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Constituent Length Affects Prosody and Processing for a Dative NP Ambiguity in Korean

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Abstract Two sentence processing experiments on a dative NP ambiguity in Korean demonstrate effects of phrase length on overt and implicit prosody. Both experiments controlled non-prosodic length factors by using long versus short proper names that occurred before the syntactically critical material. Experiment 1 found that long phrases induce different prosodic phrasing than short phrases in a read-aloud task and change the preferred interpretation of globally ambiguous sentences. It also showed that speakers who have been told of the ambiguity can provide significantly different prosody for the two interpretations, for both lengths. Experiment 2 verified that prosodic patterns found in first-pass pronunciations predict self-paced reading patterns for silent reading. The results extend the coverage of the Implicit Prosody Hypothesis [Fodor, J Psycholinguist Res 27:285–319, 1998; Prosodic disambiguation in silent reading. In M. Hirotani (Ed.), *NELS 32* (pp. 113–132). Amherst, MA: GLSA Publications, 2002] to another construction and to Korean. They further indicate that strong syntactic biases can have rapid effects on the formulation of implicit prosody.

Keywords Prosody · Korean · Sentence production · Sentence comprehension · Reading

Introduction

Many sentence comprehension studies have shown that overt prosody can disambiguate or bias the interpretation of syntactic structure ambiguities in spoken language (e.g., Schafer et al. 2000 in English; Pynte and Prieur 1996 in French; Misono et al. 1997 in Japanese;

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Kang and Speer 2003; Kim 2004 in Korean, among others). Importantly, such studies have typically varied prosodic features such as prosodic boundary strength while keeping other factors constant. Other research has established that overt prosodic phrasing (or at least the durational pattern of a sentence) is sensitive to phrase length as well as syntactic structure (e.g., Fernández et al. submitted; Gee and Grosjean 1983; Jun 2000, 2003; Selkirk 2000; Watson and Gibson 2004).

Putting these two strands of research together, one can ask how prosodic phrasing is interpreted during sentence comprehension when phrase length varies. Two proposals have been suggested in the literature. The first is an assumption within the Implicit Prosody Hypothesis (Fodor 1998, 2002) that a prosodic boundary of a given size has a consistent effect on syntactic decisions whether it is induced by length or syntactic constraints. For example, if an intonation phrase boundary induces high attachment of a subsequent phrase, it would do so regardless of the phrase length of the surrounding material (or at least, there would be a strong tendency for a syntactic interpretation of the boundary). The second proposal (Clifton et al. 2006), which we will present more fully below, predicts an interactive effect. In this proposal (applied in their work only to overt prosody), the effect of a prosodic boundary on syntactic decisions is significantly reduced when the prosodic boundary strength can be attributed to phrase length. Therefore, an intonation phrase boundary might have a significant effect in the context of short phrase lengths, but no effect in the context of long phrase lengths.

A number of studies have supported the Implicit Prosody Hypothesis, while the experiments of Clifton et al. (2006) lend support to an interactive effect (as we lay out in following sections). However, most of the research in this area has varied phrase length without controlling for syntactic or referential complexity, and much of it has been conducted on a single type of ambiguity, the association of a relative clause to N1 or N2 of a complex noun phrase (NP). And, there are cases of length effects that are not explained by prosody (described below), which suggest a general value in exploring a broader range of sentence lengths than typically found in sentence comprehension studies. We provide a test of length-driven implicit prosody using a different type of ambiguity than previously explored and vary phrase length without confounds from non-phonological factors. We do so by testing Korean, which has shown mixed support for the Implicit Prosody Hypothesis in previous research. Our experiments examine the relationships among length, overt prosody produced on initial exposure to an ambiguous sentence, overt prosody in disambiguating productions, and comprehension patterns in silent versus oral reading. Finally, we consider whether key decisions take place during initial prosodic and syntactic analysis or during reanalysis, and some of the factors employed during the construction of implicit prosody.

The Implicit Prosody Hypothesis

Fodor (1998, 2002) and Hirose (2003), among others, have argued that phrase length affects not only overt prosody but also prosody computed during silent reading, and that this implicit prosody can play a significant role in determining parsing preferences during sentence comprehension. Strong evidence for phrase length effects and the Implicit Prosody Hypothesis was provided by Hirose (2003). Using written materials as in (1), she found that matrix subject length in Japanese sentences affected the resolution of a temporary ambiguity in the association of a subsequent accusative phrase. The length contrast also affected the overt prosody speakers applied to sentence fragments in a separate read-aloud task. Hirose concluded that constituent length affected the implicit prosody built during

silent reading, which in turn influenced the resolution (during reanalysis) of the syntactic ambiguity.

(1) Example of Hirose (2003)'s materials

(Hoso'kawa-to) Mori'sita-ga [[si'nyaku-o kokoro'kara sinyoosita] yuuji'ntati-ni] shohoosen-o okutta.

(Hoso'kawa-and) Morisita-NOM [[new medicine-Acc truly trusted] friends-DAT] prescription-ACC sent

'(Hosokawa and) Morisita sent the prescription [to the friends [who truly trusted the new medicine]].'

The Implicit Prosody Hypothesis has been supported across languages by a number of studies that have explored the processing of sentences containing a complex NP modified by a relative clause (e.g., Fernández 2003; Fernández et al. under revision, submitted; Jun 2003; Jun and Koike 2003; Lovric 2003). These studies have consistently found effects of relative clause length on parsing decisions in head-initial languages such as English and Spanish, as well as in the head-final language Japanese. Yet Korean, a head-final language, has provided a challenge to the hypothesis. Jun and Kim (2004) and Jun (2007) found that 86% of productions by Korean speakers employed similar prosodic phrasing for long, medium, and short relative clauses preceding complex NPs. Across relative clause lengths speakers used neutral prosodic phrasing that placed each content word into a separate prosodic phrase, instead of the expected pattern of grouping the relative clause and first NP into an intonation phrase more frequently for shorter relative clauses than for longer relative clauses. This is particularly striking because the length of the relative clause is apparent by the time the NP attachment sites are produced.

In contrast, in an off-line study with visually presented Korean materials the same participants showed partial sensitivity to relative clause length in interpretation (Jun 2007; Jun and Kim 2004). Short relative clauses were interpreted with low (N1) attachment significantly more often than medium or long relative clauses, but the percentage of high attachment was comparable between medium and long relative clauses. The lack of length effects in production casts doubt on using implicit prosody as an explanation for the short versus non-short length effects in comprehension.

The Korean processing data led Jun (2006) to re-examine Korean phrasing data and the Jun (2000) intonation model for Korean. Some of the "neutral" prosodic phrasing patterns showed a downstep-like change in pitch range across a sequence of accentual phrases (the smallest prosodic phrase in the Korean system). Jun (2006) postulated that the Korean intonation system includes an intermediate phrase, defined by pitch range, between the accentual phrase level and the intonation phrase level. When a subset of the Jun and Kim data was reanalyzed within the revised intonation model, the percentage of early prosodic breaks was numerically higher (the article does not include inferential statistics) for long relative clauses (70%) than for medium length ones (54%) or short relative clauses (33%). Thus, under the new intonation model, the production results are more consistent with the Implicit Prosody Hypothesis by showing length differences in production that might drive length effects in comprehension. However, even in the revised intonation model, an apparent three-way split in production patterns must map to a two-way split in comprehension (contrasting short relative clauses to the other two lengths). Further, pitch range can only be evaluated in certain tonal contexts, and the pitch range cue, as currently specified, leaves ambiguity about whether the intermediate phrase boundary is aligned with the left or right edge of the critical accentual phrase, giving a high level of subjectivity to the reanalyzed results.

