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*The Accentual Phrase in the Korean prosodic hierarchy**

Sun-Ah Jun
University of California, Los Angeles

1 Introduction

A universal characteristic of speech is that utterances are generally broken down phonologically into smaller phrases which are marked by suprasegmental features such as intonational events and/or final lengthening. Moreover, phrases can be further divided into smaller-sized constituents. These constituents of varying size, or 'prosodic units', are typically characterised as performing the dual function of marking a unit of information and forming the domain of application of phonological rules. However, there is less agreement about how prosodic units are defined in generating an utterance. There are at least two different approaches (for a general review, see Shattuck-Hufnagel & Turk 1996). One approach posits that prosodic constituents are hierarchically organised and that prosodic constituents larger than a word are derived indirectly from the syntactic structure by referring to the edge of a maximal projection (Selkirk 1986), to the head–complement relation (Nespor & Vogel 1986) or to the c-command relation (Hayes 1989). This position, which I call the SYNTACTIC APPROACH, has been called the Prosodic Hierarchy theory, Prosodic Phonology or the Indirect Syntactic Approach (Selkirk 1984, 1986, Nespor & Vogel 1986, Hayes 1989).

The other position, which I call the INTONATIONAL APPROACH, also assumes a hierarchical prosodic structure, but defines the prosodic units larger than a word based on the surface phonetic form of an utterance by looking at suprasegmental features such as intonation and final lengthening (e.g. Beckman & Pierrehumbert 1986, Pierrehumbert & Beckman 1988, Jun 1993, Beckman 1996). Both approaches assume a prosodic hierarchy in which prosodic units are hierarchically organised and obey the Strict

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Layer Hypothesis (Selkirk 1984, 1986, Nespor & Vogel 1986; a prosodic unit of a given level of the hierarchy is composed of one or more units of the immediately lower prosodic unit, and is exhaustively contained in the superordinate unit of which it is a part). The prosodic units which are higher than a word, and which are commonly assumed by proponents of the syntactic approach, are the Phonological Phrase and the Intonation Phrase, while those assumed by the intonational approach are the Accentual Phrase, the Intermediate Phrase and the Intonation Phrase.[1] The prosodic units below the Phonological Phrase, i.e. the Syllable, Foot and Prosodic Word, do not differ much in the two approaches, since these units have more fixed roles *vis-à-vis* syntax or intonation.

The intonational unit corresponding to the Phonological Phrase is the Intermediate Phrase in English (Beckman & Pierrehumbert 1986) or the Accentual Phrase in Korean (Jun 1993), in that these are the units immediately higher than a Word. The Phonological Phrase is defined based on the syntactic structure, but the intonational units are defined by intonational markers. The Intermediate Phrase in English is the domain of downstep, and is delimited by a phrase accent, H- or L-; the Accentual Phrase in standard (Seoul) Korean is demarcated by a phrase-final High tone. The next higher level, the Intonation Phrase, is much more similar in the two approaches. Even though the proponents of the syntactic approach define this level in terms of syntax (e.g. a sister node of a root sentence), they claim that this level is the domain of the intonational contour and is sensitive to semantic factors (Selkirk 1980, 1984, 1986, Nespor & Vogel 1986). In this paper, we will focus on the prosodic level corresponding to the Phonological Phrase.

Another difference between the syntactic approach and the intonational approach is that the former focuses on how to predict a prosodic boundary from a sentence, while the latter focuses on how to detect a prosodic boundary from an utterance. Since the syntactic structure of a sentence is not variable in a given syntactic theory, it is predicted in the theory that sentences of the same structure would have the same phonological phrasing. However, it is now well known that it is not possible to predict all phonological phrasings purely based on syntactic information. The influence of non-syntactic factors on phonological phrasing has already been noticed, even by proponents of the syntactic approach. In order to explain exceptional phrasings due to focus and the length of a phrase,

[1] In Beckman & Pierrehumbert (1986) and Pierrehumbert & Beckman (1988), the Accentual Phrase in Tokyo Japanese is dominated by the Intermediate Phrase, which is again dominated by the Utterance. In this model, the Utterance is the domain of a boundary tone. Thus, I will equate the Utterance in Japanese with the Intonational Phrase in English and Korean. This is also true in Venditti's (1995) model of Japanese intonation, though her Intonational Phrase also includes the Intermediate Phrase in Pierrehumbert & Beckman's model. Cf. Selkirk & Tateishi's (1988) Minor Phrase, the domain of initial rise, which would correspond to the Accentual Phrase in Japanese, but their Major Phrase would correspond to the Phonological Phrase of other languages in that this unit refers to the edge of a maximal projection.

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proponents of the syntactic approach have added an optional restructuring rule to the basic prosodic formation rules. By introducing such non-obligatory restructuring rules, they have greatly weakened the predictability of phonological phrasing. This paper will show that Korean prosodic structure is not as directly related to syntactic structure as has hitherto been assumed, and that fundamental frequency (F0) patterns are a good index of this underlying prosodic structure. Since F0 contours are the most accessible data which are relevant to a quantitative description of intonation (Pierrehumbert 1980), we will use F0 contours as the phonetic representation of intonation in the intonational approach.

The main argument for syntactically defined prosodic units has been that these units are the domain of application of segmental phonological rules. On the other hand, the main argument for intonationally defined prosodic units has been that these units are the domain of tone and final lengthening, i.e. non-segmental rules. However, no extensive studies have yet been done to see if these two sets of prosodic units, the domains of segmental and suprasegmental phenomena, exist separately or refer to the same thing. Hayes & Lahiri (1990) tried to connect the syntactically defined prosodic domain with intonation by showing that the Phonological Phrase in Bengali is the domain of boundary tone insertion. Selkirk & Tateishi's (1988) Major Phrase is another example of employing syntactic information (the left edge of a maximal projection) in defining an intonationally marked domain (the domain of downstep). However, intonationally marked prosodic units such as the Intonation Phrase or the Accentual Phrase have rarely been claimed to be the domain of segmental phonological rules. In this paper, I will show that in Korean the Accentual Phrase, a prosodic unit marked by intonational events, is also the domain of several postlexical segmental rules, suggesting that there is one homogeneous prosodic hierarchy. That is, at least in Korean, the prosodic units are the domain of tonal events as well as the domain of sandhi phenomena.

The organisation of this paper is as follows. In §2, I will describe the tonal patterns of the Accentual Phrase in two dialects of Korean, the Seoul and Chonnam dialects. In §3, I will describe how the domains of phonological rules were defined by the syntactic approach, and introduce phonetic experiments which illustrate that it is the intonationally defined Accentual Phrase, rather than the syntactically derived Phonological Phrase, which best matches the domain of application of postlexical phonological rules such as Post-obstruent Tensing and Vowel Shortening. In §4, I will discuss the limitations of each approach, and conclude with suggestions for future research. Throughout the paper, Korean examples are given in phonetic transcription, annotated to show various prosodic boundaries and syntactic grouping. Braces, { }, are used to represent phrase boundaries for the Accentual Phrase or Phonological Phrase, while / / is used for the morphophonemic representation and ( ) is used to represent the boundaries of constituents in syntactic structure. Korean lenis stops are transcribed using IPA symbols for voiceless stops (e.g. [p]),

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aspirated stops are transcribed using the IPA diacritic for aspiration (e.g. [p^h]) and mildly glottalised tense stops are transcribed with the IPA diacritic for ejectives (e.g. [p']). An underlying long vowel is represented only in examples relevant to the Vowel Shortening rule.

2 The Accentual Phrase

In Korean, there are at least two prosodic levels which are marked by intonation; adopting the intonation framework developed by Pierrehumbert and her colleagues (Pierrehumbert 1980, Beckman & Pierrehumbert 1986, Pierrehumbert & Beckman 1988; see Ladd 1996 for extensive review), these are called the INTONATIONAL PHRASE and the ACCENTUAL PHRASE. The Accentual Phrase in Korean is similar to the Accentual Phrase in Tokyo Japanese (Pierrehumbert & Beckman 1988; henceforth, Japanese in this paper refers to Tokyo Japanese) or the Accentual Phrase in French (Jun & Fougeron 1995, 1997, Fougeron & Jun 1998; similar to Hirst & Di Cristo's (1984) Rhythmic Unit or to Mertens' (1993) Intonation Group) in that this is a tonally demarcated unit which can contain more than one lexical item. The Accentual Phrase in Korean and French has only phrasal tones not specific to its component words, while the Accentual Phrase in Japanese can also have a lexical pitch accent specific to its component word, in addition to a phrasal tone.

The Accentual Phrase (henceforth AP) in Korean is a prosodic level lower than an Intonation Phrase (henceforth IP) and higher than a Phonological Word (henceforth PW, a lexical item followed by case markers or postpositions). Existing data on intonational phrasing (e.g. Jun 1989, 1990, 1993) suggest that these levels are hierarchically organised following the Strict Layer Hypothesis (Selkirk 1984, Nespor & Vogel 1986, Hayes 1989). That is, an IP boundary coincides with an AP boundary which again coincides with a PW boundary; a higher level boundary never comes in the middle of a lower level boundary. A PW is never split by an AP unless a part of a PW is contrastively focused. When this happens, the focused part of the PW, which can be a case marker, a morpheme or a syllable, forms an AP by itself, separated from the rest of the PW (see Venditti *et al.* 1996). This is similar to the case of English pitch-accent assignment under narrow focus: every syllable of the word can get a pitch accent under focus (Pierrehumbert 1993). In this case, the word is parsed into a sequence of Intermediate Phrases, where each focused syllable is lengthened, has a nuclear pitch accent and is followed by a phrasal tone. In default situations, however, the PW is not split by a higher intonation unit. In general, one AP in Korean contains two to five syllables (Kang 1996, Korea Telecom 1996).[2]

[2] Based on recordings of reading newspaper columns (23 sentences and 500 words) it was found that there were 165 APs. Among them, 85·45 % had 2 to 5 syllables, and only 7·8 % had more than 6 syllables. No AP had more than 9 syllables.

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A PW has no tonal pattern specific to this level, but it has been shown that, like an AP, a PW in Korean serves as the domain of phonetic strengthening and weakening (Jun 1993: ch. 6): VOT (Voice Onset Time) is longer at the beginning of a PW than in the middle of a PW, and is longer at the beginning of an AP than in the middle of an AP. Segment duration, however, is not greater at the end of an AP (Koo 1986, Jun 1995). This differs from the duration pattern of an IP: an IP-final syllable is lengthened substantially at the end of the phrase (Jun 1993) – such a syllable is about 1·8 times longer than a non-IP-final syllable (Korea Telecom 1996). An AP further differs from an IP in that the latter is very often followed by a pause, but the former is never followed by a pause unless it is the last phrase of an IP. In addition to lengthening, the IP-final syllable is also marked by a boundary tone, indicating the pragmatic meaning of the phrase. When an AP is final in an IP, the IP-final syllable is associated with an AP-final tone as well as an IP boundary tone following the Strict Layer Hypothesis. In this case, the boundary tone of the IP preempts the tonal specification of an AP-final syllable.

The tonal pattern of the AP in Korean differs across dialects, but the phrasing is in general the same. In the following section, I will describe the tonal pattern of APs in two dialects of Korean: Seoul and Chonnam. The Seoul dialect is the standard dialect of Korean. The Chonnam dialect is spoken by at least four million people (Chonnam Province Hall 1997) in the Chonnam province of southwestern Korea.

2.1 The Accentual Phrase in the Seoul dialect

The underlying tonal pattern of the Seoul Accentual Phrase is Low–High–Low–High (LHLH) or High–High–Low–High (HHLH), where the AP-initial tone is determined by the laryngeal feature of the phrase-initial segment. When the segment is either aspirated or tense, having [+stiff vocal cords] (Halle & Stevens 1971), the AP begins with a H tone, but otherwise a L tone. (For details on this tonal difference, see Jun 1996b.) The two initial tones are associated with the two initial syllables of an AP and the two final tones are associated with the two final syllables of an AP.[3]

All these underlying tones are realised on the surface when an AP has more than four syllables, but when it has fewer than four syllables, two or three surface tonal patterns are observed, depending on the degree of undershoot of the initial H or the following L tone. That is, when an AP has three syllables, both the initial H and the following L tones can be undershot, resulting in LH (or HH for the HHLH pattern), or just the initial H can be undershot, resulting in LLH (or HLH), or just the

[3] This tone-mapping rule is from Jun (1996a), revised from Jun (1993). For motivations for this revision, see Jun (1996a: preface).

