in Korean are better analyzed as an accent shift which is triggered and governed by morphology and lexical specification. Second, I have confirmed, based on a phonetic study, that what has been considered as a phonemic long vowel in Korean is one of the acoustic correlates of stress together with the higher F0 and greater amplitude.

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