Questions about Implicit Prosody Effects

Other research raises further questions about a prosodic explanation for at least some types of length effects. Schafer et al. (2000) tested ambiguous sentences like *I asked the pretty little girl who's cold* versus *I asked the pretty little girl who is very cold*, to investigate the effects of pitch accent (on *who* versus *cold*) and phrase length in disambiguating the interpretation between an embedded question analysis (e.g., 'I asked the girl which person was cold.') and a relative clause analysis (e.g., 'I asked the cold girl something.'). As predicted they found significant effects of pitch accent placement. In addition, three separate auditory experiments demonstrated that long phrases were significantly more likely to be interpreted as relative clauses than short phrases, even though the prosodic phrasing was carefully controlled across conditions. A similar pattern was found in a written questionnaire study. The length effect persisted even in an experiment that contrasted intermediate versus intonation phrase boundaries at the left edge of the *wh*-phrase; this experiment found a significant effect of phrase length but not of prosodic boundary strength. Although the cause of the length effect was not determined (Schafer et al. 2000 speculated that it might be due to a tense mismatch in the long but not the short materials), the results demonstrate that prosodic phrasing is not at play in at least some instances of length effects.

Other non-prosodic explanations of length include Fodor's (1998) balanced sister hypothesis, which predicts that phrases are preferentially analyzed as a syntactic sister to a phrase of similar size, and a suggestion by Hemforth and Konieczny (2002) that longer relative clauses carry a greater information load, which makes them more likely to be associated with the main assertion (and hence the higher NP in the relevant ambiguous sentences). Such considerations are important, because in most previous studies employing length manipulations of implicit prosody, the changes in phonological length co-occurred with differences in number of words, number of discourse referents or their attributes, and syntactic complexity in the critical region (but see Hirose 2003 and Fernández et al. under revision for notable exceptions). Thus, several potential factors were often confounded, and relative clause attachment is known to be modulated by a number of factors.

Finally, a proposal by Clifton et al. (2006) undercuts the basis of length effects in implicit prosody. In a series of auditory studies in which length and biasing prosody were manipulated, Clifton et al. found that forced-choice disambiguating responses were more differentiated with shorter phrases than longer ones in syntactically ambiguous sentences such as *{Patricia Jones or Jacqueline Frazier and Letitia Connolly/Pat or Jay and Lee} convinced the bank president to extend the mortgage* or *Susie learned that Bill telephoned {last night/late last night after the general meeting}*. They argue that the results support a Rational Speaker Hypothesis: listeners might be less likely to take a large prosodic boundary as evidence of a large syntactic boundary if the strength of the critical prosodic boundary is justified by phrase length. The logic is that an otherwise unexplained prosodic boundary would be good evidence about syntactic structure because a rational speaker needs motivation to insert a boundary, but one explained by phonological factors is ambiguous between a phonological cause and a syntactic one. A related hypothesis can be cast in more probabilistic terms: the reliability of a prosodic break index for syntactic decisions might vary as a function of phrase length. In the case of implicit prosody, the Rational Speaker approach is put to an ideal test. Since it is the reader who is producing the implicit prosody, any effects of length on prosody should, in a rational processing system, be dismissed without cost, because their cause is unambiguous. Notice that both the Implicit Prosody Hypothesis and the Rational Speaker Hypothesis assume that longer phrases lead to stronger prosodic boundaries, but only the

Implicit Prosody Hypothesis predicts that these boundaries will significantly affect parsing decisions.

The Current Study

Coupled with the limited evidence for implicit prosody effects in Korean, the previous findings on length effects call for further exploration. The current study investigated whether implicit prosodic phrasing influences syntactic ambiguity resolution in Korean. We tested a case in which length was manipulated outside of the ambiguously parsed phrase and the phrases it potentially associates with, so that the length manipulation was unlikely to cause unintended effects on discourse complexity, matching sister size, non-phonological memory, or other factors. We also made use of long versus short versions of proper names to manipulate length, so the overall discourse complexity of the long and short sentences did not differ.

Our materials, used in both a production experiment and a comprehension one, employed an ambiguity in Korean between matrix clause and relative clause association of a dative NP, as in sentence (2):

(2a) Matrix clause association
Phigules-i Lopin-eykey [[Phwuwu-ka tta-cwu-n] pelcip-ul] unkunsulccek phala-pelye-ss-ta.
Piglet-NOM Robin-DAT [[Pooh-NOM pick-BEN-REL] honeycomb-ACC] stealthily sell-complete-PST-DECL.
'Piglet stealthily sold Robin [the honeycomb [that Pooh picked]].'

(2b) Relative clause association
Phigules-i Lopin-eykey$_i$ Phwuwu-ka t_i tta-cwu-n pelcip-ul unkunsulccek phala-pelye-ss-ta.
Piglet-NOM Robin-DAT$_i$ Pooh-NOM t_i pick-BEN-REL honeycomb-Acc stealthily sell-complete-PST-DECL.
'Piglet stealthily sold [the honeycomb [that Pooh picked for Robin]].'

The dative NP *Lopin-eykey* 'Robin-DAT' can be associated with the matrix clause ditransitive verb *phala-pelye-ss-ta* 'sold' or the relative clause ditransitive verb *tta-cwu-* 'picked'. In the former case the dative NP is in canonical position; in the latter we follow the common assumption that it has been scrambled to the left of the subject of the relative clause. Although there is some disagreement in the syntactic literature about the precise analysis of sentences such as (2b) (and so we omit syntactic brackets for it), there is no question that two grammatical interpretations are available for (2) due to the relatively free word order of Korean and the optionality of a dative argument for Korean ditransitive verbs.

Koh (1997) tested visually presented Korean sentences similar to these in an eyetracking study and showed that the matrix clause association is generally preferred, as did Kiaer (2007) with self-paced reading. Kamide and Mitchell (1999) found a similar preference in Japanese using self-paced reading. Hwang et al. (to appear) found that 74% of Korean fragments similar to the initial portion of (2) were completed with unambiguously matrix association of the dative phrase in a sentence completion task. In constructions like (2) there is no evidence of a relative clause until the second nominative phrase (*Phwuwu-ka* 'Pooh-NOM' in (2)) is encountered. The sentence can continue grammatically with no structural revisions by postulating a relative clause boundary at the left edge of the second nominative phrase and an in

situ interpretation of the dative NP, so continued matrix clause association of the dative NP provides a simpler analysis.

In contrast, Aoshima et al. (2004) demonstrated that in Japanese a dative-marked *wh*-phrase (e.g., *Dono-seito-ni* 'Which student-DAT') that has been scrambled to sentence-initial position is preferentially associated with the most embedded clause, not the matrix clause. Aoshima et al. (2004) explained with reference to Kamide and Mitchell's stimuli that both the difference in phrase location and the difference between *wh*-phrases and referential NPs may account for the switch in association preference, a claim supported by Aoshima et al. (2005). We believe that the focus assigned to a *wh*-phrase, the associated post-focus prosodic reduction (Kitagawa and Fodor 2006), and the need to assign *wh*-scope are particularly important in distinguishing the interpretive preferences for the two different types of materials.