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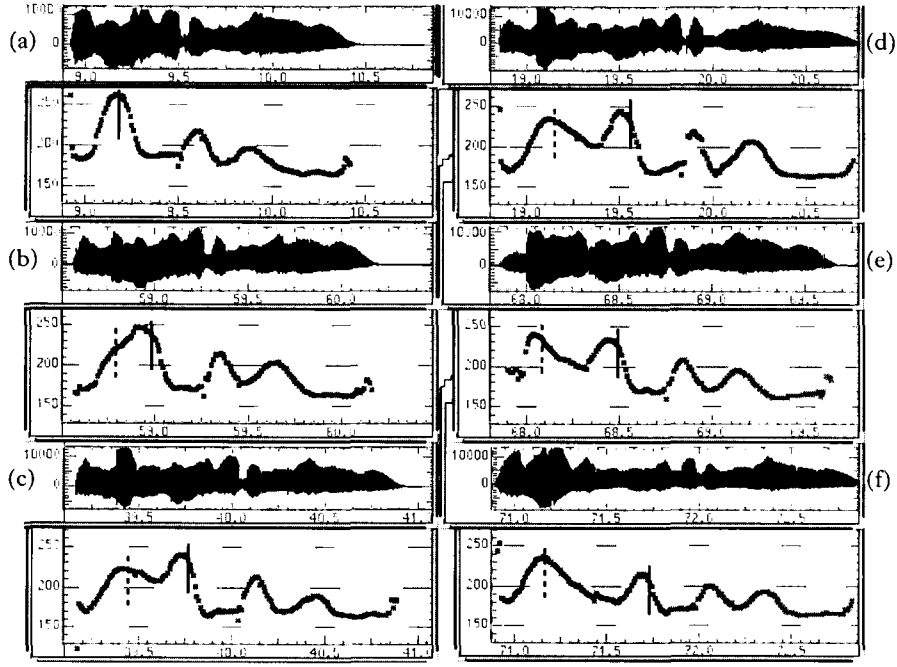


Figure 1

Pitch tracks of the six sentences in (1), showing the boundary of AP and the realisation of the initial high tone depending on the number of syllables in the AP: (a) when the first AP is 2 syllables long, (b) 3 syllables, (c) 4 syllables, (d) 5 syllables in one word, (e) 5 syllables in two words and (f) 6 syllables in two words. The solid vertical line marks the end of the first AP, and the dotted vertical line marks the end of the second syllable of the first AP. The x-axis shows the time dimension in seconds and the y-axis fundamental frequency in Hz. All pitch tracks in this paper have the same format.

following L can be undershot, resulting in LHH (or HHH).[4] When an AP has one or two syllables, only a LH (or HH) pattern is observed. When an AP is longer than four syllables, the syllables between the third and the antepenult of the AP get their surface tones by interpolation between the H tone on the second syllable and the L tone on the penult. As mentioned above, when an AP comes at the end of an Intonational Phrase (IP), the AP-final H tone is preempted by the IP-final boundary tone. That is, when the IP has a L% boundary tone, the final H tone of the last AP is not realised; thus when the last AP has four syllables, its tone pattern is LHLL% (see the tonal pattern of the last APs in Fig. 1).

Representative examples of Seoul APs showing the LHLH pattern are given in Fig. 1, which illustrates F0 patterns for utterances of the sen-

[4] The conditions triggering undershoot of the initial H or the following L are not clear. Informal observation of data shows that the choice of tone varies across speakers and across different pragmatic contexts. Furthermore, different tonal realisations do not have contrastive meaning.

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tences listed in (1), produced by a Seoul speaker. Each sentence in (1) has the structure 'topic NP–object NP–verb'. The topic NP has a varying number of syllables, ranging from two to six. In (a)–(d) the topic NP contains one PW, and in (e)–(f) two PWs. Note that the topic NPs in (d) and (e) have the same number of syllables, five, but differ in the number of words. As shown in Fig. 1, each sentence is produced in one IP with a L% boundary tone. The x-axis shows the time dimension in seconds and the y-axis fundamental frequency in Hz. All pitch tracks in this paper have the same format. Waveforms are given above the pitch track in the same time scale to show segment information. The six utterances are displayed in the same time range (2 seconds), so that the tonal patterns of APs of different size can be compared. In each case, a solid short vertical line marks the end of the first AP, and a dotted short vertical line marks the end of the second syllable of the first AP.

(1) a. na-nin jəŋa-ɾil miwəh-ejo
I-TOP Younga-ACC hate-ENDING
'I hate Younga'
phrasing: {na-nin}{jəŋa-ɾil}{miwəh-ejo}

b. jəŋmi-nin jəŋa-ɾil miwəh-ejo
Youngmi-TOP Younga-ACC hate-ENDING
'Youngmi hates Younga'
phrasing: {jəŋmi-nin}{jəŋa-ɾil}{miwəh-ejo}

c. jəŋman-inin jəŋa-ɾil miwəh-ejo
Youngman-TOP Younga-ACC hate-ENDING
'Youngman hates Younga'
phrasing: {jəŋman-inin}{jəŋa-ɾil}{miwəh-ejo}

d. jəŋman-ine-nin jəŋa-ɾil miwəh-ejo
Youngman-family-TOP Younga-ACC hate-ENDING
'Youngman's family hates Younga'
phrasing: {jəŋman-ine-nin}{jəŋa-ɾil}{miwəh-ejo}

e. uri nuna-nin jəŋa-ɾil miwəh-ejo
my older sister-TOP Younga-ACC hate-ENDING
'My older sister hates Younga'
phrasing: {uri nuna-nin}{jəŋa-ɾil}{miwəh-ejo}

f. jəŋi-əməni-nin jəŋa-ɾil miwəh-ejo
Youngi's mother-TOP Younga-ACC hate-ENDING
'Youngi's mother hates Younga'
phrasing: {jəŋi əməni-nin}{jəŋa-ɾil}{miwəh-ejo}

As we can see in Fig. 1, the first APs in (a) and (b), which consist of two and three syllables respectively, show only the LH rising pattern, whereas the first APs in the other utterances, which have from four to six syllables, have two F0 peaks, one around the second syllable and the other on the final syllable of the AP. The sequence of two LHs must form one tonal unit, because the first LH would otherwise cut the middle of one morpheme, and the two LHs are not independently realised: the falling

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slope within an AP, from the first H to the following L ($-0{\cdot}08 \sim -0{\cdot}20$ Hz/ms), is shallower than that across an AP boundary ($-0{\cdot}5 \sim -0{\cdot}7$ Hz/ms), and the falling slope within an AP is negatively correlated with the number of syllables within an AP. (The falling slope of the first AP during the 180 ms after the peak, which is the total falling duration in Fig. 1c, is $-0{\cdot}08$ (Hz/ms) in Fig. 1c, $-0{\cdot}14$ in Fig. 1d, $-0{\cdot}17$ in Fig. 1e and $-0{\cdot}20$ for Fig. 1f.) This tonal pattern is similar to that of Japanese utterances with unaccented APs (Pierrehumbert & Beckman 1988). In Japanese, the slope of the F0 fall from the AP-initial peak to the low boundary tone on the last mora of the AP is negatively correlated with the number of moras between the high peak and low boundary tone.

The height of the medial L is also correlated with the number of syllables within an AP; the medial L gets lower as the number of syllables within an AP increases. Figure 1 also shows that the lowest point of the medial L, when realised, is not in the middle of an AP, but always on the penult of an AP, suggesting that the final two tones are associated with the final two syllables of an AP. This confirms that LHLH is the underlying tone pattern of AP, but the initial H and the following L are phonetically undershot when the AP is of short duration.[5] (The second AP in each utterance has three syllables and shows a LLH pattern with the initial H undershot.) Finally, the fact that the first AP in (e) shows the same tonal pattern as that in (d) demonstrates that the tonal pattern of APs with the same number of syllables is the same regardless of the number of PWs.

The realisation of the initial H depends not only on the number of syllables in a phrase, but also on the time taken to produce the phrase, i.e. there must be enough time to realise the underlying H. For example, the initial H may appear in a four-syllable AP spoken at normal rate, but may not appear in fast speech. At the same time, a two-syllable or three-syllable AP may have the initial H tone if the syllables are lengthened due to emphasis or produced in slow speech. When the initial H is realised, it is often not as high as the final H, but the relative height can vary depending on speakers and the length of the AP (see Lee & Kim, to appear). The location of the initial H is in general on the second syllable, as shown in Fig. 1 (the initial H starts falling right after the second syllable as indicated by the dashed vertical line). Koo (1986) made a similar observation, but De Jong (1989) found that it was realised near the offset of the first syllable of an AP. More recently, Lee & Kim (to appear) found that, for speakers who tend to undershoot the penult L, the initial H is sometimes (27–40 %) realised on the third syllable in a five-syllable AP. Thus, in this paper, we will adopt Jun's (1993) claim that the initial H is *loosely* associated with the second syllable of an AP.

[5] The claim of initial H undershoot has also been made by De Jong (1989), Lee (1989) and Jun (1990). Lee & Kim (to appear) show that speakers differ in the degree of L undershoot.

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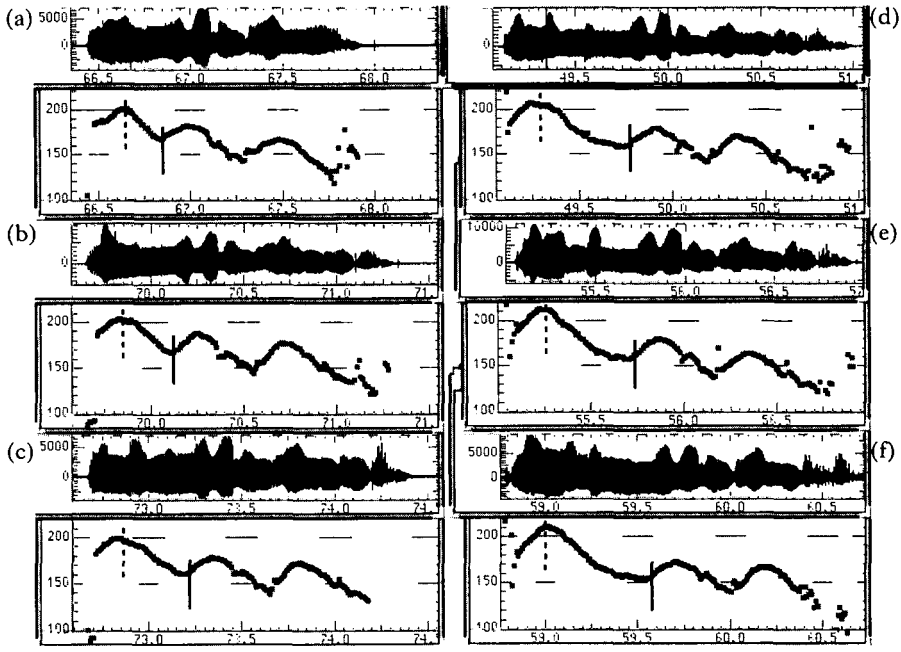


Figure 2
Same as Fig.1, except that each sentence (from (2)) differs in the number of moras: (a) 3 moras, (b) 4 moras, (c) 5 moras, (d) 7 moras in one word, (e) 7 moras in two words and (f) 8 moras in two words. All sentences are produced by a Chonnam speaker.

2.2 The Accentual Phrase in the Chonnam dialect

The underlying tonal pattern of the Chonnam Accentual Phrase is Low–High–Low (or High–High–Low when the AP-initial segment has [+stiff vocal cords], as in the Seoul dialect). The two initial tones are associated with the two initial moras of an AP and the third tone is associated with the final mora of an AP. Unlike the Seoul dialect, the Chonnam dialect has a phonemic length contrast, and a phrase-initial long syllable is realised with the initial LH tones, with each mora bearing one tone.[6] Representative F0 patterns for the AP (the LHL pattern) in the Chonnam dialect are shown in Fig. 2. The sentences in Fig. 2 are the same as those in (1), except for the topic noun phrase in two sentences, (a, e), and the verb ending [-handanda]. The topic nouns are changed to meet the requisite number of moras, and the ending is changed to reflect the Chonnam dialect. The sentence set used for the Chonnam intonation is

[6] Only a vowel, but not a coda consonant, carries a tone. Thus, when the first syllable has a short vowel and a coda, the first syllable carries only L tone and the second syllable carries the H tone, e.g. {kàáŋdò} 'a burglar' *vs.* {kàŋnáŋkʰòŋ} 'a bean'.

