9

Effects of Accentual Phrasing on Adjective Interpretation in Korean*

AMY J. SCHAFER AND SUN-AH JUN

1 Introduction

Several studies of prosody and sentence processing have now demonstrated that prosodic phrasing can exhibit strong effects on processing decisions in English (e.g. Warren, Grabe, and Nolan 1995, Schafer 1997, Kjelgaard and Speer 1999). However, very little work on prosodic effects on parsing has been done with other languages. Given that there is variability in prosodic structure and its relationship to syntactic or semantic form across languages (e.g. Beckman and Pierrehumbert 1986, Venditti, Jun, and Beckman 1996), it could be the case that prosody has very different effects on processing across languages. Thus, just as syntactic processing models can be better evaluated by testing syntactically diverse languages, experimentation on prosodically diverse languages should further our understanding of both the universal and the language-specific relationships between prosodic form and sentence processing decisions.

The research described in this paper had two primary goals. The first goal was to determine if Korean sentence comprehension could be affected by the accentual phrasing pattern of the sentence. Korean accentual phrases are similar to intermediate phrases in English in that they are the level of prosodic structure which is intermediate between phonological words and intonation phrases. A small set of studies on English have provided evidence that intermediate phrase boundaries can affect comprehension (Kjelgaard 1995, Schafer 1997, Kjelgaard and Speer 1999). However, Korean accentual phrases are arguably less phonetically salient than English intermediate phrases, as described further in Section 2. They also tend to differ in span. Korean accentual phrases generally contain fewer syllables and fewer content words than English intermediate phrases. In an analysis of the prosody produced by reading a standard passage, Jun and Fougeron (Jun 1999, Jun and Fougeron 2000) found that Korean accentual phrases contained an average of 3.2 syllables and 1.2 content words, and thus generally contained a single phonological word. In contrast, with an English version of the passage, Ueyama (1998) found that English intermediate phrases contained an average of 5.3 syllables. Using a different reading text, Ayers (1994) found that English intermediate phrases contained over 3.9 content words on average.

Accentual phrases may therefore show smaller effects on comprehension than intermediate phrases for either of two reasons. First, if they are less acoustically salient, they might be less reliably detected during sentence comprehension. Second, if syntactic disambiguation depends on grouping syntactic units into prosodic units, the small size of Korean accentual phrases may mean that they are less commonly associated with disambiguated syntactic structures than English intermediate phrases. Thus, Korean accentual phrases could be a less reliable source of information about syntactic structure than English intermediate phrases.

Nevertheless, Jun (1993, 1994) showed that correspondences exist between accentual phrasing and syntactic phrasing in Korean. She found that speakers produced different accentual phrasings for the Korean equivalent of *black cat's ankle* depending on whether *black* modified *ankle* or *cat*. Speakers grouped *black* with *cat's* to show that *black* modified *cat*, and grouped *cat's* and *ankle* to indicate the other interpretation. We therefore expected there to be some effect of accentual phrasing on sentence comprehension, and so our second goal was to compare and contrast the effects of prosodic phrasing in Korean and English.

In both languages, prosodic phrases can group together material which is closely related syntactically or semantically. This "chunking" aspect of prosodic phrasing has been captured explicitly in some models of sentence processing to explain prosodic disambiguation effects. For example, on the

basis of observations about English and Japanese, Marcus and Hindle (1990) proposed that material in separate prosodic phrases can be freely combined at later stages of processing, but material within a single prosodic phrase cannot be separated. Such a view of prosodic phrasing effects would most likely predict very similar effects of accentual phrasing in Korean and intermediate phrasing in English.

However, the structure of the prosodic system and its relationship to syntactic and semantic structure differs for Korean and English in several important respects. As mentioned above, accentual phrases and intermediate phrases tend to contain different amounts of phonological and morphological material. The two languages also differ in how their prosodic systems encode information structure. English has a large number of pitch accents, and marks information structure primarily through the type and placement of these pitch accents. Korean has no pitch accents, and marks information structure primarily by manipulating accentual phrasing. Thus, English is prominence-driven, while Korean is boundary-driven (Beckman 1995, Jun 1999). Korean might therefore show different prosodic phrasing effects from English because of such differences between the two languages in the grammatical constraints on prosodic form.

Here, we briefly report on two experiments on prosody and sentence processing in Korean, a production experiment and a comprehension experiment, which are part of an on-going research project on prosodic effects on sentence processing in Korean. The production study served to confirm our expectations about prosodic patterns in Korean under various syntactic, semantic, and discourse conditions. It also allowed us to elicit materials for our comprehension experiment from native speakers. The comprehension experiment then tested a syntactically ambiguous structure under four conditions of accentual phrasing. On the basis of the results, we will argue that sentence comprehension in Korean, like in English, shows effects of acoustically subtle prosodic phrase boundaries. Yet the two languages can differ in how prosodic phrasing effects are realized. We will claim that these apparent differences in prosodic effects stem from differences between the two languages in the grammatical constraints governing prosody and the mappings between prosodic structure and syntactic and semantic structures. In the next section, we review the intonational structure of Seoul Korean. We then turn to the description of the experiments.

2 Description of Seoul Korean Intonation

Korean has two prosodic units which are marked by intonation. These are called the "intonation phrase" and the "accentual phrase" by Jun (1993,

1998), adopting the intonation framework developed by Pierrehumbert and her colleagues (Pierrehumbert 1980, Beckman and Pierrehumbert 1986, Pierrehumbert and Beckman 1988; see Ladd (1996) for extensive review). A schematic representation of the intonational structure of Seoul Korean is shown in Figure 1. The intonation phrase (IPh) consists of one or more accentual phrases, and is demarcated by a boundary tone. An IPh boundary tone can be a simple high or low tone (H%, L%) or a combination of high and low tones (e.g. HL%, LHL%, LH%). It is realized on the phrase-final syllable and delivers pragmatic information about the sentence. An IPh-final syllable is subject to final lengthening—such syllables are about 1.8 times longer than IPh-medial syllables (Korea Telecom 1996)—and is optionally followed by a pause.
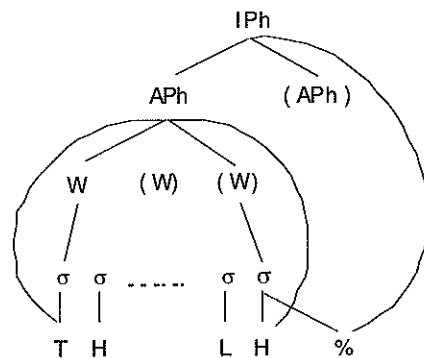
Notes: Elements in parentheses are optional. Accentual phrase tones are realized on the first, second, penultimate, and ultimate syllable of the accentual phrase, regardless of how those syllables are parsed into phonological words. (IPh = intonation phrase; APh = accentual phrase; w = phonological word; σ = syllable; T = tone, realized as H when the initial segment is aspirated/tense, L otherwise; H = high tone; L = low tone; % = intonation phrase boundary tone.)

Figure 1. Intonational structure of Seoul Korean (Jun 1993)

An accentual phrase (APh) in Korean consists of one or more phonological words (a lexical item followed by case markers or postpositions; written as "w" in Figure 1), and is defined by phrasal tones demarcating the beginning and the end of the phrase. The underlying tonal pattern of an accentual phrase in Seoul Korean is either Low-High-Low-High (LHLH) or High-High-Low-High (HHLH): thus, THLH in Figure 1. The APh-initial tone is determined by the laryngeal feature of the phrase-initial segment. When the phrase-initial segment is either aspirated or tense, having [+stiff vocal cords] (Halle and Stevens 1971), an APh begins with an H tone; oth-

erwise it carries an L tone. For details about this tonal difference, see Jun (1996, 2000).

The surface pattern of tones for an APh depends on the underlying APh contour, the length of the APh, and whether the APh is final in the IPh or not. All four underlying tones are realized on the surface when an APh has four or more syllables and is not IPh-final. The initial two tones of the underlying APh contour are associated with the initial two syllables of the APh and the final two tones of the underlying contour are associated with the final two syllables. If the APh is longer than four syllables, the tones on the syllables between the second syllable and the penult are determined by interpolation from the H tone on the second syllable to the L tone on the penult.

When an APh has fewer than four syllables, several additional surface tonal patterns can be observed, as a result of undershoot (i.e., missing the pitch target) of the medial H or the following L tone. When an APh has three syllables, both the medial H and the following L tone can be undershot, resulting in LH (or HH for the HHLH pattern); just the medial H can be undershot, resulting in LLH (or HLH); or just the following L can be undershot, resulting in LHH (or HHH).[1] When an APh has one or two syllables, only a LH (or HH) pattern is observed.

Finally, when an APh is final to an IPh, the final syllable of the APh and IPh is associated at the underlying level with both an APh-final tone and an IPh boundary tone. In this case, the boundary tone of the IPh pre-empts the tonal specification that would otherwise be realized on an APh-final syllable. For example, when the IPh has a L% boundary tone, the final H tone of the last APh is not realized; thus when the last APh has four syllables, its tonal pattern is LHLL% (or HHLL%).