The matrix preference for our materials is also supported by the most commonly observed prosodic phrasing for materials of this length, which places an intonation phrase break following the dative NP, separating the dative NP from the relative clause (Kiaer 2007). Kiaer also demonstrated significant prosodic disambiguation effects for such sentences. In an auditory fragment completion selection task she found that with an overt phrase break located after the ambiguous dative NP, participants were more likely to choose a completion with matrix (versus embedded) clause association of the dative NP, but with an overt prosodic break after the first (topic-marked) NP, participants preferred a completion requiring embedded clause association of the dative NP. A task that mixed auditory fragments with self-paced reading demonstrated converging prosodic disambiguation effects. And, a similar correspondence between overt prosody and syntactic structure was observed in a read-aloud task that disambiguated the association of the critical dative NP through the use of a second dative NP in either the embedded or matrix clause. Speakers produced a stronger prosodic break before the dative NP when it was an argument of the embedded clause, versus a stronger prosodic break after the dative NP when it was associated with the matrix clause. We extended Kiaer's work to examine whether manipulating the length of the matrix clause subject in structures such as these would affect the associated prosody and therefore comprehension. First, an off-line sentence reading experiment examined overt prosody. Then, a self-paced reading experiment tested the effects of implicit prosody in comprehension.

Production Experiment

Twelve pairs of ambiguous sentences were tested to examine length effects on overt prosodic phrasing in the production of Korean complex sentences like (2) above. The members of each sentence pair were identical except for a short versus long matrix subject, which was always the name of a well-known cartoon character. Subjects read each sentence aloud in a simple laboratory reading task. Then, in a second block, they provided their preferred interpretation of each ambiguous sentence and gave productions for each of the two interpretations. Following general patterns for overt prosody (Jun 2003; Selkirk 2000) and the specific findings in Kiaer (2007), we predicted that in initial read-aloud productions the matrix subject and the dative NP would be placed within the same intonation phrase in the short-subject condition, and so the dative NP would carry phrase-final lengthening but the matrix subject would not. In the long-subject condition, we predicted that the matrix subject would correspond to a single intonation phrase, and would therefore be marked by phrase-final lengthening.

Method

Participants

Twelve native speakers of Seoul Korean participated in this experiment in return for $7. They were all students at the University of Hawaii with normal or corrected-to-normal vision.

Materials

The stimuli consisted of 12 pairs of experimental items (a random subset of the materials used in the comprehension experiment described below), randomized with 12 filler sentences. A complete list of experimental items appears in the Appendix. The two experimental conditions were short versus long matrix subject sentences, as in (3). The short subjects averaged 3.42 syllables and the long ones averaged 7.50 syllables. According to Jun (2000, 2003), a Korean accentual phrase includes five or fewer syllables at a normal speech rate, and a Korean intonation phrase generally includes 7–15 syllables. Therefore, we expected that the short subjects could be produced in one accentual phrase while the long ones would most likely to be produced in two accentual phrases. The matrix subject was immediately followed by a dative NP, which was always 4 syllables long. Thus, the preceding matrix subject was either short enough to group readily into an intonation phrase with the dative NP or long enough that an intonation phrase boundary at the end of the subject was likely. The length of the matrix subject was manipulated by contrasting long and short versions of well-known cartoon characters' names (e.g., Korean equivalents of "Pooh" versus "Winnie the Pooh").

All of the experimental sentences were globally ambiguous complex sentences, with ditransitive verbs in both the matrix clause and the relative clause. Consequently, the ambiguous dative NP could be interpreted either in the matrix clause or in the relative clause. The filler items were unambiguous sentences, all of which contained a dative NP and a relative clause. Half of them contained a ditransitive verb in only the matrix clause and so required matrix association of the dative NP and the other half required relative clause association because a ditransitive verb appeared only in the relative clause. They served to prevent the participants from perseverating in their choice of prosodic form or syntactic interpretation of the critical sentences, and also provided clear examples of each of the target interpretations. Although the ambiguous sentences have a matrix interpretation bias, neither interpretation is particularly marked in Korean, and so it was not expected to be problematic for participants to receive 24 structurally similar sentences.

(3a) Short subject condition (globally ambiguous)
Athom-i Along-eykey Lopitha-ka penyekhay-cwu-n oykwuksi-lul wunchiisskey ulph-e-cwu-ess-ta.
Athom-NOM Along-DAT Lopitha-NOM translate-BEN-REL foreign poem-ACC elegantly recite-L-BEN-PST-DECL.
'Athom elegantly recited for Along [the foreign poem [that Lopitha translated]].' *or*
'Athom elegantly recited [the foreign poem [that Lopitha translated for Along]].'

(3b) Long subject condition (globally ambiguous)
Wucwu Sonyen Athom-i Along-eykey Lopitha-ka penyekhay-cwu-n oykwuksi-lul wunchiisskey ulph-e-cwu-ess-ta.
Astroboy Athom-NOM Along-DAT Lopitha-NOM translate-BEN-REL foreign poem-ACC elegantly recite-L-BEN-PST-DECL.

'Astroboy Athom elegantly recited for Along [the foreign poem [that Lopitha translated]].' *or*
'Astroboy Athom elegantly recited [the foreign poem [that Lopitha translated for Along]].'

The experimental sentences were divided between two lists in a counter-balanced design, so that each condition of an experimental set appeared in one list only. Each sentence and corresponding pictures of its characters and their names were printed on separate pieces of paper, all of which were bound into a stack. The materials were randomized separately for each participant for each of two blocks (described below) and presented in a single experiment session.

Procedure

Participants were tested individually in a sound-attenuated booth, equipped with a Sony FV-120 microphone. Their speech was digitized directly to a computer using the software program *Praat*. Participants were instructed to read each sentence naturally, clearly and loudly. After a short practice session of three sentences, the experimental session began. The experiment took 45–50 min to complete.

For each sentence, the participants first viewed pictures of the relevant cartoon characters along with their names, to ready them for the next trial and remind them of the characters (if necessary, although the characters were common in Korea). Then they saw the sentence, presented in standard Korean orthography. In the first block, participants read each sentence aloud as soon as they encountered the sentence (i.e., without prior skimming). We will refer to these as "first-pass" productions. In the second block, only the 12 critical items, all of which were globally ambiguous, were presented. In each of these trials the participants read the full sentence silently and then provided an interpretation describing who did what, in response to the experimenter's instruction. After that, the experimenter explained the sentence ambiguity (if necessary). Finally, participants supplied intentionally disambiguating productions of interpretations with matrix clause association and relative clause association. Half of the participants were asked to provide matrix clause associations first, and half the other interpretation.

The data from the first production block were of more interest because they show the first-pass prosody for our primary question of how matrix subject length affects prosodic phrasing, and should be most representative of the implicit prosody created during silent reading. The data from the second block provide metalinguistic judgments about dative NP association preferences, as well as data showing the extent to which speakers make use of prosodic phrasing to indicate the dative NP association when they have been instructed to provide a careful pronunciation. Although we expect that spontaneous speech might be somewhat different from this sort of laboratory speech (e.g., Schafer et al. 2005), the laboratory productions should nevertheless provide a good estimate of spontaneous prosodic disambiguation for this structure.