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shown in (2). The number of moras in the topic noun phrase increases from three to seven. The topic noun in (d) and (e) has six moras but differs in the number of PWs. As in the Seoul dialect, each sentence was uttered in one IP with a L % boundary tone, and each NP and verb are produced in one AP. The end of each AP is marked by a solid vertical line, and the end of the second mora of the first AP is marked by a dotted line.

(2) a. imo-nin jəːŋa-ɾil miwəh-andanda
aunt-TOP Younga-ACC hate-ENDING
'(My) aunt hates Younga'
phrasing: {imo-nin}{jəːŋa-ɾil}{miwəh-andanda}

b. jəːŋmi-nin jəːŋa-ɾil miwəh-andanda
Youngmi-TOP Younga-ACC hate-ENDING
'Youngmi hates Younga'
phrasing: {jəːŋmi-nin}{jəːŋa-ɾil}{miwəh-andanda}

c. jəːŋman-inin jəːŋa-ɾil miwəh-andanda
Youngman-TOP Younga-ACC hate-ENDING
'Youngman hates Younga'
phrasing: {jəːŋman-inin}{jəːŋa-ɾil}{miwəh-andanda}

d. jəːŋman-ine-nin jəːŋa-ɾil miwəh-andanda
Youngman-family-TOP Younga-ACC hate-ENDING
'Youngman's family hates Younga'
phrasing: {jəːŋman-ine-nin}{jəːŋa-ɾil}{miwəh-andanda}

e. jəːŋi nuna-nin jəːŋa-ɾil miwəh-andanda
Youngi's older sister-TOP Younga-ACC hate-ENDING
'Youngi's older sister hates Younga'
phrasing: {jəːŋi nuna-nin}{jəːŋa-ɾil}{miwəh-andanda}

f. jəːŋi-əməni-nin jəːŋa-ɾil miwəh-andanda
Youngi's mother-TOP Younga-ACC hate-ENDING
'Youngi's mother hates Younga'
phrasing: {jəːŋi əməni-nin}{jəːŋa-ɾil}{miwəh-andanda}

Unlike the Seoul dialect, the tonal pattern of AP in the Chonnam dialect is the same regardless of the number of syllables within the AP, a LHL or HHL pattern. The peak (H) in a LHL pattern is always around the end of the second mora, as indicated by the vertical line on the F0 tracks (when the AP has a HHL pattern, F0 begins to fall after the second mora, as in the LHL pattern). The six utterances in Fig. 2 differ primarily in how low F0 drops at the end of the first AP as it flattens out in the longest utterances. However, unlike the Seoul AP, the falling slope within the Chonnam AP is very similar across APs of different lengths. (The falling slope of the first AP, during the 180 ms after the peak, ranges from −0·15 Hz/ms to −0·18 Hz/ms for all utterances; −0·18 for Fig. 2a, b, −0·15 for Fig. 2c, −0·18 for Fig. 2d, e and −0·16 for Fig. 2f.) Based on this difference, Jun (1989, 1993) proposed that the second L tone of an AP is associated with the third mora of an AP, and all the following moras within the AP get their surface tone by default L tone insertion. But this

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proposal is not consistent with the interpolation hypothesis employed for the Seoul dialect. On the other hand, if we maintain the interpolation hypothesis, all moras after the third mora within an AP would get their surface tone by interpolating the L tone on the third mora of the AP and the initial L tone of the following AP. However, this proposal would still have a problem in explaining why tones are lowered until the penultimate syllable when the final syllable of an AP has a H boundary tone (H %) as in Fig. 4d. Thus, we propose that the AP-final L in the Chonnam dialect is associated with the *last* mora of the AP, and when the last mora of an AP is also the last mora of an IP, the AP-final L shifts to the penultimate mora of the AP.[7] The AP-final L tone seems not to be apparent when it is followed by an AP with a LHL pattern. However, evidence for AP-final L tone can be found when an AP is followed by an AP with a HHL pattern. In this case, the first H tone of the second AP rises sharply right after the low tone of the final mora of the first AP. To explain the different realisation of the falling slope within an AP between the Seoul and Chonnam dialects, further research is needed to develop different phonetic implementation rules.

3 The domain of phonological rules

In §3.1, I will first show how the Phonological Phrase is defined by the syntactic approach, and illustrate how this phrase has been claimed to serve as the domain of three phonological rules in Korean: Post-obstruent Tensing (POT), Vowel Shortening (VS) and Lenis Stop Voicing (LSV). In §3.2, I will report the results of phonetic experiments showing that the domain of POT and VS is not always the Phonological Phrase, but instead matches the intonationally defined domain called the Accentual Phrase (AP). Intonational phrasings and quantitative data relevant for the domain of Lenis Stop Voicing will not be discussed in this paper. Readers should refer to Jun (1993: ch. 3, 1995) for data showing that the domain of Lenis Stop Voicing is also an Accentual Phrase.

3.1 The syntactic approach

As in many other languages, the Phonological Phrase (henceforth PhP) in Korean has been defined on a syntactic basis, adopting Selkirk's end-based theory (e.g. Cho 1987, Silva 1989, 1991, Kang 1992) or Nespor & Vogel's relation-based theory (Cho 1990). Under the end-based theory, the PhP in Korean is defined as {left, X^{max}}; the PhP boundary exists at the *left* end of the maximal projection (i.e. Noun Phrase, Verb Phrase, Adjective Phrase and Adverbial Phrase). Thus, the example sentence in (3) would be phrased into two PhPs, as shown in (3b): {ki-nin}{kojaŋiril ʧ'onnin gaŋaʤiril t'eɾj-ət'e}. However, this phrasing is not natural unless

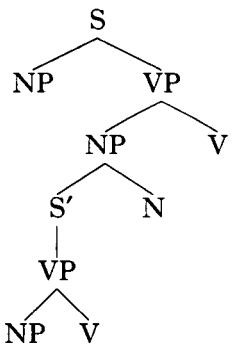
[7] We appreciate the comments of one of the reviewers, who raised a question on the syllable association of the AP-final L tone.

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the noun, [kojaŋiɾil], is narrowly focused. Based on the experimental data in Jun (1993), the most common phrasing of this sentence is the one in (3c): {kɨ-nin}{kojaŋiɾil ʧ'onnin}{kaŋadʒiɾil t'eɾj-ət'e}. Observing a tendency towards limiting the number of phonological words in the complex noun phrase to two, Silva (1989) proposed, in addition to the left-edge parameter, a constraint on the formation of phrases that limits them to binary branching structures, working from left to right. He called the small units 'the minor phrase', following Selkirk & Tateishi (1988), and proposed the Korean Phrase formation rule in (4). (5) shows the derivation of the phonological phrasing for example (3).

(3) $_{S}[_{NP}[$kɨ-nin$]_{VP}[_{NP}[_{S'}[_{VP}[_{NP}[$kojaŋi-ɾil$]_{V}[$ʧ'onn-in$]]]$
$_{N}[$kaŋadʒi-ɾil$]]_{V}[$t'eɾj-ət'e$]]]$

He-TOP a cat-ACC to chase-REL a puppy-ACC beat-PAST
'He beat the puppy that was chasing the cat'



a. X^{max}[... X^{max}[...
b. {NP} {NP V N V}
c. {NP} {NP V} {N V}

(4) *Korean Phrase Formation* (Silva 1989)
Major Phrase: {Left, Xmax}
Minor Phrase: binary branching, L-to-R

(5) a. Major Phrasing: {kɨ-nin}{kojaŋi-ɾil ʧ'onn-in gaŋadʒi-ɾil t'eɾjət'e}
b. Minor Phrasing: {kɨ-nin}{kojaŋi-ɾil ʧ'onn-in}{kaŋadʒi-ɾil t'eɾjət'e}

A similar constraint was also proposed in Kang (1992), in the form of a restructuring rule (6). She noticed that the syntactically defined PhP can be split or can combine with other PhP when the phrase is too long or too short, respectively. The conditions on branchingness or the number of syllables in a phrase in (6a, b) are intended to explain the length effect on the phrasing. The prosodic prominence in (6c) is to explain the focus effect on the phrasing, which is stronger than the length constraints.

(6) *PhP (ϕ)-restructuring rule* (Kang 1992: 297)
a. A non-branching ϕ is adjoined to the following ϕ from left to right. Monosyllabic ϕ's undergo ϕ-restructuring more often than polysyllabic ϕ's.
$\phi(\omega(\ \ ))\,\phi(\omega(\ \ ) \ldots \rightarrow \phi(\omega(\ \ )\,\omega(\ \ ) \ldots$

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b. If a non-branching ϕ is followed by a branching ϕ, the first two ω's may form an independent ϕ and the remaining ω's form a separate ϕ.

$\phi(\omega(\quad))\,\phi(\omega(\quad)\,\omega(\quad)\ldots \rightarrow \phi(\omega(\quad)\,\omega(\quad))\,\phi(\omega(\quad)\ldots$

c. Any ϕ containing prosodically prominent words (accented) remains intact.

d. There may be speaker variation.

Nespor & Vogel's (1986) relation-based theory defines the PhP as the domain which consists of a Clitic Group (if this does not exist, a Phonological Word) which contains a lexical head (X) and all Clitic Groups (or Phonological Words) on its non-recursive side up to the Clitic Group (or Phonological Word) that contains another head outside of the maximal projection of X. However, if we apply this definition to the sentence in (3), we will have the same phrasing as predicted by the end-based theory, i.e. (3b); the subject NP forms one PhP and the predicate VP as a whole forms one PhP, because V is the head and the preceding NP, which is a complex NP containing a relative clause, is its complement within VP. To predict the phrasing in (3c), Cho (1990) proposes a revised Phonological Phrase formation rule in terms of the relation-based theory.

(7) *Phonological Phrase Formation* (Cho 1990)

Apply the following rules cyclically to all maximal projections, proceeding from the bottom up. At any given stage, (a) applies before (b). Let the maximal projection under consideration on a given cycle be M.

a. If M branches, combine the head of M into a Phonological Phrase with all adjacent unphrased material, up to and including the closest XP, or if no such phrase is present, the left edge of M.

b. Phrase any focused word with the next word, unless that word is already phrased.

After (a) and (b) have applied in all possible environments, (c) applies.

c. Unphrased words form Phonological Phrases of their own.

Under this revised rule, the lowest maximal projection in (3) (VP) forms one PhP by itself. In the next maximal projection (NP), there is no unphrased complement of N, thus we mark the left edge of NP as a phrase boundary and go up to the higher maximal projection, VP. Here, the head V and its complement NP, whose only unphrased material is N, forms another PhP. Finally, at the highest maximal projection, S, the NP forms its own PhP, thus there are three PhPs, {NP}{NP V}{N V}.

Though there are a few cases where the two theories predict different PhP boundaries, they in general predict the same phonological phrasing. That is, a general rule is that the PhP includes a lexical head and its complement within a maximal category, but not across a maximal

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category. When the PhP is more than two words, the first two words form one PhP, restructuring the original PhP. Now, given these PhP formation rules and the restructuring rule, we will illustrate the predicted domain of three rules in Korean: Post-obstruent Tensing, Vowel Shortening and Lenis Stop Voicing.

First, Post-obstruent Tensing (POT) is a rule by which a lenis obstruent becomes a tense obstruent after a lenis obstruent. In Korean, tensing of lenis obstruents occurs in various conditions, such as after a Sino-Korean morpheme boundary within a word, or after a nominaliser /l/, or between words. This paper, however, will limit the discussion to the postlexical application of the tensing rule between phonological words, and after a lenis obstruent. This type of application has been claimed to apply within the PhP by various phonologists (e.g. Cho 1987, Kang 1992) and is formalised as in (8).

(8) $[-\text{son}] \rightarrow [+\text{constr gl}] \; / \; {}_{\phi}(\ldots[-\text{cont}] __ \ldots$

The examples in (9) illustrate the domain of POT predicted by these phonologists. The target lenis stop which would undergo tensing is in bold; it is predicted to become a tense stop after a word-final lenis stop within a PhP. (9a) shows a noun phrase consisting of a modifier and a head noun. (9b) is a sentence whose subject noun phrase contains a possessive noun phrase. (9c) is a verb phrase containing an object noun and a verb. The whole NP in (9a) and the VP in (9c) would form one PhP by all versions of the PhP formation rule. However, the whole NP in (9b) would form two PhPs either by Silva's minor phrase rule (4), or by Cho's rule (7a), but form one PhP by the unrevised end-based PhP rule (cf. Kang 1992).