Unlike the case for IPhs, an APh-final syllable is not consistently lengthened. In those cases when it is lengthened, the degree of lengthening is substantially smaller than for IPh-final lengthening. The final syllable of an APh is only followed by a pause when it is also the last syllable of an IPh. However, APh-initial segments have been shown to be "strengthened" (Jun 1995, Fougeron and Keating 1997, Keating et al. 1999, Cho and Keating 1999). That is, the first segment of an APh is realized with a longer duration and more extreme articulation (e.g., a greater degree of contact between articulators) than segments internal to an APh.

---

[1] The conditions triggering undershoot of the medial H or the following L are not clear. Informal observation of data shows that the choice of tones varies across speakers and across different pragmatic contexts. Furthermore, different tonal realizations do not seem to have contrastive meaning (Jun 2000).

An example of Seoul Korean intonation is shown in the pitch track in Figure 2. The sentence means 'Hyungmin's family hates Younga'. It has three phonological words, which correspond to 'Hyungmin's family' 'Younga', and 'hates'. The utterance consists of three APhs, with each phonological word forming a single APh: ((Hyungmin's family-Top)$_{APh}$ (Younga-Acc)$_{APh}$ (hates)$_{APh}$)$_{IPh}$.

The first APh shows a HHLH pattern since the phrase is five syllables long and begins with [h], [+stiff vocal folds]. The second APh shows a LH pattern since the phrase is three syllables long and begins with [j], [-stiff vocal folds]. The last APh shows a LHLL pattern because it is four syllables long, begins with [m], and is the final APh of an IPh which marks a declarative with a L% boundary tone. The underlying tonal pattern of the utterance is given in (1a) and the surface tonal pattern is given in (1b) and Figure 2. The symbol 'a' following a tone (e.g. 'LHa') marks the end of an accentual phrase in (1) and the 'tones' transcription in Figure 2.

(1) a. Underlying tones: (HHLHa) (LHLHa) (LHLHa L%)
    b. Surface tones: (HHLHa) (LHa)   (LHLL%)
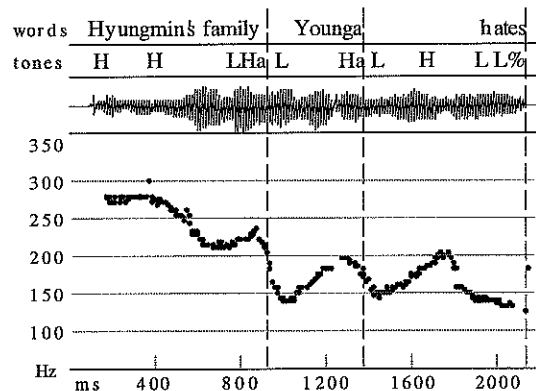
Figure 2. An example pitch track of an utterance consisting of three accen- tual phrases, (hjəŋmininenɨn 'Hyungmin's family') (jəŋalɨl 'Younga') (miwəhejo 'hates'), where each phrase includes one phonological word

Based on reading data, Kim et al. (1997), Korea Telecom (1996), Jun (2001) and Jun and Fougeron (2000) show that an APh generally contains two to four syllables; thus, an APh generally contains one phonological

word. We will call the pattern of producing each phonological word in a separate APh the "default" phrasing pattern. This seems to be the most common phrasing pattern for reading and spontaneous speech, particularly in wide-focus or "out of the blue" situations. We note, however, that further research is needed on the relative frequency of different phrasing patterns in Korean, particularly for spontaneous speech, and on the grammatical constraints that determine which prosodic structures are well-formed in various situations.

The default phrasing can be altered for adjacent words that are closely related to each other syntactically or semantically. In this case, these adjacent words often form a single APh (Jun 1993, 1998). In addition, the default phrasing pattern is often overridden when a word is contrastively focused. The focused word initiates a new APh and the following words are often dephrased, forming one large APh together with the focused word (Jun 1993; see Jun and Lee (1998) for discussion of inter-speaker variation in the realization of focused phrases).

Our experimental studies focused on these distinct accentual phrasing patterns—default phrasing, focus phrasing, and phrasings which indicate relationships among words. In the production study, we elicited these patterns from naïve speakers. In the comprehension study, we then tested whether these different patterns of accentual phrasing would have discriminable effects on the comprehension of an ambiguous structure.

3   Experimental Studies

Both our production experiment and our comprehension experiment employed an ambiguity of the sort shown in (2), in which a single adjective is followed by a complex noun phrase. The adjective in such a phrase can readily be interpreted as modifying either the entire complex NP or only the first noun. This ambiguity is not resolved by syntactic information, although it can be influenced by pragmatic information and prosodic information. (2) is given in Korean Hangul orthography, followed by a phonetic transcription, a word-by-word gloss, and the English translation. The diacritic '*' is used in transcriptions throughout this paper to indicate tense or fortis stops.

(2) 현명한   아기의   아빠
     hjənmjəŋhan   akiɰi   ap*a
     wise   baby-Gen   daddy
     'the [wise baby]'s daddy' *or*
     'the wise [baby's daddy]'

We expected that listeners who encountered constructions such as (2) would show an initial syntactic preference for the structure associated with N1 modification. This expectation is consistent with the classic 'Garden Path' depth-first model of sentence comprehension, in which a single structure is built as quickly as possible in all cases of structural ambiguity (e.g. Frazier 1987), with minimal revisions when necessary (Frazier 1990, Frazier and Clifton 1998). It also fits the predictions of Constraint-Based models (e.g. MacDonald, Pearlmutter, and Seidenberg 1994), under the assumption that N1 modification is more frequent in such constructions than N2 modification. We believe this is a reasonable assumption, given that speakers have another, unambiguous option for producing sentences with N2 modification: They can re-order the items as N1-Adj-N2. Frazier and Clifton (1996) have proposed that non-primary phrases such as our adjectives are associated less rapidly and less deterministically into the partial phrase structure, with influence from non-structural information. Under the assumption that there is a bias to associate a non-primary phrase which precedes the material it modifies with the first site encountered by the parser (cf. Frazier and Clifton 1996, Chapters 3 and 5), an initial preference for the N1-modification structure is also consistent with their proposal. Further, previous psycholinguistic work on Japanese has suggested an initial N1-modification preference for similar structures (Inoue and Fodor 1995, Kamide and Mitchell 1997).

We constructed two sets of materials, a Main set and a Control set, which were always compatible, initially, with this assumed syntactic preference for the N1-modification structure. These materials were employed in both the production study (which used complete sentences) and in the comprehension study (which used only the initial portion of each sentence). Because we know of no research on Korean that has tested the assumed N1 bias, the Control set was designed to test the strength of this potential syntactic bias in sentence comprehension (see Section 3.2). The differences between the Main and Control sets are not relevant for the central research questions in the production study.

Both the Main set and the Control set contained two lexically distinct versions for each item (when realized as a full sentence), an N1-bias version and an N2-bias version. In the Main set, modification of N2 by the adjective was implausible in the N1-bias version. In the N2-bias version, modification of N2 by the adjective was far more plausible than N1 modification. The adjective and N1 never varied across versions for the Main set; only N2 changed. A sample item is given in (3).

(3) Example of a Main Item
   a. ...hjənmjəŋhan akiɯ i   akki...   N1-bias
      ...wise   baby's   musical instrument...

   b. ...hjənmjəŋhan akiɯ i   ap*a...   N2-bias
      ...wise   baby's   daddy...

The two N2 words were matched for number of syllables, within each item, to avoid any effects of syllable count on the accentual phrasing pattern produced. Because these items would later be used in our comprehension study as fragments truncated between N1 and N2, the initial segments of the N2 pairs were also matched as closely as was practicable for manner and place of articulation, to minimize coarticulation differences between the two conditions. A full list of the experimental items used in the production and comprehension studies is given in the Appendix.

In the Control set, N2 modification was possible in the N1-bias version, although less likely than N1 modification. In the N2-bias version, modification of N2 by the adjective was far more plausible than N1 modification, as in the Main set. The Control items were created by varying N1 between versions while keeping the adjective and N2 constant. The number of syllables in N1 was matched, within items, for the two conditions. A sample item is given in (4).

(4) Example of a Control Item
   a. ...seljəntwen motelɯ i   titʃainə...   N1-bias
      ...stylish   model's   designer...

   b. ...seljəntwen kjohwaŋɯ i titʃainə...   N2-bias
      ...stylish   Pope's   designer...

These biases were tested with a written questionnaire study. Sixteen subjects, all native speakers of Korean from the UCLA community, participated in the experiment. Subjects read full sentences containing the Adj-N1-N2 strings, presented in standard Korean orthography. For each sentence, the subject rated both the plausibility of interpreting the adjective as modifying N1 and the plausibility of it modifying N2, on a scale which ranged from 1 (very unnatural) to 5 (very natural). Each subject rated both lexical versions of each item. Subjects rated 33 Main items and 17 Control items. From these, the 24 Main and 12 Control items that best fit the intended pragmatic biases were selected. The mean ratings for the selected items are given in (5).