Results

Data from one participant were lost due to equipment failure. One item in another participant's data was removed from the analysis of Block 1 due to disfluency. The analysis focused on duration measurements of the final, segmentally identical material for long and short matrix subjects (e.g., *Athom-i* in (3)) and the ambiguous dative NPs (e.g., *Along-eykey* in (3)), plus

Table 1 Number of tokens (and percentage of tokens) in first-pass productions of Experiment 1 for the matrix subject NP and dative NP sequence across possible prosodic patterns

	Prosodic pattern (Matrix subject NP, Dative NP)			
	IPh, IPh	IPh, AP	AP, IPh	AP, AP
Short subject condition ($N = 66$)	5 (8%)	0 (0%)	58 (88%)	3 (5%)
Long subject condition ($N = 65$)	45 (69%)	17 (26%)	2 (3%)	1 (2%)

Note. Each subject NP or dative NP ended an intonation phrase (IPh) or an accentual phrase (AP)

any post-NP pauses. In Korean, intonation phrases typically exhibit phrase-final lengthening but accentual phrases do not (Jun 2000). The duration data were therefore taken as reliable evidence for the presence of intonation phrase boundaries. They are summarized in Fig. 1. In addition, each production was evaluated for the presence of accentual versus intonation phrase boundaries by a native speaker of Korean who had been trained in Korean prosodic transcription (the first author).

The duration data for matrix subjects and dative NPs from first-pass reading (in Block 1) were subjected to a 2 × 2 repeated measures ANOVA with Matrix subject length (Long subject versus Short subject) and Region (Matrix subject versus Dative NP) as within-participants factors. There were significant main effects of Matrix subject length [$F_1(1, 10) = 14.528$, $p < .01$; $F_2(1, 11) = 28.720$, $p < .01$] and Region [$F_1(1, 10) = 34.564$, $p < .01$; $F_2(1, 11) = 19.702$, $p < .01$], and a significant interaction of Matrix subject length with Region [$F_1(1, 10) = 27.513$, $p < .01$; $F_2(1, 11) = 87.348$, $p < .01$]. Average durations for the segmentally identical portion of matrix subjects were significantly greater in the long-subject condition than in the short-subject condition, whereas average durations for the dative NP were significantly greater in the short-subject condition than in the long-subject condition. The duration difference was greater in the subject region than the dative region.

Prosodic transcriptions presented the same picture of the data. Table 1 presents these as the frequency and percentage of intonation phrase or accentual phrase boundaries for the two positions of interest. Most speakers showed no variation across trials in boundary choice for a given condition and position. As seen in the table, in 88% of utterances with short matrix subjects speakers produced a single intonation phrase boundary containing both NPs; the remainder contained two prosodic boundaries of equal size. In contrast, 95% of productions in the long subject condition placed an intonation phrase boundary at the right edge of the subject NP. The majority of these carried intonation phrase boundaries at the right edge of both the nominative and the dative NPs, while 26% of long subject utterances were produced with an intonation phrase boundary ending the subject NP and an accentual phrase boundary on the dative NP.

Therefore, short-subject productions were significantly more likely than long-subject productions to exhibit prosody biased toward matrix association of the dative NP. Long-subject utterances were usually pronounced with prosody that was consistent with matrix association of the dative NP (since the dative NP usually ended in an intonation phrase boundary), but also allowed ready association of the dative phrase with the relative clause (since it was in a separate intonation phrase from the preceding material). About one-fourth of the long-subject utterances contained a stronger boundary ending the matrix subject NP than the dative NP, a prosody biased toward relative clause association of the dative NP.

Data from the second block of the experiment provided additional evidence for the effects of phrase length. First, we found a shift in participants' preferred interpretation of the test

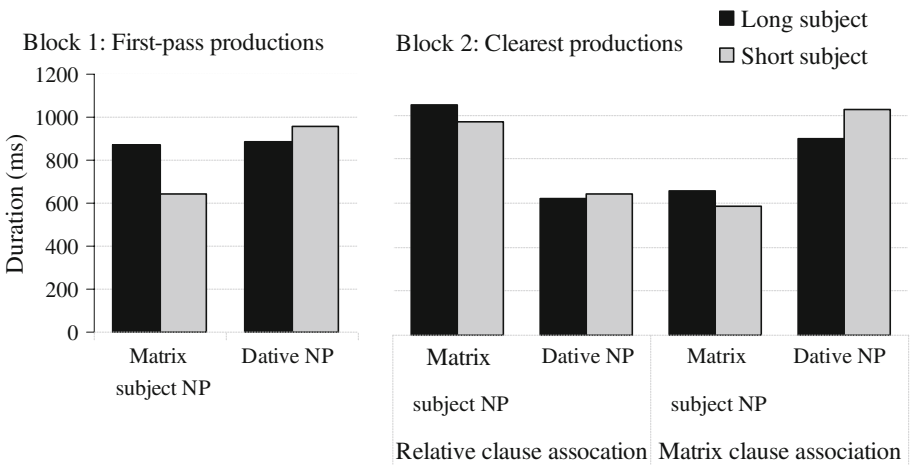

Fig. 1 Duration patterns for matrix subjects (segmentally identical portions only) and dative NPs. *Note.* Long subject = the long matrix subject condition, Short subject = the short matrix subject condition

sentences depending on the length of the matrix subject, despite an overall bias for matrix clause association. In the short-subject condition, matrix clause association was strongly preferred (82% of responses), whereas in the long-subject condition, the preference for matrix clause association decreased markedly (58% of responses) [$F_1(1, 10) = 21.695$, $p < .01$; $F_2(1, 11) = 7.603$, $p < .05$]. Even though the prosody was generated by the participants themselves, they appeared to be biased by it in their interpretations, which is inconsistent with a Rational Speaker approach (Clifton et al. 2006).

When participants were informed of the association ambiguity for the dative NP and gave intentionally disambiguating productions, the pattern of prosodic phrasing was influenced by readers' ultimate parse of the sentences, as shown in Fig. 1 . The interaction of Interpretation and Region exhibited a highly significant effect both by participants [$F_1(1, 10) = 206.853$, $p < .01$] and items [$F_2(1, 11) = 2951.520$, $p < .01$] in a 2 (Interpretation: matrix association versus relative association) × 2 (Region: matrix subject versus dative NP) × 2 (Matrix subject length: long subject versus short subject) repeated measures ANOVA. Average durations for the matrix clause subjects were always longer when the dative NP was disambiguated to the relative clause association than to the matrix clause association. Conversely, average durations for the dative NP were always longer when the dative NP was disambiguated to the matrix clause association than to the relative clause association. Even in their clearest reading, a significant effect of Matrix subject length was found [$F_1(1, 10) = 26.401$, $p < .01$; $F_2(1, 11) = 18.558$, $p < .01$], and the interaction of Matrix subject length with Region was reliable [$F_1(1, 10) = 12.053$, $p < .01$; $F_2(1, 11) = 13.629$, $p < .01$]. The interaction between Interpretation and Matrix subject length was marginal by participants [$F_1(1, 10) = 4.415$, $p < .062$], but significant by items [$F_2(1, 11) = 8.626$, $p < .05$]. Finally, the three-way interaction among Matrix subject length, Region, and Interpretation was significant only by participants [$F_1(1, 10) = 5.095$, $p < .05$; $F_2(1, 11) = 2.420$, $p < .148$].

Discussion

Manipulating the matrix clause subject length yielded overt durational differences between the conditions in first-pass reading. These differences were consistent with shifted patterns

of prosodic phrasing, so that long subjects were almost always placed in separate intonation phrases while short subjects were usually grouped into an intonation phrase with the following dative NP. The first-pass results were consistent with our predictions, although inconsistent with Jun and Kim (2004) and Jun (2007), which did not find different patterns of intonation phrase boundaries across phrase lengths when they varied relative clause length. We return to this difference in the General Discussion.