(9) a. $_{NP}(_{Mod}(\text{ʧ}^{h}\text{ət})\ _{N}(\textbf{k}\text{joʧaŋsənseŋnim}))$ 'first principal'
first principal (of a school)
predicted PhP: {ʧ^{h}ət **k'**joʤaŋsənseŋnim}

b. $_{IP}(_{NP}(_{NP}(_{N}(\text{nəne})\ _{N}(\text{toŋseŋtek}))\ _{N}(\textbf{k}\text{ohjaŋ-in}))\ _{VP}(\text{əti-ni}))$
your brother's-wife's home-town-TOP where is-INT ENDING
'Where is your brother's wife's home-town?'
predicted PhP: {nəne doŋseŋt'ek}{kohjaŋin}{ədini}[8] *or*
{nəne doŋseŋt'ek **k'**ohjaŋin}{ədini}

c. $_{VP}(_{NP}(\text{mijəkkuk})\ _{V}(\textbf{p}\text{əljə}))$ 'Throw out the seaweed soup'
seaweed-soup throw-out-IMP
predicted PhP: {mijəkk'uk **p'**ərjə}

Second, Vowel Shortening is a rule by which a phonemically long vowel is shortened in a phrase-medial position. This rule does not exist in the Seoul dialect, because the phonemic vowel-length contrast of 15th century Middle Korean is in the process of being lost in this dialect. Seoul speakers younger than about 50 do not appear to have a stable phonemic

[8] A lenis stop /t/ becomes tensed after a nasal [ŋ] by a different type of tensing rule.

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contrast between long and short vowels, even though they still pronounce certain words with long vowels.[9] In most other dialects of Korean, including the Chonnam dialect, however, the phonemic length contrast is still preserved. In these dialects, long vowels appear only in the first syllable of a word, and the long vowel is shortened when the word is not the first word of a phrase.[10] As in the case of Post-obstruent Tensing, the domain of Vowel Shortening has been claimed to be the Phonological Phrase derived from the syntactic structure (Kook 1990).

Example phrases illustrating Vowel Shortening in the Chonnam dialect are given in (10)–(12). (10) shows a set of words minimally paired for vowel length. Each word in isolation will form one PhP, revealing the underlying vowel length. (11) shows four examples of a compound noun where the second noun has an underlyingly long vowel. The target vowel is in bold. Since each compound noun is also expected to form one PhP, the underlying long vowel would surface with a short vowel. (12) shows examples of a simple noun phrase (an adjective plus a head noun), which is expected to form one PhP. Since the head noun with a long vowel is shortened in a phrase-medial position, each phrase would be ambiguous with the phrase where the head noun has an underlying short vowel. (12a) is ambiguous between 'grey snow' and 'grey eye', (12b) is ambiguous between 'what kind of seaweed' and 'which section of the Kim family' and (12c) is ambiguous between 'strange blinder' and 'strange foot'.

(10) a. $_{N}$(nu:n) 'snow' *vs.* $_{N}$(nun) 'an eye'
b. $_{N}$(s:itʃaŋ) 'mayor' *vs.* $_{N}$(sitʃaŋ) 'be hungry'
c. $_{N}$(tʃa:ŋ) 'soy sauce' *vs.* $_{N}$(tʃaŋ) '(traditional) market'
d. $_{N}$(ki:m) 'seaweed' *vs.* $_{N}$(kim) '(surname) Kim'
e. $_{N}$(pa:l) 'blinder' *vs.* $_{N}$(pal) 'foot'

(11) a. $_{NP}$($_{N}$(hampak) $_{N}$(n**u**:n)) → {hambaŋ n**u**n}[11]
big snow 'big flaked snow'
b. $_{NP}$($_{N}$(səul) $_{N}$(s**i**:)) → {səul ʃ**i**}
Seoul city 'the city of Seoul'
c. $_{NP}$($_{N}$(kotʃ^{h}u) $_{N}$(tʃ**a**:ŋ)) → {kotʃ^{h}udʒ**a**ŋ}
red-pepper soy-sauce 'red pepper paste'
d. $_{NP}$($_{N}$(p^{h}alpaŋ) $_{N}$(m**i**:in)) → {p^{h}albaŋ m**i**in}
eight-directions beauty 'a person who is not only beautiful but also good at everything'

[9] Han's (1964) study on the vowel-length distinction in Seoul Korean indicates that the phonemic length contrast existed even in young Seoul speakers in the 1960s.

[10] In the Kyungsang dialect, an underlying long vowel also appears in the non-initial syllable of a word.

[11] The first word-final stop, /k/, is nasalised before the second word-initial nasal by the Obstruent Nasalisation rule. The same is true for (12a).

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(12) a. $_{NP}(_{Adj}$(hwesek) $_{N}$(nu:n)) → {hwesəŋ nun}
grey snow 'grey snow' (*also* 'a grey eye')

b. $_{NP}(_{Adj}$(musin) $_{N}$(ki:m)) → {musin gim}
what-kind-of seaweed 'what kind of seaweed' (*also* 'which section of the Kim family')

c. $_{NP}(_{Adj}$(isaŋhan) $_{N}$(pa:l)) → {isaŋhan bal}
strange wooden-blinder 'strange blinder' (*also* 'strange foot')

Finally, Lenis Stop Voicing (also known as Obstruent Voicing) is a rule by which a lenis stop becomes voiced intervocalically. This rule was thought to apply only within a word (Lisker & Abramson 1964, Han & Weitzman 1970) until Cho (1987) showed that the domain of this effect is actually larger. She argues that this rule is a postlexical phonological rule, whose domain is the PhP. A formal description of this rule is given in (13), with some examples in (14) (Cho 1990: 48–49). The target lenis stop is in bold.

(13) [−cont, −asp, −tense] → [+voice] / $_{\phi}$(...[+voice] __ [+voice]...)

(14) a. $_{NP}(_{Adj}$(motin) $_{N}$(**k**ilim)) → {modin **g**irim}[12]
every picture 'every picture'

b. $_{VP}(_{NP}$(kilim-il) $_{V}$(**p**ota)) → {kirimil **b**oda}
a-picture to-see 'look at the picture'

c. $_{NP}(_{IP}(_{NP}$(ki-ka) $_{VP}$(mək-nin)) $_{N}$(**p**ap)) → {kiga}{məŋnin **b**ap}
he-NOM to-eat-REL CL MARKER rice 'the rice he is eating'

d. $_{IP}(_{NP}$(ke-ka) $_{VP}(_{NP}$**p**ap-il) $_{V}$(məkninta))) → {kega}{**p**abil məŋninda}
a-dog-NOM rice-ACC to-eat 'The dog is eating rice'

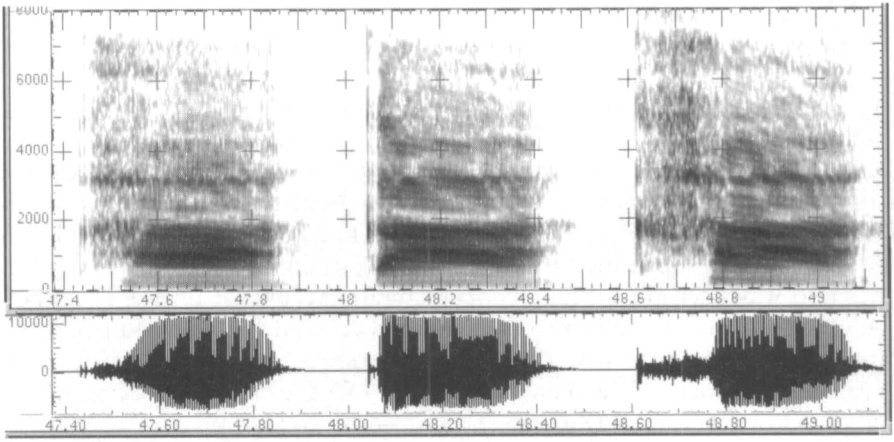
Following Cho's PhP formation rule, (14a–c) each form one PhP, and (d) forms two PhPs. Among these, only the target lenis stop in (d) will remain voiceless, since it occurs at the beginning of the PhP while the others occur in the middle of the PhP. Other versions of the PhP formation rule would predict the same phrasing for (a), (b) and (d), but not for (c). Following Kang's restructuring rule (6b), (14c) would form two PhPs with a different boundary: {kiga məŋnin}{pap}.

In sum, all three rules have been claimed to apply within the PhP, but not across a PhP boundary. When the structure of a phrase is simple, the predicted phonological phrasing is the same among different versions of the PhP formation rules, but when the structure is more complicated, the predicted phrasings may differ from one another even though the syntactic structure of the sentence is the same. This does not mean that there should be three distinct hypotheses about phrasing. In most cases, the phrasings predicted by the three hypotheses are all observed in actual phrasing. This means that each PhP formation hypotheses predicts only some of the actual phrasings of a given sentence.

In the next section, actual phrasings of the sentences relevant to the

[12] Flapping applied in the data: /l/ becomes a flap between vowels.

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(a) /ka/ (b) /k'a/ (c) /k^ha/

Figure 3
Spectrograms and waveforms for the three stops in Korean: (a) lenis stop (/ka/), (b) tense stop (/k'a/), (c) aspirated stop (/k^ha/).

domain of Post-obstruent Tensing and Vowel Shortening will be examined based on spectrograms and pitch tracks. Quantitative data will show that the domain of these two rules is the Accentual Phrase.

3.2 The intonational approach

3.2.1 *Post-obstruent Tensing.* Before introducing experimental data for POT, I will briefly describe the acoustic characteristics of the three types of Korean stop: lenis (or lax), aspirated and tense (or fortis). All stops are underlyingly voiceless, but differ in their degree of aspiration and glottal tension. Lenis stops, /p t k/, in general have weak release bursts, moderately long VOT (35–90 ms) with weak aspiration energy, and breathy vowel onset after the consonant; aspirated stops, /p^h t^h k^h/, have strong release bursts and long VOT (75–120 ms) with strong aspiration energy; tense stops, /p' t' k'/, have strong release bursts and short VOT (0–35 ms) (Kim 1965, Han & Weitzman 1970, Kagaya 1974, Silva 1992, Cho 1996). For comparison, spectrograms and waveforms of underlying lenis, tense and aspirated stops produced by a Seoul speaker are shown in Fig. 3: (a) a lenis stop (/ka/), (b) a tense stop (/k'a/) and (c) an aspirated stop (/k^ha/).

As shown in Fig. 3, the lenis stop has moderately long VOT duration compared with other stops. The onset of the following vowel does not show a sharp amplitude change, especially at high frequencies, indicating breathy quality. The tense stop shows shortest VOT duration while the onset of the following vowel has a sharp amplitude rise even at high frequencies, indicating tense quality. The aspirated stop shows the longest VOT duration and strong aspiration noise.

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3.2.2 *Experiment 1.*

Method and procedure. Eight subjects (four Seoul, four Chonnam) participated in the experiment. To examine the domain of POT, each speaker read the phrases in (9) six times. Speakers were told to read the sentences, especially phrases in (9b, c), in conversational style. They were not given any specific instruction regarding the phrasing. Sentences were digitised and F0 tracks were analysed using Entropic Research Laboratory's XWAVES speech analysis software. The accentual phrasing of each utterance was determined by examining F0 tracks and by listening. This method was used for all data concerning an Accentual Phrase boundary. A spectrogram of each target segment was examined to determine the manner characteristics of the stop. The target stop was categorised as either tense or lenis, based on the duration of VOT and the spectral energy at vowel onset, as described in the preceding paragraph.