(5) Mean ratings of the naturalness of the adjective modifying N1/N2

    Main Set: N1-Bias: N1: 4.27, N2: 1.73
                       N2-Bias: N1: 2.45, N2: 4.38

    Control Set: N1-Bias: N1: 3.58, N2: 3.42[2]
                      N2-Bias: N1: 2.03, N2: 4.44

Phrases like the ones in (3) and (4) can be grammatically produced with multiple prosodic patterns, as described in Section 2. We were particularly interested in the four patterns indicated in (6).[3] The first pattern, in (6a), is the default prosodic pattern. As noted above, this pattern appears to be quite frequent in Korean, particularly in wide focus ('out of the blue') situations. It commonly occurs with both the interpretation in which the adjective modifies only the first noun and the interpretation in which the adjective modifies the entire complex NP. Patterns (6b) and (6c) are used for purposeful disambiguations toward N1 modification and complex-NP (or N2) modification, respectively; they reflect the 'semantic closeness' factor described in Section 2. Pattern (6d) occurs when contrastive focus is placed on the adjective, for either interpretation, following Korean's general pattern of dephrasing after a focused constituent that was described above. Henceforth, we will refer to the pattern in (6a) as the default prosody, to the patterns in (6b) and (6c) as N1-modification prosody and N2-modification prosody, respectively, and to the pattern in (6d) as Adj-focus prosody.

(6) a. (hjənmjəŋhan)$_{APh}$ (akiɯi)$_{APh}$ (ap*a)$_{APh}$ **Default Prosody**
          (wise)$_{APh}$ (baby's)$_{APh}$(daddy)$_{APh}$ (Adj)$_{Aph}$ (N1)$_{APh}$ (N2)$_{APh}$

     b. (hjənmjəŋhan akiɯi)$_{APh}$ (ap*a)$_{APh}$ **N1-mod. Prosody**
          (wise baby's)$_{APh}$ (daddy)$_{APh}$ (Adj N1)$_{APh}$ (N2)$_{APh}$

     c. (hjənmjəŋhan)$_{APh}$ (akiɯi ap*a)$_{APh}$ **N2-mod. Prosody**
          (wise)$_{APh}$ (baby's daddy)$_{APh}$ (Adj)$_{APh}$ (N1 N2)$_{APh}$

     d. (hjənmjəŋhan akiɯi ap*a)$_{APh}$ **Adj-focus Prosody**
          (wise baby's daddy)$_{APh}$ (Adj N1 N2)$_{APh}$

---

[2] The N1-Bias condition shows a weaker lexical bias than the N2-Bias condition. As discussed below, this allows a stronger test of whether there is an initial bias for the N1-modification structure.

[3] Other prosodic patterns which are possible for this string include productions with an intonation phrase boundary at one or more of the accentual phrase boundary positions and productions in which the phonetic indications for a prosodic boundary are ambiguous.

3.1 Production Study

3.1.1 Introduction

The production experiment was designed to confirm that native speakers of Korean would reliably produce the four prosodic structures of interest (see (6) above) under the expected conditions. The production study also allowed us to collect a set of utterances produced by naïve speakers for use in the comprehension study. The differences between Main and Control items will not be relevant for the brief discussion of the production study presented here, so the distinction will not be noted below.[4]

3.1.2 Methods

The experimental items were produced under three sets of instructions, which were intended to elicit productions appropriate for three different discourse situations. Four native speakers of Seoul Korean first produced the sentences in Set 1, followed in order by Sets 2 and 3.

Set 1 was designed to elicit the default prosody. For this set, subjects were simply instructed to read a list of printed sentences out loud in a natural manner. To discourage them from inserting intonation phrase boundaries into the sentences, they were told to utter each sentence in one breath group, without pausing between words. With Set 2, subjects were instructed to read the sentences with contrastive focus on the adjective. The adjective was underlined and in boldface, and the subject was instructed to imagine that it contrasted with another adjective. With Set 3, subjects were informed of the ambiguity and instructed to prosodically disambiguate the sentences. As with Set 1, they were told to produce each sentence in one breath group, without pausing between words, to discourage them from inserting intonation phrase boundaries into the sentences.

Utterances were digitized at 16 kHz and $F_\emptyset$ tracks of each utterance were created using Entropic's xwaves (v. 5.3). The phrasing of each utterance was determined on the basis of the pitch contour, amplitude, and segment realizations in critical regions and the perception of one of the authors (Jun). For example, the existence of an APh boundary was confirmed by high $F_\emptyset$ at the end of a phonological word followed by low $F_\emptyset$ when the initial segment of the next word was not aspirated nor tensed.

---

[4] The Main and Control sets have the same syntactic structure, and so were expected to elicit the same range of prosodic structures in the production study. In the comprehension study, the Control items will be used to test the syntactic bias of the ambiguous structure, and the Main items will be used to test for effects of prosodic structure.

3.1.3 Results

The results largely confirmed our expectations. For the sentences in Set 1, over 90% of the target noun phrases were produced with the default prosody, for both N1- and N2-bias sentences. For Sets 2 and 3, the expected phrasing pattern was always the most frequent pattern, although other patterns, particularly the default phrasing pattern, were also common. The distribution of phrasing patterns across the three sets can be seen in Figures 3 through 6. In Figures 5 and 6, "Other" phrasing patterns include productions with intonation phrase boundaries and productions with prosodic boundaries that were ambiguous between levels of phrasing.
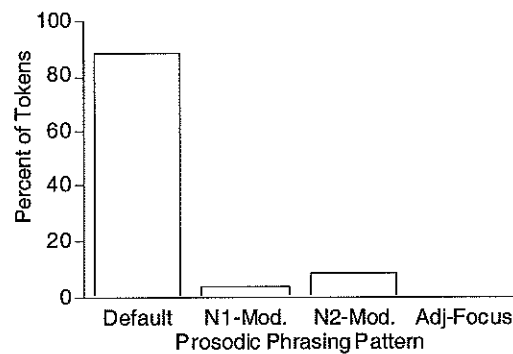

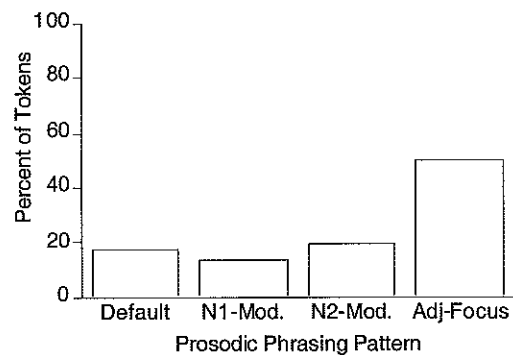Figure 3. Percentage of each phrasing pattern for Set 1: Default reading style

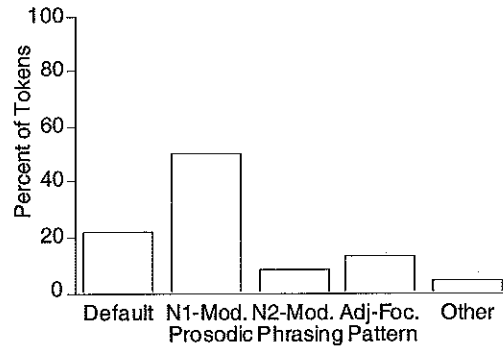Figure 4. Percentage of each phrasing pattern for Set 2: Adjective focus

Figure 5. Percentage of each phrasing pattern for Set 3: Intentional disambiguation, N1-modification bias sentences
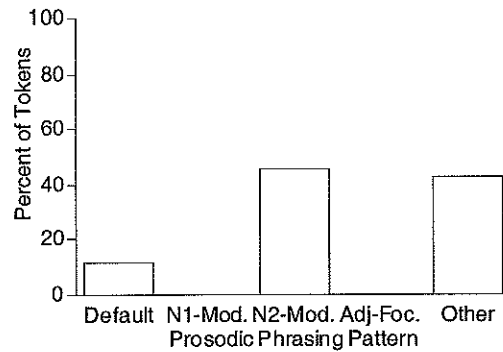
Figure 6. Percentage of each phrasing pattern for Set 3: Intentional disambiguation, N2-modification bias sentences[5]

Thus, when speakers read the sentences without being told to disambiguate or use a particular focal structure, they generally uttered each

---

[5] A substantial majority of the "Other" phrasing patterns for these items employed a prosodic structure that somehow indicated a stronger prosodic boundary between the adjective and N1 than between N1 and N2. However, because these did not follow the specific pattern of accentual phrasing that we were interested in, we have coded them separately.

phonological word in a separate accentual phrase, using the default pattern.[6] When speakers were told to contrastively focus the adjective, they tended to produce the adjective, N1, and N2 together in a single prosodic phrase, following the Adj-focus pattern. When speakers were instructed to prosodically disambiguate the sentences, they tended to combine the adjective and N1 into a single accentual phrase for items pragmatically biased toward N1 modification, and tended to combine N1 and N2 into a single accentual phrase for items pragmatically biased toward N2 modification.

The production study succeeded in eliciting the four prosodic patterns that we planned to test in the comprehension study. It also supported our assumption that the default prosody and the Adj-focus prosody are both ambiguous, and that the other two prosodic patterns are disambiguating. As expected, we found that the default prosody and the Adj-focus prosody were produced for both interpretations of the Adj-N1-N2 string, and that each disambiguating prosody was produced most frequently with sentences in which the pragmatic bias matched the assumed prosodic bias. We now turn to discussion of the effects of these four prosodic structures on comprehension.