At least durationally, the first-pass productions for the short-subject condition were very similar to the disambiguating matrix-association productions, while the first-pass productions for the long-subject condition were more neutral prosodically. The first-pass long-subject items carried longer dative NP durations than when participants gave intentional relative clause association productions, and were more likely to have separate intonation phrases for the matrix subject and the dative NP, as indicated by the similar durations for these two phrases and corroborated by trained listener judgments. These production patterns converge well with the interpretation data, which showed a strong bias for matrix association in the short-subject condition, but only a 58% matrix bias in the long-subject condition. Further, the data show that when participants were aware of the difference in interpretation and instructed to give their clearest pronunciation, they could provide significantly different prosodies for the two meanings. Overall the data demonstrate that a tightly controlled length difference can affect first-pass prosodic production as well as the ultimate interpretation, and that there are straightforward associations between prosodic patterns and final interpretation. With this established, we now turn to an experiment that tested the effects of implicit prosody in on-line comprehension.

Comprehension Experiment

A self-paced reading experiment was designed to examine the on-line effect of phrase length on the interpretation of the ambiguous dative NP in silent reading. As in the production experiment, non-prosodic factors associated with length variation were carefully controlled, so that any effects found in the experiment would most likely reflect implicit prosody. Four experimental conditions crossed Length of the matrix subject (long versus short) with Ambiguity (ambiguous dative association versus disambiguated dative association).

If prosodic phrase boundaries induced by length are discounted during syntactic analyses, there should be no effect of length on self-paced reading patterns. Clifton et al. (2006) discuss such a claim only with respect to English data, for which we expect the alignment of the right edges of prosodic phrases and syntactic phrase to be most critical (e.g., Selkirk 2000). In Korean, left-alignment is more important (e.g., Jun 1996) and syntactic phrases are head-final, so there is room for interpretation about how to generalize Clifton et al.'s idea to our materials. A non-significant effect of length-induced prosody clearly follows from the general spirit of their proposal, though, and could in principle be described with respect to prosodies generated either in the short-subject condition (when length constraints support a stronger prosodic boundary ending the dative NP than the matrix subject NP) or in the long-subject condition, or both.

We predicted, however, that there would be an overall preference for matrix clause association, and that the implicit prosody induced by long matrix subjects would facilitate relative clause association of the ambiguous dative NP, relative to short subjects, as predicted by the Implicit Prosody Hypothesis.

Method

Participants

Forty-eight college students in Seoul participated in return for $5. All participants reported that they were native speakers of Seoul Korean with normal or corrected-to-normal vision. None were aware of the purpose of the experiment, and none participated in the production experiment.

Materials

There were 24 sets of four experimental conditions, illustrated by the examples in (4) below. Twelve of these items were identical (in the ambiguous conditions) to the materials in the production study, and the 12 new items followed the same pattern of construction. Each set employed characters from a cartoon that is relatively well-known in Korea. Sentences with matrix subjects containing seven or more syllables ("long" matrix subjects as in (4c) and (4d)) were contrasted to ones containing no more than four syllables ("short" subjects as in (4a) and (4b)), and followed by dative NPs of four syllables. The length contrast was always created by contrasting a long version of a cartoon character's name with a short version to avoid referential confounds.

All of the four conditions contained two ditransitive verbs, one for the matrix clause and one for the relative clause. Thus, both clauses were potential attachment sites for the ambiguous dative NP (*Lopin-eykey* 'Robin-DAT' in (4)). Globally ambiguous sentences such as (4a) and (4c) contained an adverb (e.g., *unkunsulccek* 'stealthily') before the matrix verb. Disambiguated counterparts such as (4b) and (4d) contained a second dative NP (e.g., *Thige-eykey* 'Tigger-DAT') at the same position as the adverb in (4a) and (4c). The second dative NP forces the ambiguous dative NP to associate with the relative clause because it appears after the relative clause verb and the matrix clause cannot have two dative arguments. The disambiguating dative NP and the adverb were matched on number of syllables within each set.

(4) 1-Matrix subject / 2-Dative NP/ 3-Relative clause subject/ 4-Relative clause verb/ 5-Accusative NP/ 6-Adverb or Dative NP/ 7-Matrix verb

a. Short subject ambiguous condition

Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/unkunsulccek/ phala-pelye-ss-ta.
1-Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-stealthily/ 7-sell-complete-PST-DECL.
'Piglet stealthily sold Robin [the honeycomb [that Pooh picked]].' *or*
'Piglet stealthily sold [the honeycomb [that Pooh picked for Robin]].'

b. Short subject disambiguated condition

Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ Thige-eykey/ phala-pelye-ss-ta.
1-Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-Tigger-DAT/ 7-sell-complete-PST-DECL.
'Piglet sold Tigger [the honeycomb [that Pooh picked for Robin]].'

c. Long subject ambiguous condition

Saykkitwayci Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ unkunsulccek / phala-pelye-ss-ta.
1-Little Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6- stealthily/ 7-sell-complete-PST-DECL.
'Little Piglet stealthily sold Robin [the honeycomb [that Pooh picked]].' *or*
'Little Piglet stealthily sold [the honeycomb [that Pooh picked for Robin]].'

d. Long subject disambiguated condition

Saykkitwayci Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ Thige-eykey/ phala-pelye-ss-ta.
1-Little Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-Tigger-DAT/ 7-sell-complete-PST-DECL.
'Little Piglet sold Tigger [the honeycomb [that Pooh picked for Robin]].'

The sentences were divided into seven frames, as indicated by slashes and numbers in example (4). The region of interest was frame 6, at which relative clause association is forced in the two disambiguated conditions. Based on the overt prosodic phrasing found in the production experiment and the predictions of the Implicit Prosody Hypothesis, we predicted that in the short-subject conditions an intonation phrase boundary would be postulated immediately after the (first) dative NP, but not before it. Such a prosody should facilitate matrix clause association of the dative NP and interfere with relative clause association. Therefore, we expected that RTs would be longer at frame 6 for the short-disambiguated condition, in which reanalysis would be forced, than in the short-ambiguous condition, in which the default preference for matrix clause association could persist.

In the long-subject conditions, we predicted that readers would reliably assign an intonation phrase boundary to the right edge of the matrix subject. Since such a boundary separates the matrix subject from the following dative NP, its presence should facilitate relative clause associations of the dative phrase, at least when such a reading becomes forced by the presence of a second dative NP downstream. We also predicted that a second intonation phrase boundary would often be postulated at the right edge of the ambiguously associated dative NP, as we found in the first-pass production results. If present, this boundary should do nothing to interfere with the default preference for matrix clause association. If absent, relative clause association should be facilitated, because the dative NP would be prosodically grouped with material from the relative clause. Therefore, we predicted that the long-disambiguated condition might still have longer RTs than the long-ambiguous one, since reanalysis would be required on at least some trials in the former case, but never in the latter. Crucially, though, we also predicted that the long-disambiguated condition would produce significantly shorter RTs than the short-disambiguated condition, since the implicit prosody would be more compatible for relative clause association in the long-subject condition than the short-subject one.

To summarize, in ambiguous conditions, either interpretation is allowed, but unambiguous conditions force the generally dispreferred relative clause association. Therefore, processing difficulties were expected to be greatest in the short-subject disambiguated condition, at the point when the second dative NP was read, because the first dative NP must be disassociated from the matrix clause and associated to the relative clause. Processing was expected to be easier in the long-subject disambiguated condition because the implicit prosody would either support a correct initial analysis of relative clause association, or allow easier reanalysis than the implicit prosody of the short-subject disambiguated sentences.