Results and discussion. The actual phrasings produced by the eight native Korean speakers were not always the same as that predicted by the syntactic approach. The noun phrase in (9a) was always produced as two APs, {ʧʰət}{**k**jocʤaŋsənseŋnim}, and the target lenis stop remained the same in all utterances. Representative examples of a F0 track, waveform and spectrogram produced by a Seoul speaker are shown in Fig. 4a. The F0 track and waveform are aligned in time, but the time scale of the spectrogram is expanded to show the lenis or tense quality of the target stop. The numbers on the x-axis of the spectrogram refer to the same time points as those in the corresponding F0 track and waveform. The same format is used in Figs 5–6. The first word, {ʧʰət} 'the first', forms one AP with a high tone (because the phrase-initial segment is an *aspirated* affricate), and the second word, the noun compound {kjocʤaŋsənseŋnim} 'principal (of a school)', forms one AP showing a LHLL% tonal pattern (to distinguish the initial H from the final H, 'Hi' is used in Fig. 4); the initial L on [kjo], the next H on [cʤaŋ], the penult L on [seŋ] and L% on [nim]. (If this whole phrase were uttered in one AP, it would have a HHLL% tonal pattern with the initial H on [ʧʰət], the next H on [kjo], the penult L on [seŋ] and L% on [nim].) An expanded spectrogram of a portion of the utterance ([ʧʰət **k**jocʤaŋsənseŋ]) shows that the target lenis stop /k/, which is at the beginning of an AP (the release of the stop starts at 26·65 sec in the figure), remains a lenis stop similar to that of /k/ in Fig. 3a: moderately long VOT (around 60 ms) and breathy vowel onset (each tick at the bottom of the spectrogram is 10 ms).

The noun phrase in (9b) was most often produced as three APs, with boundaries different from those of the PhPs, i.e. {nəne}{toŋseŋ-t'ek**k'**ohjaŋin}{ədini}. The phrasing corresponding to the revised PhP (i.e. three PhPs in the Silva and Cho approaches) was found less often, but the phrasing corresponding to the end-based PhP (i.e. two PhPs) was never found. This confirms that the prosodic phrasing is not generated directly from the syntactic structure in the kind of strictly sequential, rule-based derivational approach of *SPE* (Chomsky & Halle

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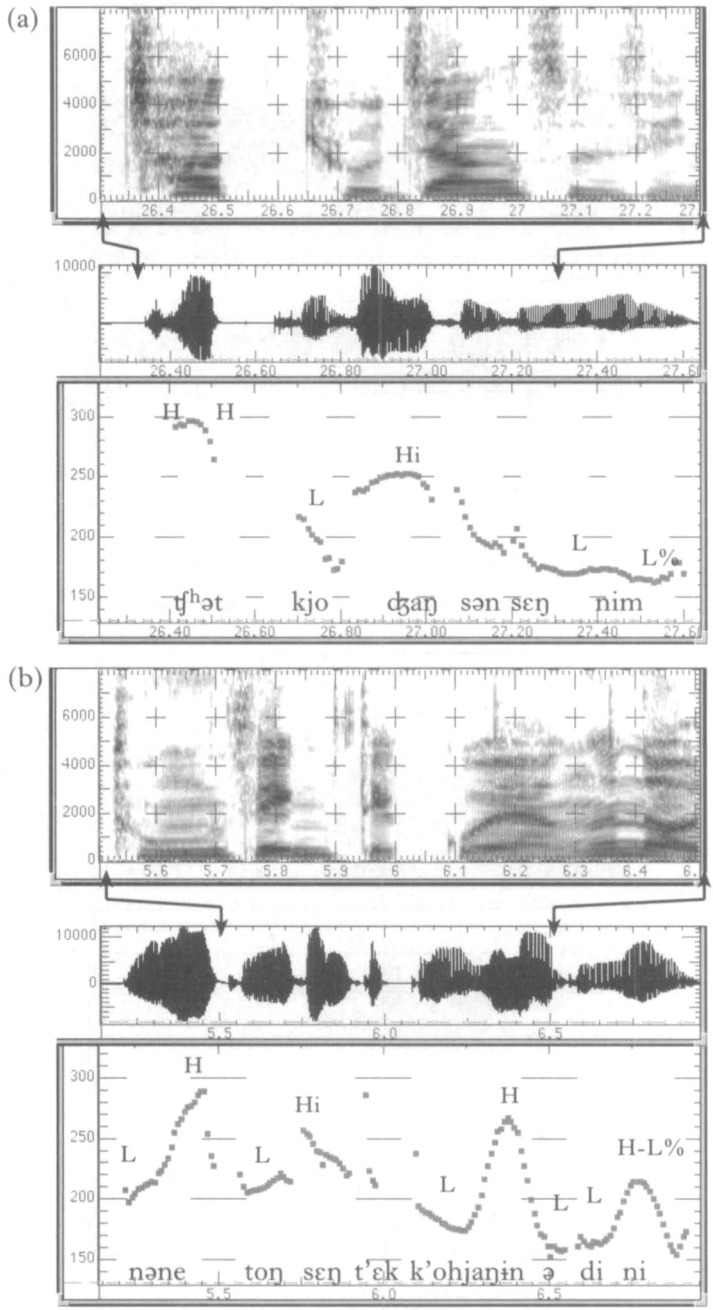


Figure 4

The phrases in (9a) and (9b); the spectrograms show the parts of the utterances corresponding to (a) [ʧʰət kjoʤaŋsənsəŋ] and (b) [toŋseŋt'ekk'ohjaŋin ə], respectively. Pitch tracks/waveforms of the sentences are below the spectrogram. Arrows indicate alignment between the expanded spectrogram and the waveform.

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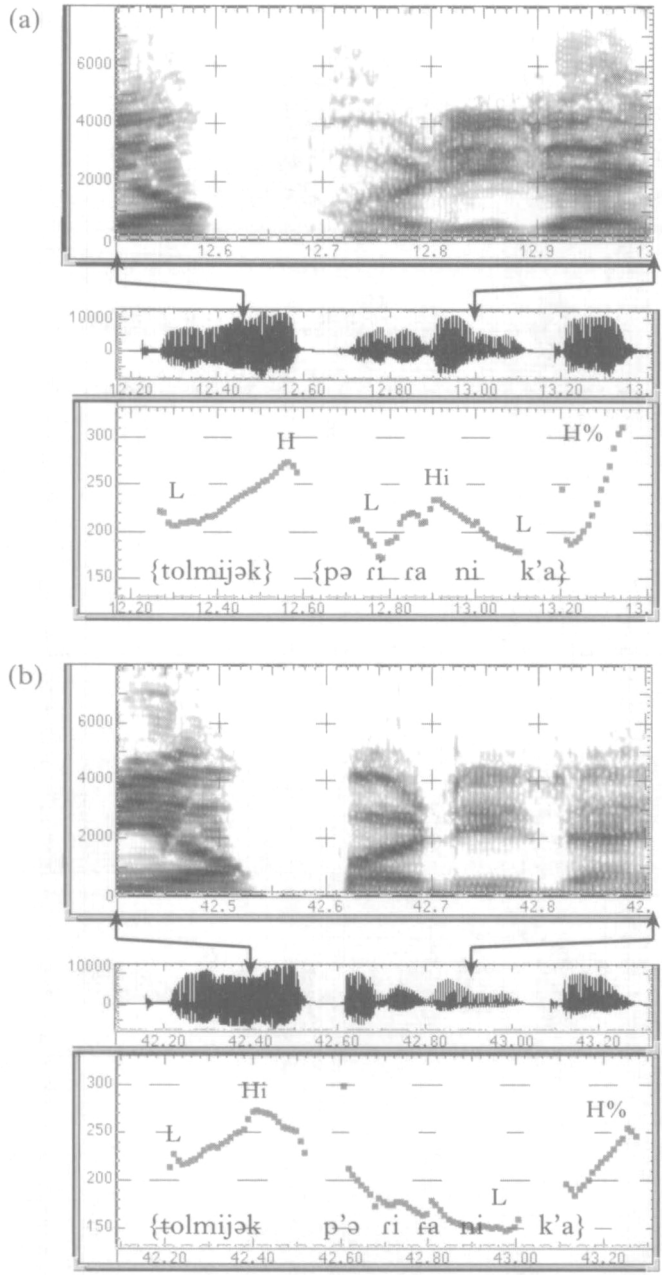


Figure 5
Two types of phrasing of the phrase in (15), produced by a Seoul speaker. (a) shows two APs and (b) shows one AP; the spectrogram shows the part of the utterance corresponding to [jək pəriɾa].

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1968). An example F0 track of the most common phrasing produced by a Seoul speaker is shown in Fig. 4b. An expanded portion of the spectrogram, including the target stop, [toŋseŋt'ek**k'**ohjaŋin ə], is shown above the F0 track. As shown by the F0 pattern, the sentence is uttered in three APs: a LH pattern for the first AP {nəne} 'your', a LHLH pattern for the second AP {toŋseŋt'ek k'ohjaŋin} 'home-town of younger brother's wife' and a LL HL% pattern for the third AP {ədini} 'where is?'.[13] Here, the spectrogram shows that the target lenis stop /k/ (the release of the stop starts around 6·1 sec in the figure), which is in the middle of an AP, becomes a fortis stop [k'], with short VOT (about 20 ms) as in that of /k'/ in Fig. 3b, and stronger energy at high frequencies at vowel onset compared with that of the lenis /k/ in (9a).

The phrase in (9c), however, was produced in either of two phrasings: as one AP, {mijəkk'uk **p'**ərjə}, or two APs, {mijəkk'uk}{**p**ərjə}. These two phrasings were found across speakers and sometimes even within a speaker, but the two-AP pattern was far more frequent than the other phrasing. The syntactically predicted phrasing (one AP pattern) was often made possible by narrowly focusing the first word. Since the F0 value of this phrasing, especially around the target segment, is hard to determine due to segmental perturbation of the voiceless obstruent, a different sentence, with the same syntactic structure but with sonorant segments, was given to the speaker. The sentence is shown in (15) and F0 tracks of the two possible phrasings are shown in Figs. 5 and 6: Fig. 5a, {LH}{LHL H%}, with each word forming one AP and a H% boundary, and Fig. 5b, {LHL H%}, with two words forming one AP and a H% boundary, produced by a Seoul speaker; and Fig. 6a, {LHL} {LHL LH%}, with each word forming one AP and a LH%, and Fig. 6b, {LHL H%}, with two words forming one AP and a H%, produced by a Chonnam speaker. For each F0 track, an expanded part of the spectrogram, [jək pəriɾa], is shown. Again, the spectrograms in both Figs. 5b and 6b show that when the trigger and the target segments are in the same AP, the target lenis stop becomes tense, showing short VOT duration and tense vowel onset (the target segment starts right after 42·6 sec in Fig. 5b and right before 18·8 sec in Fig. 6b), but when there is an AP boundary between the target and the trigger (Figs. 5a and 6a), the target lenis stop remains a lenis stop, showing longer VOT duration and breathy vowel onset (the target segment starts around 12·7 sec in Fig. 5a and right after 14·3 sec in Fig. 6a).

(15) $_{VP}$($_{NP}$(tolmijək) $_{V}$(**p**əliɾanik'a))
stone-seaweed throw-out-IMP
'(I told you before and I am saying it again:) throw out the stone seaweed'
predicted PhP: {tolmijək **p'**əliɾanik'a}

[13] The tonal pattern of the third AP shows that the initial H is not realised, because the AP has three syllables. The last syllable of the AP is realised with a HL% boundary tone (as mentioned in §2.1, the AP-final H tone is overridden by the IP boundary tone).