3.2 Comprehension Study

3.2.1 Introduction

The comprehension study tested a subset of the materials collected in the production study in a cross-modal naming task. This task was designed to test whether accentual phrasing could have early effects on the interpretation of the ambiguous phrase. Subjects heard auditory fragments that consisted of the beginning of the sentence through N1, and then named N2, as indicated in (7) and (8). It is at N2 that the phrase becomes pragmatically disambiguated. Thus, collecting naming times for N2 allowed us to evaluate whether accentual phrasing information which preceded the point of prag-

---

[6] The low percentages of N1-modification and N2-modification prosodies for Set 1 could be taken to suggest that prosodic disambiguation of syntax is somewhat uncommon in Korean. However, we believe that such a conclusion is premature. Studies of English have found differences in prosodic phrasing between spontaneous and read speech (Lehiste 1975, Brown, Currie, and Kenworthy 1980, French and Local 1986, Ayers 1994), so the frequency of the default pattern with sentences read aloud in the laboratory may not generalize well to spontaneous speech styles. In addition, studies of prosodic disambiguation of syntax have found higher percentages of disambiguation in quasi-spontaneous speech than in speech produced through oral reading tasks (Speer, Warren, Schafer, White, and Kneale 1999, Schafer, Speer, Warren, and White 2000). Thus, while we believe that it is safe to conclude that the default pattern is very common in Korean, we cannot predict on the basis of these results whether ambiguous prosodies are more common in Korean than disambiguating ones.

matic disambiguation could influence initial processing decisions for the ambiguous string. A finding that accentual phrasing affects cross-modal naming times for such structures would suggest that the processor makes use of accentual phrasing information incrementally, and early in the course of processing, as it is first building the appropriate syntactic and semantic structures.[7]

We tested both Main and Control items. The Control items provided an explicit test of the syntactic bias for N1-modification structures that we have assumed for these sentences. Two lexically distinct conditions were tested, as shown in (7). In the N1-bias condition, N1 modification was pragmatically supported; in the N2-bias condition, N2 modification was supported. All Control items were presented with default prosody; the prosody does not differ across conditions. We predicted that an N1-modification structure would be constructed initially for both versions, but that reanalysis would often occur for the condition pragmatically biased toward N2 modification. Naming times were therefore predicted to be shorter in the N1-biased condition than in the N2-biased condition. Note, however, that both conditions are ambiguous: N2-modification is possible, although unlikely, in the N1-bias condition, and N1-modification is possible, but again unlikely, in the N2-modification condition.

(7) Example of Control item, Comprehension Experiment

Auditory Fragment:		Visual Target:	Condition:
a. (seljəntwen)$_{APh}$ (moteluɟi)$_{APh}$		디자이너도	N1-bias
...(stylish)$_{APh}$	(model's)$_{APh}$	DESIGNER-ALSO	
b. (seljəntwen)$_{APh}$ (kjohwaŋuɟi)$_{APh}$		디자이너도	N2-bias
(stylish)$_{APh}$	(Pope's)$_{APh}$	DESIGNER-ALSO	

For the Main items, we tested only the lexical version of each item that was pragmatically resolved toward N2 modification. These 24 sentences were tested under four prosodic conditions, using the four accentual phrasing patterns described above and repeated in (8). Recall that patterns (8b) and (8c) are disambiguating prosodies, but that patterns (8a) and (8d) are ambiguous. Note that the lexical content of the auditory fragment and the visual target never varies across conditions for Main items. Only the prosody differs across conditions.

---

[7] Note that alternative tasks such as paraphrase selection require that all of the complex NP be presented, and thus are less useful in assessing whether there are early and incremental effects of prosody on parsing.

(8) Example of Main item, Comprehension Experiment

Auditory Fragment:		Visual Target:	Condition:
a. ...(hjənmjəŋhan) $_{APh}$ (akiɯɟi) $_{APh}$		아빠	Default Prosody
...(wise) $_{APh}$	(baby's) $_{APh}$	DADDY	
b. ...(hjənmjəŋhan akiɯɟi) $_{APh}$		아빠	N1-mod. Pros.
...(wise baby's) $_{APh}$		DADDY	
c. ...(hjənmjəŋhan) $_{APh}$ (akiɯɟi		아빠	N2-mod. Pros.
...(wise) $_{APh}$	(baby's	DADDY	
d. ...(hjənmjəŋhan akiɯɟi		아빠	Adj-focus Pros.
...(wise baby's		DADDY	

We predicted that, first, accentual phrasing would be salient enough to listeners to affect the processing of the ambiguous structure. Assuming that it would be, there are several tenable hypotheses about how prosodic phrasing might affect processing decisions, and thus how these four phrasing patterns should affect interpretation. We briefly describe three possibilities. In all cases, we assume that there is the initial syntactic preference for N1 modification discussed above, possibly modulated by the accentual phrasing, and reanalysis (if necessary) at the point that the disambiguating pragmatic information in N2 is interpreted.

One reasonable hypothesis is that disambiguating prosody should strongly support the relevant interpretation, but ambiguous prosody should have little effect on the parsing process (Warren, Grabe, and Nolan 1995, Kjelgaard and Speer 1999). This hypothesis can be viewed as predicting a relationship between the whole contour (for the critical region) and the syntactic and semantic structures that are built. For our materials, this would predict that the syntactic N1 bias would be followed initially for the default prosody, Adj-focus prosody, and N1-modification prosody, but the N2-modification prosody would block the otherwise preferred N1-modification structure. Thus, no reanalysis would be required for the N2-modification prosody, and naming times for it should be quite short. Reanalysis would be required in the remaining conditions, and would presumably be harder for the N1-modification prosody, in which the prosodic information conflicts with the pragmatic information. Naming times for the two ambiguous prosody conditions would thus be similar to each other, but longer than for the N2-modification prosody and shorter than for the N1-modification prosody. These predictions are summarized in (10), along with the predictions of the two other hypotheses we consider.

A second possibility is that only the "local" prosodic boundary matters: Processing is influenced only by prosodic information that occurs at the point where the parser must choose between attachment sites (for further discussion of this idea, and a review of its occurrence in the psycholinguistic literature, see Schafer (1997)). For our study, the critical processing point is when the parser encounters N2. Thus, the presence of an accentual phrase boundary between N1 and N2 would be predicted to support N1 modification, and the absence of an accentual phrase boundary in that position would support N2 modification, but no prosodic information that occurs earlier in the sentence would be relevant to the ambiguity resolution. Naming times would therefore be predicted to be similar for the two prosodies which contain an APh boundary between N1 and N2 and similar for the two prosodies which lack that boundary. They would also be expected to be longer in the former two prosodies, in which the prosody conflicts with the pragmatic information, than in the latter two prosodies, in which the prosodic and pragmatic information both support the same interpretation.

We predicted a third possibility: Prosodic information would have an incremental effect on interpretation. Specifically, we predicted that Korean accentual phrases would cause the effects proposed by Schafer (1997) for English intermediate phrases, since the two kinds of phrases are found at the same level of the prosodic hierarchy (i.e. above the phonological word but below the intonation phrase level). Schafer's hypothesis, adapted for Korean accentual phrases, is given in (9).[8]

(9) Prosodic Visibility (adapted from Schafer (1997))
    a. The accentual phrasing of an utterance determines the *visibility* of syntactic nodes.

    b. Nodes projected by material within the accentual phrase currently being processed are more visible than nodes associated with material outside of that accentual phrase; visibility is gradient across multiple accentual phrases.

    c. In first analysis and reanalysis, attachment to a node with high visibility is less costly in terms of processing/attentional resources than attachment to a node with lower visibility.

---

[8] Prosodic Visibility is closely related to Frazier and Clifton's more general Visibility Hypothesis (Frazier and Clifton, 1998). However, because Prosodic Visibility claims that visibility is graded across prosodic phrases, it makes slightly different predictions from their proposal.

According to the Prosodic Visibility hypothesis, the presence of an accentual phrase boundary between the adjective and N1 should impede construction of the initially preferred N1-modification structure, since the adjective and all nodes it has projected would be less visible to the parser at the point that it is processing N1. Assuming a depth-first processor, a structure which supports N1 modification would nevertheless be constructed at N1 for all four prosodies, but this syntactic structure should be built more quickly, and thus undergo further interpretive processing, when no APh boundary intervenes between the adjective and N1 than when one is present. Similarly, the presence of an APh boundary between N1 and N2 should impede construction of the N2-modification structure (or reanalysis to this structure), since N1 and all nodes it has projected would be less visible at the point that N2 is being processed when that boundary is present than when it is not.

The N1-modification prosody and the Adj-focus prosody both lack an APh boundary between the adjective and N1. Therefore, both of them should support at least partial semantic interpretation with N1 modification before the pragmatic information in N2 is interpreted. Following the Minimal Revisions principle (Frazier 1990, Frazier and Clifton 1998), when N2 is first encountered and identified as a noun, it should initially be integrated into the N1-modification structure. Reanalysis should be initiated for both prosodies when N2 is interpreted. This reanalysis should be easier with Adj-focus prosody than with N1-modification prosody, because the former has no APh boundary between N1 and N2 while the latter contains one. Naming times for N2 should thus be longer for the N1-modification prosody than for the Adj-focus prosody.