The experimental items were counter-balanced across four lists using a Latin-square design, such that each version of an experimental item appeared in exactly one list. In each list, the 24 sets of experimental items were combined with 48 fillers and presented in a random order. The filler items were unambiguous sentences, most of which were similar to the experimental items in length and complexity, but which varied the location of longer phrases through the use of conjoined NPs. Because all of the unambiguous critical items forced relative clause association of the second NP, half of the filler items required matrix clause association of such a dative NP because a ditransitive verb appeared only in the matrix clause and half required relative clause association because a ditransitive verb appeared only in the relative clause.

Procedure

The experiment was controlled by E-Prime version 1.1 on a PC. Sentences were presented on a single line from left to right in a frame-by-frame, self-paced, non-cumulative moving-window display. Participants could see only one segmented region (as described above) at a time as the preceding region disappeared, in response to their button-presses. The time taken to read one region and press the space bar to move on to the next region was recorded by the computer for each region.

A brief practice session with six trials preceded the 72 trials of the experiment. The task took 25–35 min in total. Each trial began with the presentation of a set of familiar cartoon characters by displaying pictures of the characters with their names. Upon pressing the space bar, the first display, a visual cue "+" was presented on left side of the screen, indicating the starting point of the sentence. The next press initiated display of the first region of the sentence, replacing the fixation cross with the first region. Participants continued this operation until the final region of the sentence was reached, which was indicated by a period. When the space bar was pressed again, a short paraphrase appeared in the center of the computer screen (e.g., the Korean equivalent of "Piglet sold Robin the honeycomb."). Half of the paraphrases described content from the matrix clause, and half from the relative clause. Paraphrase probes for fillers never mentioned dative arguments, to avoid calling attention to the question of interest, and were balanced between correct and incorrect paraphrases. Participants responded by pressing buttons labeled as "correct", "incorrect" and "unsure". These probes primarily served to encourage the participants' attention to the meaning of the sentences.

Results and Discussion

Comprehension Probes

Responses to the comprehension probes showed low accuracy both for the filler items and the critical items. The inaccurate responses were broadly distributed across participants and items. For filler items, approximately 75% of the responses were correct, regardless of whether the participant had to accept or reject a paraphrase, or whether the sentence had matrix or relative clause association of the dative NP. Responses were significantly more accurate for filler items with paraphrases about the matrix clause (78% correct) than for those with paraphrases about the relative clause (72% correct) [$t = 2.540$, $p < .014$].

Paraphrases for critical items were also split between items. Half of the critical items received a monoclausal paraphrase of the matrix clause that included the critical dative NP

as an argument, while the other half received a monoclausal paraphrase of the relative clause with the dative NP as an argument. In conditions with ambiguous syntax, 82% of the matrix association paraphrases were accepted as correct paraphrases, and 38% of the relative clause association paraphrases, suggesting a matrix bias for each subset of items and perhaps a bias to accept any grammatical paraphrase or a tendency to build both interpretations. Less than 1% of the responses were "unsure" for matrix clause paraphrases, and 6% for relative clause paraphrases. There was no effect of length, for either type of paraphrase [t's = 0, p's = 1].

In critical conditions that were syntactically disambiguated to relative clause association of the dative NP, 66% of responses correctly rejected the matrix paraphrase and only 8% of responses were "unsure", suggesting that reanalysis of the matrix clause was frequently successful. For the item subset that received a relative clause association paraphrase, only 43% of responses were correctly accepted, and 7% were "unsure". It is not clear from this data whether reanalysis was sometimes incomplete (i.e., dissociating the dative NP from the matrix clause, but not succeeding in associating it to the relative clause), whether reanalysis tended to be more difficult with the subset of items followed by relative clause paraphrases, or whether the lower accuracy merely reflects poorer performance on paraphrases about the relative clause, as seen for the filler paraphrases. However, reading times were extremely similar in comparisons of the items with matrix versus relative clause paraphrases. Length was again not significant, for either paraphrase subset, except for a marginal effect by participants for higher accuracy with short subjects than long subjects with matrix paraphrases [matrix paraphrase: $t_1 = 1.856$, $p = .076$, $t_2 = 1.417$, $p = .184$; relative clause paraphrase: $t_1 = 1.093$, $p = .286$, $t_2 = .650$, $p = .529$].

Overall, the results for paraphrase probes verify the matrix association bias for these materials that has been found in other studies and indicate that reanalysis was frequently successful. The lack of a length effect is inconsistent with the interpretation results from Experiment 1 and with the strongest predictions of the Implicit Prosody Hypothesis. This might result from the difference between choosing a preferred interpretation in Experiment 1, and accepting or rejecting an offered paraphrase in Experiment 2: the first task might be more sensitive to the ease of building an analysis than the second one. However, given the poor performance on the probes, especially for paraphrases of the relative clause, these results should be interpreted with caution.

Reading Times

The reading time results are presented in Fig. 2, which shows adjusted reading times for all regions in each condition. In each region, all reading times beyond two standard deviations from the mean for individual participants were trimmed to the value of two standard deviations, affecting 5.77% of the data.

A 2 (Matrix subject length: long versus short) × 2 (Ambiguity: ambiguous versus disambiguated) repeated measures ANOVA and paired t-tests were performed for each region. For frame 1, unsurprisingly, reading times were significantly longer for the long-subject conditions than for the short-subject conditions [$F_1(1, 47) = 41.992$, $p < .01$; $F_2(1, 23) = 42.527$, $p < .01$]. Paired t-tests showed significant differences between the long- and short-subject conditions [t_1's > 4.585, p's < .01, t_2's > 4.343, p's < .01]. Frames 2, 3, 4, and 5 are non-critical regions, which presented the same lexical items across conditions. There were no significant differences in reading times by participants or by items, except a difference by items between the short-subject ambiguous and disambiguated conditions in frame 2 [$t_2 = 2.135$, $p < .05$]. Since this difference was prior to the point that these two conditions diverged, we assume it is a Type I error. Overall, the results indicate that frames 2–5 were read

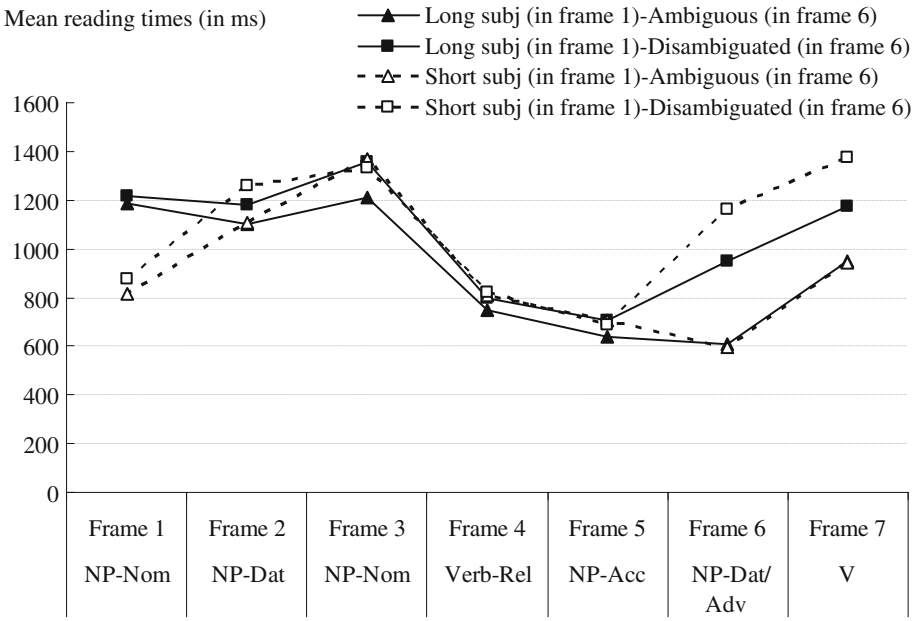

Fig. 2 Adjusted mean reading times as a function of experimental condition

with similar ease across conditions, suggesting no differences in memory burden between long versus short conditions (Gibson et al. 1996).