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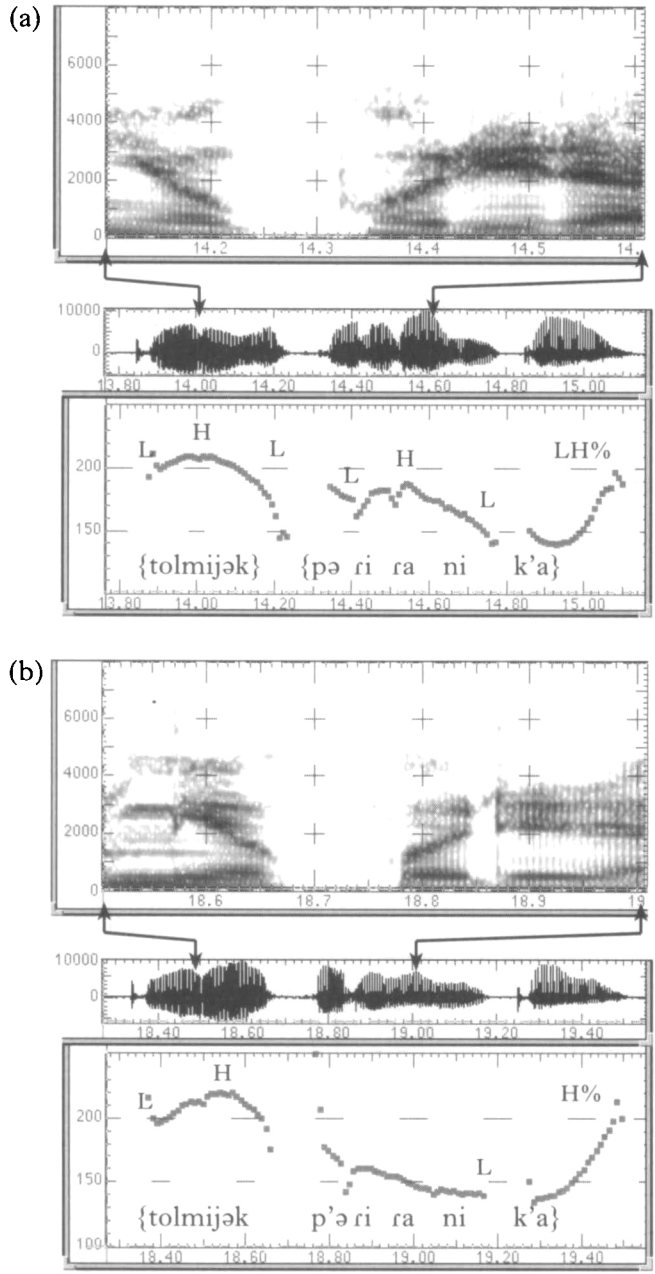


Figure 6
Two types of phrasing of the phrase in (15), produced by a Chonnam speaker. (a) shows two APs and (b) shows one AP; the spectrogram shows the part of the utterance corresponding to [jək pəɾiɾa].

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The fact that the phrase in (9a), though it is a simple noun phrase, is always uttered in two phrases suggests that actual phrasing of a sentence/phrase is sensitive to the number of syllables within the phrase. That is, a short noun phrase (Adj + N) often forms one AP as predicted by the PhP rules, but when the phrase is longer than five syllables, it tends to form two APs (see Jun 1993, 1998 for more detail). Furthermore, the fact that the actual phrase boundary of the subject noun phrase in (9b) occurs most often in the middle of a possessive noun phrase, i.e. {nəne}{doŋseŋt'ek...} 'your brother's wife', while the second part of the possessive noun is combined with the following head noun into one phrase, i.e. {doŋseŋt'ek k'ohjaŋin} 'brother's wife's home-town', confirms that the actual phrase boundary does not necessarily match the syntactic constituent boundary. This also confirms that the minor phrasing of a long phrase is not necessarily a binary branching from left to right. Similarly, the common phrasing of (9c) was different from what has been predicted by the syntactic approach; the verb phrase (verb + object NP) is predicted to form one PhP. This VP is not long (five syllables), and thus should form one AP, or at least form one AP most often. Possible reasons for the observed phrasing are that the meaning of the verb ('to throw') may be less easily predictable from the object noun ('seaweed soup') compared to the verb ('to eat'), or that the two words are not so frequently used as to be included in one phrase. Furthermore, in all cases except for (9a), there was a variation in the actual phrasing of a sentence/phrase. This suggests that the actual phrasing of a sentence is not so straightforwardly predictable from the syntactic structure as has been assumed, but is variable, depending on many factors, such as the length of the phrase and the meaning of the components, in addition to syntactic constituency (for more factors affecting the actual phrasing, see Jun 1993, 1998). Regardless of the variable phrasing, however, we have shown that what changes the lenis stop into a tense stop depends on how speakers intonationally phrase the sentence. That is, the domain of the application of Post-obstruent Tensing is an Accentual Phrase.

3.2.3 *Experiment 2.*

Method and procedure. To verify quantitatively that the domain of Post-obstruent Tensing is the AP, a second experiment was performed. The same eight speakers (four Seoul and four Chonnam) who participated in Experiment 1 produced eight more sentences similar to the one in (9c). These nine sentences are shown in (16). The sentences were randomised, and produced six times by each speaker. The sequence of lenis stops, one at the end of the object noun and the other at the beginning of the following verb, is shown in bold in (16).[14] As in Experiment 1, speakers

[14] In the examples given, verb stems /i/ and /o/ before the imperative ending /-a/ or /-ə/ become glides /j/ and /w/, respectively.

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were told to produce these sentences as they pleased and no expected phrasing was mentioned. However, all subjects preferred to produce the sentences in two APs with the phrase boundary between the object noun and the verb. To trigger speakers to produce the whole phrase in one AP, thus putting the target lenis stop in the middle of an AP, they were later told to put focus on the first word. This always made the whole sentence into one AP.

(16) a. /ketʃip **p**əljə/ 'Throw out the dog house!'
/ketʃip/ 'a dog house', /pəli-a/ 'to throw out-IMP ENDING'
b. /ketʃip **k**atʃəwa/ 'Bring the dog house!'
/ketʃip/ 'a dog house', /katʃəo-a/ 'to bring-IMP ENDING'
c. /ketʃip **t**ukowa/ 'Leave the dog house!'
/ketʃip/ 'a dog house', /tuko-a/ 'to leave-IMP ENDING'
d. /ʧakinnat **p**əljə/ 'Throw out the small sickle!'
/ʧakinnat/ 'a small sickle', /pəli-ə/ 'to throw out-IMP ENDING'
e. /ʧakinnat **k**atʃəwa/ 'Bring the small sickle!'
/ʧakinnat/ 'a small sickle', /katʃəo-a/ 'to bring-IMP ENDING'
f. /ʧakinnat **t**ukowa/ 'Leave the small sickle!'
/ʧakinnat/ 'a small sickle', /tuko-a/ 'to leave-IMP ENDING'
g. /mijəkkuk **p**əljə/ 'Throw out the seaweed soup!'
/mijəkkuk/ 'seaweed soup', /pəli-ə/ 'to throw out-IMP ENDING'
h. /mijəkkuk **k**atʃəwa/ 'Bring the seaweed soup!'
/mijəkkuk/ 'seaweed soup', /katʃəo-a/ 'to bring-IMP ENDING'
i. /mijəkkuk **t**ukowa/ 'Leave the seaweed soup!'
/mijəkkuk/ 'seaweed soup', /tuko-a/ 'to leave-IMP ENDING'

To determine whether the word-initial lenis stops remain the same in AP-initial position but categorically become tense stops in AP-medial position, these segments were compared with underlying lenis and tense stops in word-initial position in terms of VOT duration and energy difference between the first and the second harmonic (H1 − H2). The list of words representing underlying lenis and tense stops is shown in (17). Each word was located in a carrier sentence /ikən __ ja/ 'This is __', and the target stop was always produced in AP-initial position. The sentences were randomised, and each sentence was produced six times by each speaker.

(17) *word-initial underlying lenis stop*: /pəl/ 'a bee'
/katʃi/ 'an eggplant'
/tupu/ 'tofu'
word-initial underlying tense stop: /p'ək'uki/ 'cuckoo'
/k'aʧʰipap/ 'magpie's food'
/t'uʃeŋi/ 'matchmaker (derogatory)'

Each sentence was digitised and its F0 track was analysed and displayed

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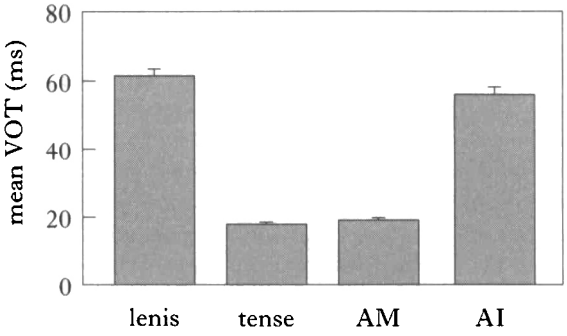


Figure 7
Mean VOT durations (ms) of underlying lenis stop ('lenis'), underlying tense stop ('tense'), target lenis stop in AP-initial position ('AI'), and target lenis stop in AP-medial position ('AM'), averaged from four Seoul and four Chonnam speakers.

to confirm the accentual phrasing of the utterance. In each sentence, VOT duration of the target stop was measured from the spectrogram aligned with its corresponding waveform (from the release of the stop to the onset of the vowel's second formant energy, which was aligned with the beginning of the complex sinusoidal waveform of the vowel). Though a previous study has claimed that there are some overlap VOT values among the three manner categories (Lisker & Abramson 1964), my own pilot study and other studies (e.g. Hardcastle 1973, Silva 1992, Han 1996) show that VOT duration does not overlap among the three categories when stops of the same place of articulation are compared. Next, to measure the tenseness of the vowel following each target stop, the energy difference between the first harmonic (H1) and the second harmonic (H2) at the vowel onset was compared. This measure was chosen because studies have shown that breathiness is characterised by stronger H1 energy than H2 energy, while laryngeality or glottal tension is characterised by stronger or equal H2 energy than H1 energy (Kirk *et al.* 1984, Ladefoged *et al.* 1988, Childers & Lee 1991). Since the energy of the second harmonic of the vowel is influenced by the vowel's first formant energy when the first formant is low as in high vowel, only the tokens with a low vowel /a/ after the target consonant were examined for H1 − H2 energy difference.

Results and discussion. Figure 7 shows the mean and standard error of VOT duration (in ms) of the underlying lenis stop ('lenis') and underlying tense stop ('tense') in an AP-initial position, and the VOT duration of the target lenis stop in AP-medial (AM) *vs.* AP-initial position (AI). Since there are no significant differences among the eight speakers (four Seoul and four Chonnam), averaged VOT data across all speakers are presented. There were in total 144 tokens in each of the lenis and tense category (18 tokens × 8 speakers), but about 390 tokens in each of the AM and AI

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categories. To match the number of tokens across the four categories (i.e. lenis, tense, AM and AI), only the first 18 tokens of AM and AI categories from each speaker were selected for a statistical test, i.e. 144 tokens in total in each category. This reduced data from these two categories showed very similar mean values to those of the original data (mean of the original data: AM = 18·47, AI = 51·37; mean of the reduced data: AM = 19·08, AI = 56·05). Two independent t-tests were performed on the reduced data (144 tokens of each category); one between tense and AM and the other between lenis and AI. Results show that there is no significant difference between lenis and AI ($t = 1{\cdot}90$, $p = 0{\cdot}06$), nor between tense and AM ($t = -1{\cdot}30$, $p = 0{\cdot}19$). This indicates that subjects in both dialects reduce the VOT duration of the target lenis stop when it is produced in AP-medial position, so that it is appropriate for a tense stop category.

Unlike the results of VOT duration, the results of the energy difference of H1 − H2 for lenis *vs.* tense stops were not consistent within a speaker or across speakers. For some speakers, the expected pattern was observed, but for others, no significant H1 − H2 difference was observed between underlying lenis and tense stops. It seems that Korean speakers may not use this phonetic dimension as the main phonetic cue distinguishing lenis from tense stops (for detailed results of H1 − H2 measurements, see Jun, in preparation). Or, as Blankenship (1997) found, the phonation type of Korean lenis *vs.* tense stops may be distinguished by measuring the energy difference between the first harmonic and the second formant: H1 − F2. A similar method has been used in other studies to distinguish breathy *vs.* laryngealised phonation (Ladefoged 1983, Kirk *et al.* 1984, Gobl & Ni Chasaide 1992, Stevens & Hanson 1994). Further experiments are needed to confirm this possibility. Given the results, however, it is possible that the acoustic property of the voice quality at vowel onset is not systematically different after lenis *vs.* tense stops in Korean. This property may be used as an enhancing feature when other phonetic cues are not apparent in the output (Stevens & Keyser 1989).

In sum, the two phonetic experiments discussed above have shown that the domain of POT is an AP, not the syntactically defined PhP: POT occurs within an AP, but not across an AP boundary, though the two APs form one PhP. That is, the VOT of the lenis stop remains long at the beginning of an AP, but is significantly reduced in the middle of an AP to the degree that it belongs to the range of VOT for the underlying tense stop.

3.2.4 *Vowel Shortening.* In this section I will show that, as in Post-obstruent Tensing, the domain of Vowel Shortening is not reliably predicted from the PhP, but corresponds to the AP, based on data produced by Chonnam speakers.