For the remaining two contours, the processor should be less strongly committed to N1 modification at the point it encounters N2, because the presence of the early APh boundary has decreased the likelihood of semantic interpretation of the initial N1-modification structure. When N2 is received in the N2-modification prosody condition, the absence of an APh boundary between N1 and N2 should allow relatively easy reanalysis, because of the high visibility of N1. The N2-modification condition should thus show the shortest naming times. Reanalysis should be harder with default prosody than with N2-modification prosody, because of the additional APh boundary in the default contour between N1 and N2. However, reanalysis should be easier with the default prosody than with the Adj-focus prosody, because the presence of the early APh boundary in the default conditions should mean that less interpretive processing of the ultimately incorrect structure will have taken place with the default prosody than with the Adj-focus prosody. To summarize, the N2-modification prosody should show the

shortest naming times, followed in order by the default prosody, the Adj-focus prosody, and the N1-modification prosody.

(10) Summary of Predictions

Hypothesis:	Pattern of Naming Times:
Hyp 1: Whole contour effects	N2-mod < Def, Adj-foc < N1-mod
Hyp 2: Local boundary effects	N2-mod, Adj-foc < Def, N1-mod
Hyp 3: Prosodic Visibility	N2-mod < Def < Adj-foc < N1-mod

As can be seen in the summary in (10), all three hypotheses predict a difference in naming times for the two disambiguating prosodies. The hypotheses differ in their predictions for the ambiguous prosodies.

3.2.2 Methods

Productions from one of the four speakers who participated in the production experiment were selected for use in the comprehension experiment, and the phrasing of each token was confirmed to match the planned prosodic condition.[9] The 24 Main items and 12 Control items were mixed with an additional 24 filler sentences. Half of the fillers contained a prenominal adjective followed by a simplex NP; half contained an adjective followed by a complex NP. In all cases, the materials were pragmatically biased toward N1 modification (if a choice existed). Thus, the material set as a whole contained equal numbers of items pragmatically biased for N1 modification and items pragmatically biased for N2 modification. Each experimental sentence was truncated with a digital waveform editor just before the second noun in the ambiguous string. The truncation point in the filler sentences varied across a range of structural points, and included points that were early, medial, and late in the original sentence.

The four prosodic conditions for each Main item and the two lexical conditions for each Control item were distributed across four experimental lists, following a Latin-square design. These lists were then presented to thirty-six native speakers of Seoul Korean from the UCLA community. None of the subjects had previously participated in the production experiment or the pretest of the materials. All could comprehend, speak, and read Korean fluently, and all had lived in the U.S. for at most 10 years.

Subjects were tested individually in a sound-attenuated booth equipped with a computer monitor, headphones, a hand-held microphone, and a

---

[9] A small number of the items produced by this speaker in the production study failed to meet our segmental and prosodic criteria. These items were re-recorded by the speaker for the comprehension experiment, following a similar procedure to the one used in the production experiment.

CMU button box with a voice-operated relay for millisecond timing. Subjects were seated next to an experimenter and in front of the computer monitor. On each trial, there was a visual prompt, and then subjects heard a sentence fragment over the headphones. Immediately following the offset of the auditory stimulus, a word appeared on the monitor in standard Korean orthography. Subjects named the visual target out loud as quickly as possible and then completed the sentence, using the visual target as the first word in the completion. For the Main and Control set items, the visual target was N2. For the filler items, the visual target was whatever word had originally occurred next in the full sentence; a range of syntactic categories were instantiated in these targets. Naming times appeared on the monitor after each response. If a subject did not name the visual target within 2000 ms, a reminder to respond quickly appeared instead of the response time.

The accuracy of the naming response was noted by the experimenter. Trials in which the subject failed to name the correct word, mispronounced the word, or failed to set off the voice relay at the beginning of the word were noted and subsequently excluded from analysis. The fragment completions were recorded in writing by the experimenter and the entire session was recorded onto audiotape. Completions which indicated that the subject had not understood the sentence fragment were noted and excluded from analysis.

Following the complete set of experimental naming trials, subjects completed a second block of control naming trials. These trials consisted of a neutral carrier phrase followed by a visual target. Each visual target from the experimental set (for both Main and Control items) was presented three times in a pseudorandomized order. These trials served to measure lexical effects on naming times, such as effects of word frequency, orthography, or the initial phonetic segment. Individual reaction times for the experimental items were corrected for lexical variability by subtracting the difference between the mean of the three neutral context tokens for each item and the grand mean of the neutral-context trials from each item for each subject.

3.2.3 Results

The results are shown in Figures 7 and 8. As predicted, the Control items exhibited shorter naming times in the N1-bias condition than the N2-bias condition. This result was significant by subjects ($F1(1,35) = 4.2$, $p < .05$), although not by items ($F2(1,10) = 2.4$, $p = .15$).[10] The pattern of naming times supports the prediction that there was an initial syntactic preference for the N1 modification structure. Presumably, this preference could be maintained for the N1-bias condition, but could not always be maintained

---

[10] One item was eliminated from the analysis because of experimenter error in truncating the stimuli.

for the N2-bias condition, resulting in reanalysis and longer naming times.[11]
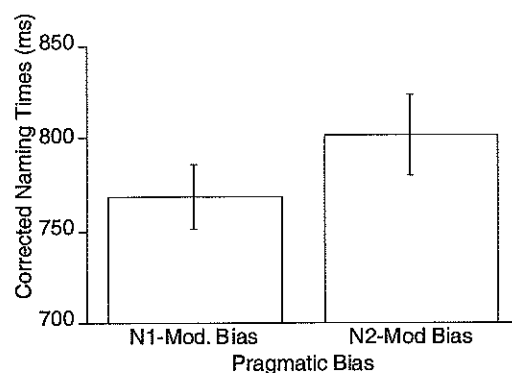
Figure 7. Corrected naming times for Control items
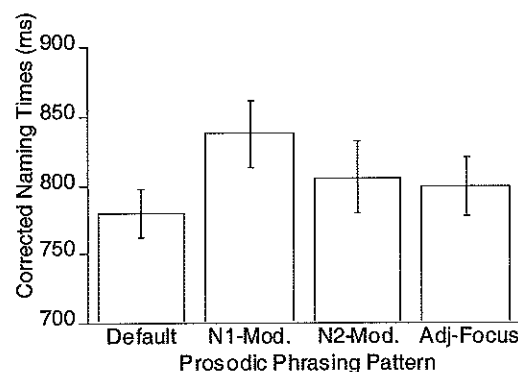
Figure 8: Corrected naming times for Main items

---

[11] Note that the pattern of results does not follow from an assumption that naming times would be longer for the condition in which the two interpretations were more equally balanced in their pragmatic bias. According to the results of the written questionnaire, the difference in bias for the Control items between the two interpretations was actually stronger in the N2-bias condition (2.03 vs. 4.44) than in the N1-bias condition (3.58 vs. 3.42).

For the Main items, as predicted by two of the three prosodic hypotheses, naming times were significantly longer for the N1-modification prosody, which conflicted with the ultimate interpretation of the ambiguous phrase, than for the default prosody ($F1(1,35) = 7.9$, $p < .01$; $F2(1,23) = 4.2$, $p < .05$). This is consistent with the first hypothesis, which posits differences between ambiguous and disambiguating contours. It is also consistent with the Prosodic Visibility hypothesis, which posits an incremental effect from each prosodic boundary in the string. However, the difference between the default and N1-modification conditions disconfirms the second hypothesis, which predicted that processing would be affected only by a prosodic cue which occurred at the point of a clear syntactic attachment ambiguity. Thus, these data support the claim of Schafer (1997) that a complete prosodic representation is constructed during the early stages of sentence comprehension, and that all information encoded in this structure is available to influence subsequent processing decisions.

Contrary to the predictions of all three hypotheses, naming times for the remaining two conditions were intermediate between the times for the N1-modification and default prosodies, and not significantly different from either of them. Most strikingly, naming times were not significantly different for the two disambiguating conditions, although they did show a trend in the predicted direction. In addition, the disambiguating N2-modification prosody condition did not show significantly shorter naming times than the ambiguous default and Adj-focus prosody conditions, and the default condition was numerically shorter than the N2-modification condition. This suggests that processing was just as easy with ambiguous prosody as with disambiguating prosody.

The pattern of relatively short naming times for the default prosody condition cannot be attributed to an effect of additional processing time due to its additional APh boundaries. The duration of the adjective was not significantly different across prosodic conditions. The duration of N1 was significantly longer in the N2-modification condition than in the other three conditions, which did not differ significantly from each other. Thus, the duration of the Adj-N1 region was not longer in the default condition than in other conditions, nor was the region shorter in the N2-modification condition than in the other conditions. Therefore, the unexpectedly long naming times for the N2-modification condition relative to the times for the default and Adj-focus conditions cannot be explained by a lack of sufficient processing time in the critical region. However, it is conceivable that the longer duration N1 for the N2-modification condition allowed further time for interpretation of the ultimately incorrect N1-modification structure. If so, this could lead to longer reanalysis times than expected for this condition.