Reading times at frame 6, the critical region, showed significant effects of Matrix subject length [$F_1(1, 47) = 8.598$, $p < .01$; $F_2(1, 23) = 5.470$, $p < .05$] and Ambiguity [$F_1(1, 47) = 17.320$, $p < .01$; $F_2(1, 23) = 137.839$, $p < .01$], and a significant interaction of Matrix subject length with Ambiguity [$F_1(1, 47) = 15.295$, $p < .01$; $F_2(1, 23) = 6.082$, $p < .05$]. The disambiguated conditions provided the critical contrast in length and implicit prosody. As predicted, paired t-tests found that frame 6 was read significantly more slowly in the short-subject disambiguated condition than in the long-subject disambiguated condition [$t_1 = 3.933$, $p < .01$; $t_2 = 2.601$, $p < .05$] while the two ambiguous conditions did not differ from each other [$t_1 = .2544$, $p < .800$; $t_2 = .249$, $p < .806$].

The shorter reading times found for the long-disambiguated condition versus the short-disambiguated condition suggest that an intonation phrase boundary, projected during silent reading in response to the length of the long subject, facilitated the normally dispreferred relative clause association of the dative NP (or the lack of such a boundary at the right edge of short subjects interfered with reanalysis). Either interpretation supports the argument that the preferred syntactic analysis tends to conform to implicit prosody projected during the initial parse (Bader 1998; Fodor 1998, 2002) and that first-pass prosodic boundaries are maintained during processing and "recycled" to influence reanalysis decisions (Hirose 2003).

Turning to the ambiguity factor, the two ambiguous conditions were read significantly more quickly than the disambiguated conditions at frame 6. This also held true for frame 7 [t_1's > 2.328, p's $< .05$; t_2's > 2.689, p's $< .05$], suggesting that the global ambiguity yielded a processing advantage, not extra processing costs (Van Gompel et al. 2005). Looking in more detail, the short-ambiguous condition produced significantly shorter readings times at frame 6 than the short-disambiguated condition [$t_1 = 4.545$, $p < .01$; $t_2 = 8.625$, $p < .01$].

This was expected, since the ambiguous condition allows the preferred interpretation of the dative NP, and is consistent with findings of Kamide and Mitchell (1999), Kiaer (2007), and Koh (1997).

More interestingly, the difference between the two long-subject conditions also reached significance [$t_1 = 3.446$, $p < .01$; $t_2 = 6.669$, $p < .01$]: frame 6 was read significantly more slowly in the long-subject disambiguated condition than in the long-subject ambiguous condition. This result (like the preceding one) could potentially be attributed to the different lexical items in the two conditions (adverbs versus second dative NPs), although the difference continues in frame 7, which did not differ across conditions. It seems more likely though that the implicit prosody in the long-subject conditions, while different in bias from that of the short-subject conditions, did not reliably force the first dative NP to associate with the relative clause during first-pass processing.

Such an analysis converges with the results of the production experiment. There we often found evidence in the first-pass productions for prosody that biases toward relative clause association of the dative NP, but collected more than twice as many productions which showed intonation phrase boundaries ending both the long matrix subject and the following dative NP. As discussed above, we believe this double-boundary implicit prosody would not impede matrix clause association during initial processing of the dative phrase, nor would it be a strong signal to reanalyze before the second dative NP was encountered. Therefore, reanalysis would be required in at least some of the disambiguated trials at the point the second dative is parsed, but in none of the ambiguous ones, since the adverb is compatible with either interpretation. In short, we conclude that our participants tended to construct relatively neutral implicit prosody in the long conditions versus prosody biased toward matrix clause association in the short conditions, affecting the ease of reanalysis.

General Discussion

The results of the production and perception experiments showed significant effects of phrase length in prosodic phrasing and parsing decisions. The production experiment found that overt prosodic phrasing changed in response to the length of the matrix subject, leading to a significant shift in interpretation with a metalinguistic comprehension question. It also replicated findings by Kiaer (2007) for a significant relationship between prosodic phrasing and dative NP association, seen most dramatically when speakers gave their clearest production of each interpretation.

In the comprehension experiment, the reading time results indicated that the length of the first region affected the association of the second region during silent reading. On-line processing difficulties in the short-disambiguated and long-disambiguated conditions, plus the difference between these two conditions, closely followed predictions generated by the overt prosodic patterns in the production experiment. These results support the Implicit Prosody Hypothesis, verify its role in Korean sentence processing, and are in accord with Hirose (2003), which showed on-line effects of matrix subject phrase length on the parsing of a following accusative phrase in Japanese (see example (1), above). The results also mirror previous evidence that dative NPs show a general matrix association bias (Hwang et al. to appear; Kamide and Mitchell 1999; Koh 1997) that can be influenced by explicit prosody in Korean (Kiaer 2007).

We saw little evidence to support predictions that follow from the Rational Speaker Hypothesis (Clifton et al. 2006). This hypothesis would lead us to expect significant effects of length on overt prosodic phrasing in the production study, and similar (yet difficult to mea-

sure) effects of length on implicit prosody in the perception study, coupled with the absence of length-driven prosodic effects on first-pass parsing decisions or reanalysis. The one hint of support we saw for this hypothesis was the lack of a length effect in probe responses from Experiment 2. Yet, performance was very poor on these probes, casting doubt on their reliability. All of our other results show that once prosodic structure is established, it remains important for subsequent parsing decisions even if its cause could have been solely attributed to length constraints and therefore could have been discounted (see Fodor 2002 for related discussion).

Finally, we note some implications for the question of how implicit prosody is built. We assume that implicit prosody is quite different from overt prosody in that in typical overt production a speaker has a meaning and syntactic structure in mind as each prosodic phrase is formulated, but a reader must construct the syntax and meaning through bottom-up processes and simultaneously create the implicit prosody. Implicit prosody therefore raises the question of the extent to which syntactic or semantic analyses versus phonological constraints (and the alignment of these) influence the prosody that is formulated. Fodor (2002) discusses cases in which phonological length seems dominant in establishing implicit prosody. Hirose (2003) tests materials (as in (1)) that are superficially similar to ours, in that both examine whether the length of a matrix clause subject affects the association of the subsequent phrase to the matrix clause or a relative clause. Yet our materials differ in the timing of the cue for a relative clause, in a way that appears to affect constraints on the implicit prosody. In Hirose's materials, the relative clause could not be identified until the third word after the ambiguously associated accusative phrase. The accusative NP was followed by an adverb and the relative clause verb, and then finally by the relative clause head that signaled the need for revision. Her participants would have had no strong motivation to construct anything more than a simple clause in the prosodically critical region, and so optimal prosodic length constraints would not have interacted during initial processing with constraints that align the left edge of a relative clause with a prosodic boundary.