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3.2.5 *Experiment 3.*

Method and procedure. Two Chonnam speakers participated in this experiment. To examine the domain of Vowel Shortening, the four sentences in (18) were randomised, and repeated six times by each speaker. The same experimental procedures as in POT were used regarding the phrasing and recording. The waveform and spectrogram of each target segment were examined to measure the duration of the target word. The word duration was defined from the release of the onset /n/ to the release of the coda /n/.

The four sentences in (18) are minimally paired in such a way that sentences (a) and (b) as well as sentences (c) and (d) differ only in the vowel length of the target noun. For each pair of sentences, the first has an underlyingly short vowel, and the second has an underlyingly long vowel. By the syntactic approach, the sentences in (18a, b) are predicted to form two PhPs with a boundary between the subject and the complement predicate, i.e. {igənin}{nu(:)niranda}. Thus, the underlying long vowel in (18b) would remain long. For (18c, d), however, there are two possible PhP groupings. The first is to have two PhPs with a boundary between the subject noun phrase and the predicate as in {adʒu hajan nuni}{anija}. This is the result of applying the end-based parameters, {left, X^{max}}. The second is to have three PhPs, as in {adʒu hajan}{nu(:)ni}{a:nija}, following either Silva's minor phrase rule (4) or Cho's revised PhP formation rule (7). Thus, the underlying long vowel in (18d) would be shortened under the first grouping, but remain long under the second.

(18) a. $_{IP}(_{NP}$(ikə-nin) $_{VP}(_{NP}$(**nu**n) $_{V}$(ilanta)))
this-TOP an-eye to-be
'This is an eye'
predicted PhP: {igənin}{**nu**niranda}

b. $_{IP}(_{NP}$(ikə-nin) $_{VP}(_{NP}$(**nu**:n) $_{V}$(ilanta)))
this-TOP snow to-be
'This is snow'
predicted PhP: {igənin}{**nu**:niranda}

c. $_{IP}(_{NP}(_{AP}(_{Adv}$(adʒu) $_{Adj}$(ha:jan)) $_{N}$(**nu**n-i)) $_{VP}$(a:nija))
very white an-eye-NOM is-not
'It is not a very white eye'
predicted PhP: {adʒu hajan n**u**ni}{a:nija} *or*
{adʒu hajan}{**nu**ni}{a:nija}

d. $_{IP}(_{NP}(_{AP}(_{Adv}$(adʒu) $_{Adj}$(ha:jan)) $_{N}$(**nu**:n-i)) $_{VP}$(a:nija))
very white snow-NOM is-not
'It is not very white snow'
predicted PhP: {adʒu hajan n**u**ni}{a:nija} *or*
{adʒu hajan}{**nu**:ni}{a:nija}

Results and discussion. The F0 tracks of the actual utterances produced by two speakers showed that the AP boundary of (18a, b) matched the PhP

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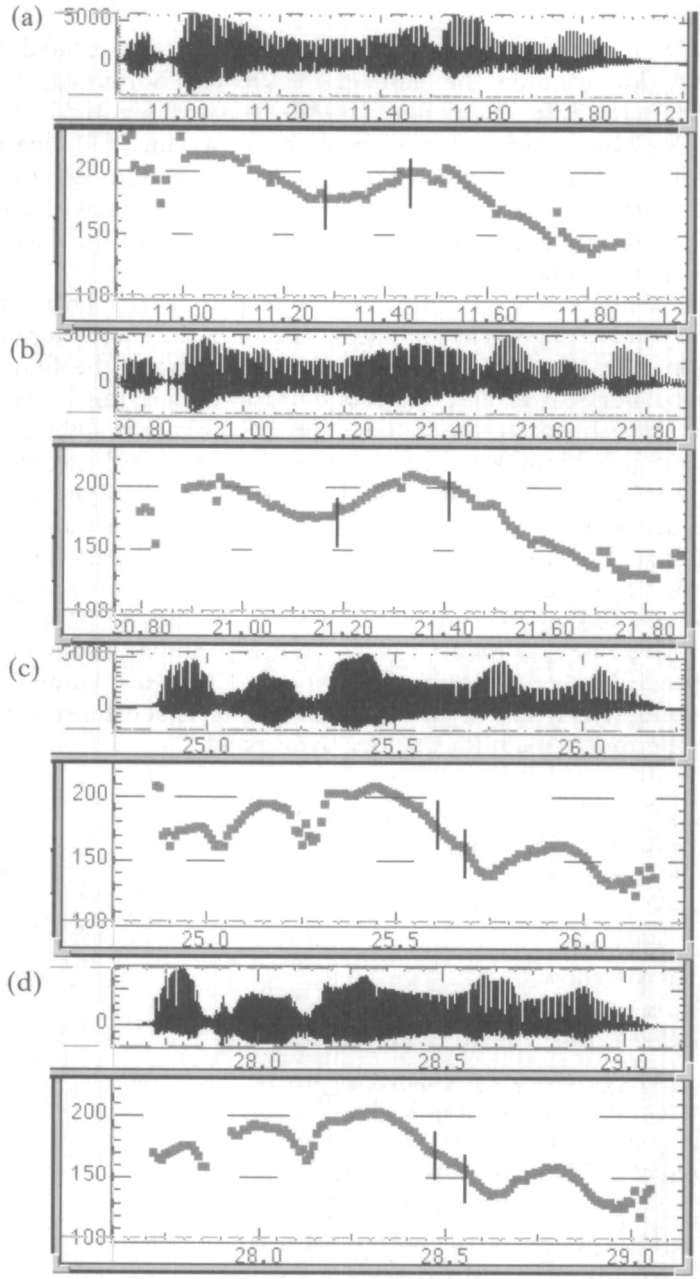


Figure 8

Pitch tracks and waveforms of phrasings for (18a–d): (a) underlying short vowel (/u/ in /nun/) in AP-initial position, (b) underlying long vowel (/u:/ in /nu:n/) in AP-initial position, (c) underlying short vowel (/u/) and (d) underlying long vowel (/u:/) in AP-medial position. The duration of the word, either /nun/ or /nu:n/, is marked by the two vertical lines on pitch tracks.

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boundary. The F0 tracks and waveforms of these sentences are shown in Fig. 8a, b. Since the target vowel is in AP-initial position, the underlying long vowel is realised long in the second sentence. The duration of the word is marked by two vertical lines in the figure: 160 ms for /nun/ in Fig. 8a and 200 ms for /nu:n/ in Fig. 8b. However, the AP boundary of (18c, d) did not match either of the two PhP groupings. The actual phrasings of the two sentences always showed three AP boundaries, as in {adʒu}{ha:jan nuni}{a:nija}; the second AP begins with a H tone due to /h/. The F0 tracks and waveforms of these sentences are shown in Fig. 8c, d. Here, the second AP boundary, between the noun phrase and the predicate, is predictable from the revised versions of the syntactic approach, but the first AP boundary is not predictable from any version of the syntactic approach. The AP boundary is in the middle of a syntactic constituent, the Adjective Phrase. The target vowel of the sentence in Fig. 8d is in the middle of an AP, and the underlying long vowel is shortened, similar to the duration of the underlying short vowel in Fig. 8c. The duration of the word, /nun/ 'an eye' *vs.* /nu:n/ 'snow', is marked by the vertical lines in the figure: 90 ms for Fig. 8c and 96 ms for Fig. 8d.

3.2.6 *Experiment 4.*

Method and procedure. To verify quantitatively that the domain of Vowel Shortening is the AP, a second experiment was performed. The two Chonnam speakers who participated in Experiment 1 produced the sentences in (19) ten to twelve times each. As in Experiment 1, speakers were told to produce these sentences as they pleased and no expected phrasing was mentioned. However, both subjects preferred to produce the sentences in three APs as in {ki saram}{pa(:)ɾin}{tʃəŋmal kʰidiɾa}, with one boundary between the possessor noun {ki saram} and the possessee noun {pa(:)ɾin}, and the other boundary between the subject noun phrase and the verb. This phrasing is the same as one of the predicted PhP groupings. This made the target vowel always come at the beginning of an AP. To show that the underlying long vowel is shortened in AP-medial position, subjects were told to focus the word preceding the target word. This always made the whole noun phrase into a single AP, which however was still separated from the verb phrase, perhaps because the verb phrase begins with an emphatic adverb, [tʃəŋmal] 'really'.

(19) a. $_{IP}(_{NP}(_{NP}(_{Det}(ki)\ _{NP}(sa:lam))\ _{N}(pal\text{-}in))\ _{VP}(_{AdvP}(tʃəŋmal)\ _{VP}(k^{h}itila)))$
that man(-POSS) a-foot-TOP really big-ENDING
'That man's foot is really big'
predicted PhP: {ki saram barin}{tʃəŋmal kʰidiɾa} *or*
{ki saram}{parin}{tʃəŋmal kʰidiɾa}

b. $_{IP}(_{NP}(_{NP}(_{Det}(ki)\ _{NP}(sa:lam))\ _{N}(pa:l\text{-}in))\ _{VP}(_{AdvP}(tʃəŋmal)\ _{VP}(k^{h}itila)))$
that man(-POSS) a-blinder-TOP really big-ENDING
'That man's blinder is really big'
predicted PhP: {ki saram barin}{tʃəŋmal kʰidiɾa} *or*
{ki saram}{pa:ɾin}{tʃəŋmal kʰidiɾa}

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All these sentences were uttered at a normal rate. As a reference for speech rate, the duration of /al/ of the adverb, /ʧɛŋmal/ 'really', was measured from the spectrogram for each sentence. /al/ was measured from the point at which there was substantial second formant energy for the vowel /a/ to the point where the sonorant energy of /l/ disappeared and silence for /k/ closure started. The target vowel /a/ was measured from the point where the second formant energy started for this vowel to the point when the second formant energy was weakened before the flap. To confirm whether speakers produced the sentences in two different accentual phrasings, {kɨ saram barin}{ʧəŋmal k^hidira} *vs.* {kɨ saram}{pa:rin}{ʧəŋmal k^hidira}, F0 tracks of all sentences were analysed and displayed on XWAVES.

Results and discussion. The F0 track of each utterance showed that each speaker produced the sentences in two accentual phrasings, putting the target vowel in the AP-initial and AP-medial positions. Table I shows the mean (and one standard deviation) of the short *vs.* long vowel in the two AP positions for each speaker. The number in each cell is based on 10–12 tokens. The speech rate was consistent within each speaker for all four conditions (short and long vowels in AP-initial and AP-medial position): the duration of /al/ was very similar across tokens within each speaker, ranging from 90 to 96 ms for speaker CJ and 79 to 83 ms for speaker CP. Table I shows that each speaker produced long vowels which were about 1·9 times longer than the short vowels when the vowels were in AP-initial position, but that lengths were similar when vowels were in AP-medial position, i.e. not significantly different at a $p < 0{\cdot}05$ level (speaker CP: $t = -1{\cdot}53$, $p = 0{\cdot}14$, speaker CJ: $t = -0{\cdot}14$, $p = 0{\cdot}88$). This shows that the domain of Vowel Shortening changes depending on how a sentence is produced, but not on the syntactic structure of a sentence. That is, the domain of Vowel Shortening is the intonationally marked AP.

	AP-initial		AP-medial	
	speaker CP	*speaker CJ*	*speaker CP*	*speaker CJ*
/a/	80·32 (9·54)	57·13 (5·52)	80·98 (9·10)	63·81 (4·51)
/a:/	148·76 (9·03)	111·80 (12·50)	86·76 (9·03)	64·17 (6·95)

[Table I. Mean durations (and one standard deviation) of vowel /a/ and /a:/ of (19a, b) in AP-initial and AP-medial position]

In §3, I have shown that the Accentual Phrase in Korean, defined intonationally and smaller than the Intonational Phrase, is the domain of postlexical phonological rules such as Post-obstruent Tensing and Vowel Shortening. Since the intonational phrasing of a sentence varies influenced by many non-syntactic factors, these domains are not strictly predictable from the syntactically based rule, as has been assumed.