3.2.4 Discussion

The results confirm that the subtle acoustic information which demarcates accentual phrase boundaries in Korean was salient enough to be exploited by listeners during sentence comprehension. In this respect the Korean results are similar to results for English that show effects of acoustically subtle intermediate phrase boundaries on comprehension. The Korean results are also similar to English results in showing that the processor is sensitive not just to prosodic information that occurs at a syntactic choice point, but to the larger contour. The one significant difference that emerged in the Main items was between conditions that were identical at the point that a choice had to be made between attachment sites: Both the default condition and the N1-modification condition contain an APh boundary between N1 and N2. However, the overall pattern of naming times failed to show contrasts predicted by each of the hypotheses we considered, and was very different from what might be expected on the basis of English results.

Prosodic experiments on English have shown that a sentence with an ambiguous prosodic structure can be processed as easily as a sentence with a disambiguating prosodic structure when an ambiguous phrase is resolved to what is arguably the preferred syntactic structure (Slowiaczek 1981, Speer, Kjelgaard, and Dobroth 1996, Kjelgaard and Speer 1999). However, these studies have found that when an ambiguity is resolved toward an initially dispreferred syntactic structure, as in our Main items, a prosodic contour that is associated with the ultimately correct syntactic structure results in significantly faster processing than an ambiguous contour. In other words, a 'cooperating' prosody might not facilitate processing relative to an ambiguous prosody for the preferred syntactic structure, but it will facilitate the processing of a dispreferred syntactic structure. We believe several factors may account for why our N2-modification prosody did not appear to facilitate processing of the syntactically dispreferred N2-modification structure.

First, the nature of the default prosody in Korean may have significantly facilitated processing in the default prosody condition at the lexical level. Recall that the default prosody places each phonological word into a separate accentual phrase. This may have made the identification of phonological word boundaries, and thus lexical access, significantly easier in the default condition than in the other three conditions. We hope to explore this possibility further in future research.

Second, the Korean structure we tested differs from the English cases that have been studied in the relative timing of key syntactic and prosodic information. In studies of English, the crucial disambiguating prosodic information has been the presence of a prosodic boundary preceding an ambiguously attached phrase, such as an NP that could be the direct object of a

subordinate clause or the subject of a matrix clause. Arguably, the presence of the prosodic boundary could prevent or delay the parser from building the otherwise preferred attachment during the first stage of syntactic analysis and, crucially, no structural revisions were required for material which preceded the disambiguating boundary.

In the Korean case, it is the absence of an APh boundary between N1 and N2 which distinguishes the N2-modification contour from the default contour. However, by the time the parser reaches this point, it has presumably already attached N1 to the partial phrase structure.[12] Unlike the cases tested in English, where no other attachments must be modified to incorporate the material which follows the disambiguating prosodic break, the Korean case requires some revision of the previously built structure to support the N2-modification interpretation. N1 must be lowered, so a new node can be inserted to attach N1 and N2, and any semantic interpretation of the adjective-N1 relation must be undone. Thus, in Korean, the most critical prosodic information in the N2-modification contour arguably arrives too late to influence all of the initial attachment decisions, and is limited to having effects on semantic interpretation and reanalysis. It is therefore not surprising that the disambiguating contour might show relatively weak effects in Korean.[13]

Finally, although what we have been calling the N2-modification prosody is indeed the prosodic structure that speakers used to indicate N2-modification in our production study, it is possible that this is not the parser's preferred interpretation of this prosodic structure. Recall from Section 2 that Korean marks focus by grouping the words which follow a contrastively focused word into an accentual phrase that begins with the focused word. Thus, the N2-modification prosody may have occasionally been interpreted as indicating contrastive focus on N1 instead of the N2-modification structure. This strikes us as a somewhat unlikely interpretation given that there were no other indications of focus on N1, such as an expanded pitch range or greater amplitude (Jun and Oh 1996, Jun and Lee 1998), but it is not one that we can currently rule out.

---

[12] Note that Prosodic Visibility predicts that this attachment is delayed for the default prosody and N2-modification prosody relative to contours without a boundary between the adjective and N1, but the attachment has not been completely prevented.

[13] We assume that it is easy for the processor to recover from the short-duration misanalysis that we are postulating for this prosodic-syntactic structure. We also believe that this structure may have a relatively low frequency in Korean, either because speakers tend to use a stronger prosodic boundary between the adjective and the complex NP (see Figure 6 above) or because they tend to adopt an N1-Adj-N2 word order for N2 modification.

More generally, we cannot say with certainty which interpretation of the ambiguous structure was ultimately chosen for any item or condition. Although the cross-modal naming task we employed was useful in indicating early effects of accentual phrasing, it has limitations: It does not directly show whether the adjective was taken to modify N1 or N2. Thus, it is possible that the percentage of items that were reanalyzed varied across conditions. For example, the presence of focus on the adjective may have licensed the less plausible N1-modification interpretation in the Adj-focus condition, and an interpretation of the N2-modification prosody as an indication of focus on N1 could conceivably have led to more interpretations of the adjective modifying N1 (cf. Schafer, Carter, Clifton, & Frazier, 1996). We are presently conducting further research on these structures to address this issue.

Each of these possible explanations for why the N2-modification prosody did not appear to facilitate processing rests on differences in the linguistic structures of Korean and English. We thus conclude that prosodic phrasing likely has, at an abstract level, very similar effects on sentence comprehension across languages, but that the specific effects of prosody on the interpretation of particular structures must be interpreted with respect to the grammatical patterns of the language. Such a conclusion challenges psycholinguistic models of prosody which have effectively treated prosodic boundaries as cues from outside of the grammatical system (e.g. Marcus & Hindle, 1990). It is unsurprising, though, from a linguistic perspective that predicts that the processor is sensitive to all grammatical structure, including phonetic and phonological structure, and to the relationships between phonological structure and other levels of linguistic structure.

4 Conclusion

We have presented findings on how accentual phrasing is used during sentence production and comprehension in Korean. Our production study showed that Korean speakers use distinct patterns of accentual phrasing in a systematic fashion, at least for sentences read aloud in a laboratory setting. We found that in wide focus, "out of the blue" situations, speakers show a very strong tendency to produce each phonological word in a separate accentual phrase, while in contrastive focus situations speakers tend to produce multiple phonological words in a single accentual phrase. In addition, speakers can disambiguate syntactically or semantically ambiguous structures by grouping related phrases into a single accentual phrase. These findings are consistent with previous reports of the Korean prosodic structures produced in reading tasks. Further work remains, though, to determine

whether the patterns found in reading tasks generalize well to spontaneous speech.

We also found that differences in the accentual phrasing pattern of a sentence affect listener's comprehension of the sentence. This result provides further evidence that subtle phonetic differences can ultimately influence higher-level linguistic processing. Intriguingly, we discovered that, at least at a superficial level, the pattern of prosodic effects on sentence comprehension differs for Korean and English. Nevertheless, we believe these differences stem from grammatical contrasts between the two languages, and not from highly variable use of prosodic information by the processing system across languages.

The experiments presented here are in keeping with an ever-increasing set of studies which demonstrate prosodic influences on sentence comprehension. Yet they also highlight how little we currently know about how prosody's effects should be modeled. Most of the experimental results in the literature are consistent with multiple hypotheses of how the processor treats prosodic information. In addition, the grammatical constraints on prosody, and particularly those governing the relationships between prosodic structure and syntactic, semantic, and discourse structure, are far from being fully understood. It is our hope that continued cross-linguistic psycholinguistic research on prosody will be particularly helpful in specifying more precisely how and when the processor makes use of critical prosodic, syntactic, and semantic information. We also hope that continued work on the connections between production patterns and comprehension patterns will help illuminate such matters as how default contours or frequent contours might have significant effects on comprehension even when the contours do not disambiguate syntactic or semantic structures.

References

Ayers, G. 1994. Discourse Functions of Pitch Range in Spontaneous and Read Speech. *Ohio State University Working Papers in Linguistics* 44, 1-49.

Beckman, M. 1995. On Blending and the Mora: Comments on Kubozono. *Papers in Laboratory Phonology* IV, eds. B. Connell & A. Arvaniti, 157-167. Cambridge: Cambridge University Press..

Beckman, M. & J. Pierrehumbert. 1986. Intonational Structure in Japanese and English. *Phonology Yearbook* 3, 255-309.

Brown, G., K.L. Currie, & J. Kenworthy. 1980. *Questions of Intonation*. London: Croom Helm.

Cho, T. & P. Keating. 1999. Articulatory and Acoustic Studies of Domain-initial Strengthening in Korean. To appear in *Journal of Phonetics*.

Frazier, L. 1987. Sentence Processing: A Tutorial Review. *Attention and Performance*, ed. M. Coltheart, 559-586. Hillsdale, NJ: Lawrence Erlbaum.

Frazier, L. 1990. Identifying Structure under X0. *Yearbook of Morphology* 3, eds. A. Jongman & A. Lahiri, 87-109.

Frazier, L. & C. Clifton. 1996. *Construal*. Cambridge, MA: MIT Press.

Frazier, L. & C. Clifton. 1998. Sentence Reanalysis, and Visibility. *Reanalysis in Sentence Processing*, eds. J.D. Fodor & F. Ferreir, 143-176. Dordrecht: Kluwer.

French, P. & J. Local. 1986. Prosodic Features and the Management of Interruptions. *Intonation in Discourse*, ed. C. Johns-Lewis, 157-180. San Diego, CA: College-Hill Press.

Halle, M. & K. Stevens. 1971. A Note on Laryngeal Features. *MIT Quarterly Progress Report* 101, 198-212.

Inoue, A. & J.D. Fodor. 1995. Information-paced Parsing of Japanese. *Japanese Sentence Processing*, eds. R. Mazuka & N. Nagai, 9-64. Hillsdale, NJ: Lawrence Erlbaum.

Jun, S.-A. 1993. The Phonetics and Phonology of Korean Prosody. Doctoral dissertation, The Ohio State University.

Jun, S.-A. 1994. The Domain of Laryngeal Feature Lenition Effects in Chonnam Korean. *OSU Working Papers in Linguistics* 43, 15-29. Department of Linguistics, The Ohio State University.

Jun, S.-A. 1995. Asymmetrical Prosodic Effects on the Laryngeal Gesture in Korea. *Papers in Laboratory Phonology* IV, eds. B. Connell and A. Arvaniti, 235-253. Cambridge: Cambridge University Press.

Jun, S.-A. 1996. Influence of Microprosody on Macroprosody: A Case of Phrase Initial Strengthening. *UCLA Working Papers in Phonetics* 92, 97-116.

Jun, S.-A. 1998. The Accentual Phrase in the Korean Prosodic Hierarchy. *Phonology* 15, 189-226.

Jun, S.-A. 1999. Prosodic Typology. To appear in *Prosodic Models and Transcription: Toward Prosodic Typology*, ed. S.-A. Jun. Oxford: Oxford University Press.

Jun, S.-A. 2000. K-ToBI (Korean ToBI) Labelling Conventions, Version 3. *The Korean Journal of Speech Sciences* 7:143-169.

Jun, S.-A. & C. Fougeron. 2000. A Phonological Model of French Intonation. *Intonation: Analysis, Modelling and Technology*, ed. A. Botinis, 209-242. Dordrecht: Kluwer.

Jun, S.-A. & H.J. Lee. 1998. Phonetic and Phonological Markers of Contrastive Focus in Korean. *Proceedings of the 5th International Conference on Spoken Language Processing*, 1295-1298. Sydney, Australia, November 30 - December 4 1998.

Jun, S.-A. & M. Oh. 1996. A Prosodic Analysis of Three Types of Wh-phrases in Korean. *Language & Speech* 39:37-61.

Kamide, Y. & D.C. Mitchell. 1997. Relative Clause Attachment: Nondeterminism in Japanese Parsing. *Journal of Psycholinguistic Research* 26:247-254.

Keating, P., T. Cho, C. Fougeron, & C.-S. Hsu. 1999. Domain-initial Articulatory Strengthening in Four Languages. To appear in *Laboratory Phonology* VI. Cambridge: Cambridge University Press.

Kjelgaard, M.M. 1995. *The Role of Prosodic Structure in the Resolution of Phrase-Level and Lexical Syntactic Ambiguity*. Doctoral dissertation, Northeastern University.

Kjelgaard, M.M. & S.R. Speer. 1999. Prosodic Facilitation and Interference in the Resolution of Temporary Syntactic Closure Ambiguity. *Journal of Memory & Language* 40:153-194.

Kim, J.-J., S.-H. Lee, H.-J. Ko, Y.-J. Lee, S.-H. Kim, & J.-C. Lee. 1997. An Analysis of Some Prosodic Aspects of Korean Utterances Using K-ToBI Labeling System. *Proceedings of the International Conference on Speech Processing*. Seoul.

Korea Telecom Research & Development Group Report. 1996. *A Study of Korean Prosody and Discourse for the Development of Speech Synthesis/Recognition System in Korean*.

Ladd, D.R. 1996. *Intonational Phonology*. Cambridge: Cambridge University Press.

Lehiste, I. 1975. The Phonetic Structure of Paragraphs. *Structure and Process in Speech Perception*, eds. A. Cohen & S. G. Nooteboom, 195-203. Springer-Verlag.

MacDonald, M.C., N.J. Pearlmutter, & M.S. Seidenberg. 1994. The Lexical Nature of Syntactic Ambiguity Resolution. *Psychological Review* 101:676-703.

Marcus, M. & D. Hindle. 1990. Description Theory and Intonation Boundaries. *Cognitive Models of Speech Processing: Computational and Psycholinguistic Perspectives*, ed. G. Altmann, 483-531. Cambridge, MA: MIT Press.

Pierrehumbert, J. 1980. The Phonetics and Phonology of English Intonation. Doctoral dissertation, MIT.

Pierrehumbert, J.B. & M.E. Beckman. 1988. *Japanese Tone Structure*. Cambridge, MA: MIT Press.

Schafer, A.J. 1997. Prosodic Parsing: The Role of Prosody in Sentence Comprehension. Doctoral dissertation, University of Massachusetts.

Schafer, A.J., J. Carter, C. Clifton, & L. Frazier. 1996. Focus in Relative Clause Construal. *Language & Cognitive Processes* 11:135-163.

Schafer, A.J., S.R. Speer, P. Warren, & S.D. White. 2000. Intonational Disambiguation in Sentence Production and Comprehension. *Journal of Psycholinguistic Research* 29:169-182.

Slowiaczek, M. 1981. Prosodic Units as Language Processing Units. Doctoral dissertation, University of Massachusetts.

Speer, S.R., M.M. Kjelgaard, & K.M. Dobroth. 1996. The Influence of Prosodic Structure on the Resolution of Temporary Syntactic Closure Ambiguities. *Journal of Psycholinguistic Research* 25:247-268.

Speer, S.R., P. Warren, A.J. Schafer, S.D. White, & J. Kneale. 1999. Situational Constraints on the Prosodic Resolution of Syntactic Ambiguity. *Proceedings of the Fourteenth International Congress of Phonetic Sciences*, 1301-1304. San Francisco, 1-7 August 1999.

Venditti, J.J., S.-A. Jun, & M.E. Beckman. 1996. Prosodic Cues to Syntactic and Other Linguistic Structures in Japanese, Korean, and English. *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition,* eds. J. Morgan & K. Demuth, 287-311. Mahwah, NJ: Lawrence Erlbaum.

Warren, P., E. Grabe, & F. Nolan. 1995. Prosody, Phonology and Parsing in Closure Ambiguities. *Language & Cognitive Processes* 10:457-486.

Ueyama, M. & S.-A. Jun. 1998. Focus Realization in Japanese English and Korean English Intonation. *Japanese and Korean Linguistics* 7, 629-645. Stanford: CSLI.

Ueyama, M. 1998. Speech Rate Effects on Phrasing in English and Japanese. Unpublished manuscript, University of California, Los Angeles.

Appendix: Experimental Materials

Full pairs of sentences, used in the production study, are shown. In the comprehension study all materials were truncated at the onset of N2. The two words in parentheses are the alternate N2s (for the Main set) and alternate N1s (for the Control set). The first of the pair in parentheses supports an N2-modification interpretation; the second supports an N1-modification interpretation. Each Korean sentence is given in its phonemic representation below, using the International Phonetic Alphabet, and followed by a word-by-word gloss and an English translation. Case markers and postpositions are indicated only for the parenthesized words.

Main Set:
1. ulininhjənmjəŋhan akiɯi (ap*a-e/akki-e)   tehesə malhes*ta
   we wise   baby's   (daddy/muscial instrument)-about   talked
   'We talked about wise baby's (daddy/musical instrument)'
2. ulininkopaltwen pekkomɯi (milsupəm-il/moktəlmi-lil) poas*ta
   we reported   white bear's(smuggler/nape)-Acc   saw
   'We saw the reported white bear's (smuggler/nape)'
3. tʃʰepʰotwen tʃokʰaɯi   (jukwepəm-i/ilkitʃaŋ-i) sinmune   nawas*ta
   arrested   niece's/nephew's (kidnapper/diary)-Nom newspaper appeared
   'The arrested niece/nephew's (kidnapper/diary) was in the newspaper.'

4. hakseŋtilin kwijəun toŋmulwənuɨi (tʰok*i-e/tʰoŋpʰuŋ-e) tehesə koŋpu hes*ta
   students cute zoo's (rabbit/ventilation)-about about studied
   'The students studied about the cute zoo's (rabbit/ventilation)'.

5. nanin tʃʰaŋpekhan sonjəuɨi (əlkul-i/usim-i) itʃʰjətʃitʃika anhas*ta
   I pale girl's (face/smile)-Nom forget could not
   'I could not forget the pale girl's (face/smile)'.

6. isaŋhaketo kiltʃ*ukhan namhakseŋuɨi (tali-ka/tesa-ka) nune t*iəs*ta
   strangely longish male-student's (leg/line)-Nom eye outstanded
   'Stangely, the longish student's (leg/line) came into (my) sight'.