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4 Discussion

4.1 Limitations of the syntactic approach

It is true that syntax plays a significant role in forming a phonological phrase, and there are many cases where the syntax-based Phonological Phrase does match actual prosodic phrasing. The problem is that the mapping is not perfect, because the syntactic structure of a sentence is not flexible with respect to factors such as meaning, speech rate or the length of the phrase, while the prosodic phrasing of an utterance is sensitive to these factors. To accommodate variable phrasings not predictable from syntax, prosodic phonologists proposed optional restructuring rules sensitive to meaning (i.e. focus) and performance-related factors such as speech rate and the number of syllables within the constituent. But, as mentioned earlier, adding an optional restructuring rule weakens the predictability of the syntactic approach. At the same time, the restructuring rule can overpredict a phrasing. For example, a sequence of two PhPs where the first PhP has only one PW, $\{PW_1\}\{PW_2\ PW_3 \ldots\}$, was claimed to be restructured as $\{PW_1\ PW_2\}\{PW_3 \ldots\}$ (Kang 1992). This rule will predict the right phrasing when the first PW_1 is the subject noun of a relative clause but not when it is the subject of a main clause. That is, {kiga mənnin}{pap} is a possible phrasing of (14c), but {kega babil}{mənninda} is not a possible phrasing of (14d).

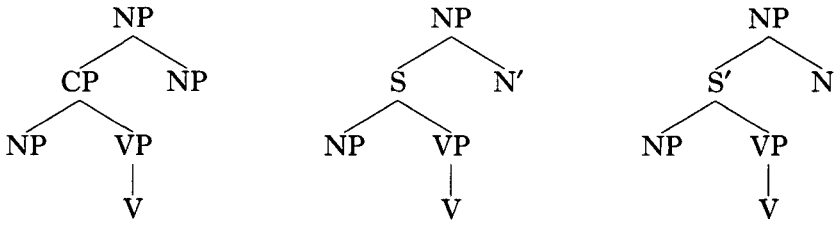
Furthermore, it is also true that the restructuring rule still cannot predict all possible phrasings, since there are variations in phrasing which are not systematic. The actual phrasings of an utterance vary across speakers and even across tokens produced by the same speaker. Observation of the actual phrasings of more than 200 sentences repeatedly produced by several Korean speakers shows that there seems to be no 'neutral' phrasing of a sentence. Moreover, the most frequent phrasing produced by speakers does not always match the so-called 'neutral', i.e. syntactically predicted, phrasing. The variability is greater with phrasings *within* a maximal projection category than that *between* maximal projection categories. This suggests that the syntactically defined PhP is partly an artefact of looking at a few tokens of 'citation form' utterances isolated from more natural discourse contexts. If we derive prosodic phrases based on syntax, we can predict only some but not all of the actual phrasings.

Another limitation of the syntactic approach is that the predicted phonological phrase changes, depending on which model of syntax is used or which syntactic category is assumed. For example, under the end-based approach (which uses an XP as the parameter for defining PhP in Korean) a head noun modified by a relative clause can form two or three PhPs, depending on the syntactic category of the head noun. If we assume an N category (e.g. Cho 1987) or N′ (single-bar) category (e.g. Silva 1989) for the head noun, we will predict two PhPs, {NP}{V N} or {NP}{V N′}, because N and N′ are not maximal projections. But if we assume an NP category (e.g. Kang 1992), we will predict three PhPs, {NP}{V}{NP}. The

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syntactic structure/category and predicted phonological phrasing for the three proposals are shown in (20).

(20) *posited syntactic category*



predicted phonological phrasing

{NP} {V} {NP} {NP} {V N′} {NP} {V N}

Cases related to a different syntactic model can be exemplified by Steedman (1991). Noting examples where an intonational unit straddles the traditional syntactic unit as in (21) (where stress is indicated by small capitals), he proposes to generate a phonological phrase directly from a Combinatory Categorial Grammar (CCG). CCG combines syntactic elements by function composition, which is closely linked to the representation of semantic and information structure, thus allowing ways to create a non-traditional syntactic constituent.

(21) a. I know that Alice likes velvet. But what does MARY prefer?
b. (MARY prefers) (CORDUROY).

This model of flexible syntax surely accounts for many cases where the traditional syntactic boundary is mismatched with the phonological phrase boundary. However, as Croft (1995: 855) notes, CCG is not fully satisfactory for predicting prosodic structures: CCG underpredicts the possible intonational units in contexts other than right node raising or gapping. At the same time, CCG overpredicts intonational units: the analysis predicts that an intonational phrase boundary can appear between any two words since, in theory, any sequence of syntactic elements may form a constituent by using forward/backward composition and type-raising. But, as found in Croft (1995), not every syntactic unit forms an intonational unit, and not every word boundary is a possible intonation boundary. Furthermore, Steedman's model still cannot explain variability across speakers and across repetitions within a speaker. It also cannot predict variations in phrasing due to speech rate or the number of syllables within a phrase, or due to the semantic weight or frequency of a lexical item. Finally, this model focuses on the Intonation Phrase boundary (marked by %), the highest phonological tonal unit. It is not clear how this model can predict the mapping between syntactic units and an Accentual Phrase or a Phonological Phrase.

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To determine how often a syntactic unit is realised as an intonational unit, or how often an intonational unit comprises a syntactic unit, we need to examine actual utterances, as demonstrated in Croft (1995). Based on a corpus of English oral narratives, Croft found that a majority of intonational units (IUs, referring only to an Intonation Phrase) are full grammatical units (GUs) – full noun phrases, prepositional phrases and clauses of various sorts (finite and non-finite). But he found that not all GUs are one IU. These results confirm that there is a regularity between syntax and phrasing, but that phrasing is not directly derived from syntax. This seems to be similar to the claims of the syntactic approach, but Croft's approach differs from the syntactic approach in that he looked at utterances (already prosodified) and tried to find out how GU matches IU, instead of trying to predict which syntactic boundary matches a prosodic boundary.

Finally, the syntactic approach proposes the prosodic units based on the distribution of allophones, i.e. the domain of phonological rules. A problem lies in how the allophones are categorised. The category of an allophone is determined on the basis of native speakers' judgements of sound realisation. However, native speakers' judgements of allophones created by the application of *postlexical* phonological rules are not always as clear as judgements of those created by the application of *lexical* phonological rules. Unless the native speaker is a trained phonetician, s/he tends to believe that s/he produced or heard the underlying sound of the target, not the surface form of the target sound. This is the reason why one of the postlexical phonological rules in Korean, Obstruent Nasalisation, had been claimed to apply within a PhP by some studies (e.g. Cho 1987, Kang 1992) but within an IP by others (e.g. Kang 1990). Furthermore, naive native speakers are not good at perceiving an allophone whose phonetic feature is not contrastive in the language. An example can be found in Korean Lenis Stop Voicing. In Korean, all obstruents are underlyingly voiceless. Thus, [−sonorant] segments are not contrastive in terms of [voice], and native speakers have trouble perceiving the voiced allophone of a lenis stop. Since the prosodic units defined by syntax are justified only on the basis of the distribution of allophones, it is crucial to know the correction distribution. It is important to reflect native speakers' intuitions, but intuitions do not always match reality, especially when we are dealing with allophonic variation or the subphonemic level of a sound. This is the reason why we need to examine phonetic data recorded from native speakers.

4.2 Limitations of the intonational approach

The intonational approach defines prosodic units based on intonational tones, either a boundary tone marking the edges of the unit or a pitch accent tone marking the head of the unit. Thus, the prosodic units in this approach are the domain of the boundary tones or the head tone. At least for Korean, these units have also been shown to be the domain of non-

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tonal phonological rules (for phonological rules whose domain is a tonally defined Intonational Phrase, see Jun 1992, 1993: ch. 4). However, we have shown that the same phonological rules have been claimed by prosodic phonologists to apply within a domain which is syntactically defined. Thus, the question is whether these two prosodic hierarchies, intonationally defined and intonationally cued *vs.* syntactically defined and segmentally cued, refer to the same thing. And if so, to what extent should we expect the correspondence between these two constituents to hold up cross-linguistically?

Although it has been assumed by some prosodic phonologists (e.g. Nespor & Vogel 1986, Selkirk 1986) that there exists only one prosodic hierarchy, it has never explicitly been mentioned in the literature whether there exists one or more prosodic hierarchies, and if there is more than one, how they would correspond to each other. We believe that there is one homogeneous prosodic hierarchy, which is cued in many possible ways. It would be ideal to have a single prosodic hierarchy if the two hierarchies are intended to describe the same phenomena, or as Steedman puts it, the grammar would become unreasonably complicated if we assume two hierarchies referring to the same thing. Examples suggesting one hierarchy would include the Intonational Phrase in many languages (e.g. Selkirk 1986, Nespor & Vogel 1986), the Phonological Phrase in Bengali (Hayes & Lahiri 1990), and the Major Phrase in Japanese (Selkirk & Tateishi 1988). All these syntactically defined units are also the domain of tonal properties.

However, it may not always be true cross-linguistically that all the prosodic units in the prosodic hierarchy are cued by intonation. It is possible that intonation can be limited in such a way that only the highest or the second highest unit is marked by intonation. Intonation can also be constrained by the lexical properties of a language, such as pitch accent or tone. It is also possible that intonation marks the head of a unit, but not the boundary of a prosodic unit. Thus, whether a language has an intonationally defined prosodic hierarchy or not would depend on the richness of the intonational features of the language. As a result, we expect that there would be a different degree of correspondence between the segmentally cued hierarchy and the intonationally cued hierarchy, depending on the relationship between intonation and the lexical properties of a language. The degree of correspondence would be greatest if the language were a non-tonal and non-lexical stress language such as Korean, French and Bengali. The degree of correspondence would be the least if the language were a tone language. Intonation would be heavily influenced by the lexical properties of a word, and would hardly be used to mark the boundary or the head of the prosodic unit. An intermediate degree of correspondence would be found in a language with lexical stress or lexical pitch accent, where only one syllable within a word is marked in the lexicon for a tone or stress. Japanese and Basque would belong to this category, but the correspondence would be higher for Japanese than for Basque because the underlying pitch accent is always preserved at the

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postlexical level in Basque (Jun & Elordieta 1997), but not always in Japanese.

In sum, correspondence between the segmentally cued hierarchy and the intonationally cued hierarchy will be greater if intonation is less influenced by lexical properties of the language. Of course, we need experimental data to prove whether this correlation exists. That is, we need to examine whether a language has intonationally definable units, and if so, whether the intonational units are indeed the domain of segmental phonological rules.

Finally, it is generally assumed that the intonationally defined hierarchy is correlated with the degree of phrase-final lengthening and the existence of pause. This assumption, however, seems to be challenged by studies based on non-laboratory speech data. For example, the ToBI transcription systems for English (Beckman & Hirschberg 1994), Japanese (Venditti 1995) and Korean (Beckman & Jun 1995) have all found it necessary to allow for discrepancies between the sense of disjuncture and the tonally marked phrase boundary. Woodbury (1992) similarly found that pausing is used orthogonally to intonationally marked units in very conventionalised rhetoric of oral narratives in Central Alaskan Yupik Eskimo, and a pair of routines from an American television comedian. He claims that patterns of pitch and pause converge in the usual or default case, but do not converge in a specific genre or speech style, thus drawing special pragmatic inferences. This suggests that the correspondence between the intonationally cued and segmentally cued hierarchies would differ, depending on the discourse structure of the spoken data or literature genre. The evidence for prosodic units proposed in this paper is based on pretend-conversational style utterances recorded in a laboratory. Within this type of data, at least in Korean, it is clear that the tonally defined prosodic unit is also the domain of segmental phonological rules. This perfect congruence may suggest that the laboratory data are, or are close to, the default case in Woodbury's sense. Further research is needed to confirm whether the degree of congruence changes, depending on genres and discourse structure.

5 Conclusion

In this paper, we have shown that the phonological phrasing of a sentence is not straightforwardly predictable from the syntactic structure alone. Results of phonetic experiments show that in Korean the domain of phonological rules such as Post-obstruent Tensing and Vowel Shortening coincides with the intonationally defined prosodic unit, an Accentual Phrase. This suggests that there is one homogeneous prosodic hierarchy in Korean which is the domain of both tone and segmental phonological rules. We also discussed limitations of both the syntactic and the intonational approach to the prosodic hierarchy. To model the mechanism by which native speakers construct a prosodic structure, we need to know what kinds of factors native speakers refer to in forming the prosodic

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structure, and how they rank these factors when there is more than one. We believe that the intonational approach will help us to understand what these factors are and how they interact, by providing objective criteria on phrasing. In fact, the surface form of a sentence, i.e. an utterance with intonation and timing information, is the input to the listener to parse the prosodic structure of a sentence. Further research is needed to establish an intonational structure for various languages, and to discover factors influencing the prosodic structure and their interactions.

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