7. jutʃʰaŋhan sitʃaŋuɨi (tʰonjəkkwan-i/tʰutʃiljək-i) hwatʃeka t*weəs*ta
   fluent mayor's (translator/clairvoyance)-Nom issue became
   'The fluent mayor's (translator/clairvoyance) became an issue.'

8. onil tʃənjəkenin palkin pamkəliuɨi (kalotiŋ-i/kukjəŋk*un-i) manhi pojəs*ta
   today evening bright night-street's (lamp/spectator)-Nom many could see
   'Tonight, there were many bright night-street's (lamp/spectator).'

9. nanin jumaŋhan tʃənlatouɨi (totʃisa-ka/tankjəlljək-i) tʰikhi maime tinta
   I promising Cholla-do's (governor/unity)-Nom especially mind entered
   'I especially like the promising Cholla-do's (governor/unity).'

10. ulinin posutʃəkin k*omauɨi (ap*a-lil/inhjəŋ-il) pokilohes*ta
    we conservative child's (daddy/doll)-Acc meet-decide
    'We decided to meet the conservative child's (daddy/doll).'

11. uli ənninin pʰjənanhan kəsiluɨi (anlakɯitʃa-lil/juli inhjəŋ-il) tʃeil tʃoahanta
    my sister comfortable living room's (armchair/glass doll)-Acc best likes
    'My sister likes the comfortable living room's (armchair/glass doll) the
    best.'

12. sinkihaketo nals*inhan k*omauɨi (imo-ka/ilim-i) tʃənhjə natʃʰsəltʃika
    marvelously slim child's (aunt/name)-Nom not at all unfamiliar
    anhas*ta
    was not
    'Marvelously, the slim child's (aunt/name) was nothing unfamiliar.'

13. sinkihaketo tʃalseŋkin kanhowənuɨi (nampʰjən-i/nole-ka) tʃeil p*alli nawas*ta
    marvelously handsome nurse' (husband/song)-Nom the best fast came out
    'Marvelously, the handsome nurse's (husband/song) came out the fastest.'

14. salamtilin silmaŋhan pəminuɨi (pumo-ka/punno-ka) ki sakənuɨi wəninilako
    people disappointed criminal's (parents/rage)-Nom that event's cause
    seŋkakhes*ta
    thought
    'People thought that disappointed criminal's (parents/rage) was the cause
    of that event.'

15. manhɨn salamtɨli putʃiɬənhan tesauɥi (pʰatʃʰulpu-e/pʰjotʃʰaɳtʃaŋ-e) tehesə
    many people diligent ambassador's (housekeeper/award)-about
    malɨlhakois*əs*ta
    were talking
    'Many people were talking about the diligent ambassador's (house-
    keeper/award).'

16. kɨ pjənhosanɨn sukamtwen toseŋuɥi (salɨntʃa-lɨl/satʃintʃʰəp-ɨl) tʃasehi
    that lawyer   arrested yngr-brother's (assassin/album)-Acc attentively
    salpʰjəpoas*ta
    observed
    'That lawyer attentively observed the arrested younger brother's (assas-
    sin/album).'

17. ipən tʃumalenɨn pit*ulətʃin temunuɥi (munpʰe-lɨl/munuɥi-lɨl) pak*ul
    this weekend crooked front door's (nameplate/pattern)-Acc change
    kjehwekita
    plan to
    'This weekend, (I) plan to change the crooked front door's (name-
    plate/pattern).'

18. sənseŋnimk*esə kansahan waŋuɥi (nesi-etehe/neljək-etehe) tʃasehi
    teacher   sly   king's (eunuch/history)-about explicitly
    səlmjəŋhasjəs*ta
    explained
    'The teacher explained explicitly about the sly king's (eunuch/history).'

19. sənseŋtilɨn sutasilən kjotʃaŋuɥi (puin-ɨl/pimil-ɨl) tʃʰəim manas*ta/alas*ta
    teachers   talkative principal's (wife/secret)-Acc first time met/knew
    'The teachers met/knew the talkative principal's (wife/secret) for the first
    time.

20. salamtɨlɨn kopunkopunhan jəŋsauɥi (pisə-lɨl/pinso-lɨl)   silhəhes*ta
    people   obedient   consul's (secretary/coffin room)-Acc dislike
    'People did not like the obedient consul's (secretary/coffin room).'

21. amuto sutʃupɨn kuninuɥi (t*al-ɨl/t*ɨs-ɨl)   mollas*ta
    no one timid   soldier's (daughter/will)-Acc knew not
    'No one knew the timid soldier's (daughter/will).'

22. əsekhan tʃʰinkuuɥi (usɨm-i/ilɨm-i)   kaptʃaki seŋkaknas*ta
    awkward friend's (smile/name)-Nom suddenly remembered
    '(I) suddenly remembered the awkward friend's (smile/name).'

23. kotʃaŋnan kapaŋuɥi (tʃipʰə-lɨl/tʃoŋlju-lɨl) tʃʰatʃninte sikani k*we tɨləs*ta
    broken   purse's (zipper/kind)-Acc   find time quite spent
    'It took (me) quite a lot of time to fine the broken purse's (zipper/kind).'

24. salamtɨlɨn k*ank*anhan pəminuɥi (pʰansa-etehe/pʰankjəl-etehe) malhes*ta
    people   tenacious   criminal's (judge /judgment)-about   talked
    'People talked about the tenacious criminal's (judge/judgment).'

Control Set:

1. salamtiłin pantʃ*akinin (kʰapale-ɰi/neonpitʃʰ-ɰi) kanpʰanił tʃoahaninkət
   people   shiny   (cabaret's/neon light's)   sign-Acc   like
   katʰta
   seem
   'People seem to like the shiny (cabaret's/neon light's) sign.'

2. ipəneto pujuhan (kohakseŋ-ɰi/salipte-ɰi)   huwəntʃanin
   this time wealthy (self-supporting-student's/private univ.'s) sponsor
   palkhjətʃitʃi anas*ta
   revealed   not
   'This time too, the wealthy (self supporting student's/private univ.'s)
   sponsor was not revealed'

3. uli motunin saljəkipʰin (k*aŋpʰe-ɰi/sunjə-ɰi) kʰaunsiłłə-etehe
   we all   thoughtful (gangster's/nun's)   counselor-about
   kuŋkimhehes*ta
   wondered
   'We all wandered about the thoughtful (gangster's/nun's) counselor.'

4. nanin uahan (pʰjəntʃiptʃaŋ-ɰi/pʰatʰipok-ɰi) puinkwa tehwalił nanuəs*ta
   I   elegant (editor's/party-dress's)   wife/lady-with conversation shared
   'I had a conversation with the elegant (editor's/party-dress's) wife/lady.'

5. nanin silljəkis*nin (toŋseŋ-ɰi/tʃipan-ɰi)   katʃəŋkjosalił manas*ta
   I   competent (younger-brother's/family's) private tutor   met
   'I met the competent/powerful (younger-brother's/family's) private tutor.'

6. kwijəun (kjotʃaŋ-ɰi/pisə-ɰi) jətoŋseŋi   mikukilojuhakkantako tiləs*ta
   cute   (principal's/secretary's) younger-sister US-to study abroad (I) heard
   '(I) heard that the cute (principal's/secretary's) younger sister was going to
   America to study'

7. ipənenin seljəntwen (kjohwaŋ-ɰi/motel-ɰi) titʃainəto   pʰatʰi-e
   this time stylish   (Pope's/model's)   designer-also party-at
   tʃʰamsəkhes*ta
   attended
   'This time, the stylish (Pope's/model's) designer attended the party too.'

8. imsinhan (k*oma-ɰi/jətʃa-ɰi) əməninin miinisjəs*ta
   pregnant (child's/woman's)   mother beauty was
   'The pregnant (child's/woman's) mother was a beauty.'

9. onił sinmune tʰiksuhan (jənkusił-ɰi/tʃʰiljojak-ɰi) silhəmtʃaŋtʃʰika
   today newspaper special (laboratory's/medicine's) exp. equipment
   tʃʰəimilo pototweəs*ta
   first time reported
   'In today's newspaper, a special (laboratory's/medicine's) experimental
   equipment was reported for the first time.'

10. nanɨn joŋkamhan (motel-ɯi/tʃaŋkjo-ɯi) kjəŋhowəni nukuintʃi alko
    I   brave   (model's/officer's)   bodyguard who is   know
    sipʰəs*ta
    wanted
    'I wanted to know who the brave (model's/officer's) bodyguard was.'

11. kɨ jətʃanɨn tʰoɲɓoŋhan (pallelina-ɯi/atʃuməni-ɯi) akilɨl
    that woman chubby   (ballerina's/lady's)   baby
    pwatʃukois*tako hajəs*ta
    caring   said
    'That woman said that she's taking care of the chubby (ballerina's/lady's)
    baby.

12. kapspis*an (supʰəmakʰes-ɯi/suipkake-ɯi) tʃaŋmik*otʃʰin siŋsiŋhatʃiman
    expensive (supermarket's/import store's) rose-Top   fresh-but
    hjaŋkika əpəs*ta
    fragrance no
    'The expensive (supermarket's/import store's) rose was fresh but had no
    fragrance.'