In the structure we tested, the nominative phrase that immediately follows the ambiguously associated dative phrase provides a strong cue for the presence of a relative clause. Therefore, we can examine whether this cue has an immediate effect on the prosody built for the dative phrase. The first-pass production results for the long-subject sentences indicate the matrix subject NP and dative NP were placed in separate intonation phrases in 69% of the utterances. The first intonation phrase was justified by the length of the matrix subject (at 7.50 syllables). Yet the dative phrase was only 4 syllables long. Such a length is sufficient for an intonation phrase (although on the short side), but certainly does not force one. The fact that speakers often produced such a boundary suggests that prosody-syntax alignment constraints interact with prosodic length constraints during the first pass and prosodic length constraints are not strong enough to consistently override the syntactic bias of this construction. Instead, speakers regularly adopted a prosody that reflects the preferred syntactic analysis (see also Lovric 2003 for a prosodic phrasing cue from a specific preposition). Readers show incremental sensitivity to phrase length, but phrase length effects can be rapidly dominated by syntactic parsing preferences, even in first-pass reading.

The evidence of rapid use of syntactic information in the first-pass productions is important for our understanding of how prosodic structure is determined in the course of processing. When speakers construct overt prosody during spontaneous speech, one can view the relationship between prosodic phrase boundaries and major syntactic boundaries as being driven completely by processing demands. For example, Watson and Gibson (2004) proposed that

prosodic boundaries occur at the edges of long syntactic phrases because the production system uses the additional time generated by prosodic boundaries to plan or recover from the construction of complex syntactic phrases. Alternatively, the grammar of a language may specify constraints relating syntactic form and prosodic form, leading to the alignment of prosodic and syntactic phrase edges in production and comprehension without a direct dependence on processing load (e.g., Blodgett 2004; Frazier et al. 2004). (Naturally, it's possible for both explanations to be simultaneously true, and for the grammatical constraints to have processing origins.)

It seems unlikely that readers, constructing implicit or first-pass prosody, have as many processing demands at the left edge of a major syntactic boundary as they would in spontaneous production, when they must plan upcoming syntactic and lexical material. The fact that we still see such a strong tendency to place a prosodic boundary at the left edge of a relative clause in our first-pass readings supports the position that the relationship between prosodic boundaries and major syntactic boundaries has become an independent constraint in production; that is, it seems unlikely that the prosody is fully determined by functional motivations such as processing load. Schafer et al. (2000, 2005) have argued that read-aloud tasks can underestimate the relationship between prosody and syntax in spontaneous sentence production. The current results point out that read-aloud studies on first-pass prosody can be informative about prosody-syntax mappings when the signal for a syntactic boundary has sufficient strength and the right timing and that reading studies can help tease apart explanations for how overt prosody is determined in spontaneous production.

Questions remain about when syntactic biases and cues are strong enough to override length considerations, versus when they are not. We speculate that differences in prosodic and syntactic constraints between our dative association materials and the relative clause attachment tested by Jun (2007) and Jun and Kim (2004) may account for why we found robust effects of length on prosodic phrasing, but their effects were more mixed. For example, there should be no strong constraint against placing a long matrix subject in a separate intonation phrase, but there might be some tendency to avoid splitting relative clauses or genitive NPs from their heads (Jun 1996; Selkirk 2000; Truckenbrodt 1999; but see also Jun 2003). In addition, if there is a strong correlation in Korean between the left edge of a relative clause and the presence of an intonation phrase boundary, but a much weaker correlation between intonation phrase boundaries and the right edges of phrases (Venditti et al. 1996; Selkirk 1986), we would expect stronger results for the dative ambiguity than for the relative clause one.

To conclude, our results demonstrate significant effects of length on prosodic phrasing that are nevertheless sensitive to previously established syntactic biases. The patterns from Korean join with those from other languages in showing widespread support for implicit prosody effects in comprehension, and effects that persist when syntactic complexity, information load, and referential status have been controlled. Further, the variability that exists among implicit prosody tests with Korean materials converges with claims about prosody-syntax alignment constraints. Tests of implicit prosody can thus contribute to our understanding of both non-prosodic parsing biases and the constraints on overt prosody, as well as generally illuminating the cognitive processes that take place during reading.

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Appendix

The critical items for Experiment 2 are given below. The critical items for Experiment 1 were the ambiguous conditions of the 12 items marked by an asterisk. Yale Romanization is used for the representation of Korean examples. The abbreviations used in the glosses are as follows:

NOM: Nominative case, ACC: Accusative case, DAT: Dative case, BEN: Benefactive, REL: relative clause marker, L: Linker, PST: Past tense, DECL: Declarative marker. Each condition is listed separately for item 1. For the remainder, the distinctive portion of long matrix subjects is in parentheses, as are adverb versus second dative NP alternates.

*1.

a. Short subject ambiguous condition

Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ unkunsulccek/ phala-pelye-ss-ta.
1-Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM / 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-stealthily/ 7-sell-complete-PST-DECL.
'Piglet stealthily sold Robin [the honeycomb [that Pooh picked]].' *or*
'Piglet stealthily sold [the honeycomb [that Pooh picked for Robin]].'

b. Short subject disambiguated condition

Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ Thige-eykey/ phala-pelye-ss-ta.
1-Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-Tigger-DAT/ 7-sell-complete-PST-DECL.
'Piglet sold Tigger [the honeycomb [that Pooh picked for Robin]].'

c. Long subject ambiguous condition

Saykkitwayci Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ unkunsulccek/ phala-pelye-ss-ta.
1-Little Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6- stealthily/ 7-sell-complete-PST-DECL.
'Little Piglet stealthily sold Robin [the honeycomb [that Pooh picked]].' *or*
'Little Piglet stealthily sold [the honeycomb [that Pooh picked for Robin]].'

d. Long subject disambiguated condition

Saykkitwayci Phigules-i/ Lopin-eykey/ Phwuwu-ka/ tta-cwu-n/ pelcip-ul/ Thige-eykey/ phala-pelye-ss-ta.
1-Little Piglet-NOM/ 2-Robin-DAT/ 3-Pooh-NOM/ 4-pick-BEN-REL/ 5-honeycomb-ACC/ 6-Tigger-DAT/ 7-sell-complete-PST-DECL.
'Little Piglet sold Tigger [the honeycomb [that Pooh picked for Robin]].'

2. (Mosmallinun) Ccangkwu-ka/ Chelswu-eykey/ Hwuni-ka/ thelenohu-n/ pimil-ul/ (sulkumeni | Yuli-eykey)/ malhay-cwu-ess-ta.
(Unstoppable) Ccangkwu-NOM/ Chelswu-DAT/ Hwuni-NOM/ confide-REL/ secret-ACC/ (furtively | Yuli-DAT)/ tell-BEN-PST-DECL.
'(Unstoppable) Ccangkwu (furtively) told (Chelswu | Yuli) the secret that Hwuni confided (to Chelswu).'

3. (Aki Konglyong) Twuli-ka/ Ttochi-eykey/ Hitongi-ka/ sa-cwu-n/ cangnankam-ul/ (calangsulepkey | Towune-eykey)/ poye-cwu-ess-ta.
(Baby Dragon) Twuli-NOM/ Ttochi-DAT/ Hitongi-NOM/ buy-BEN-REL/ toy-ACC/ (proudly | Towune-DAT)/ show-BEN-PST-DECL.
'(Baby Dragon) Twuli (proudly) showed (Ttochi | Towune) the toy that Hitongi bought (for Ttochi).'

*4. (Malkwallyangi) Ppippi-ka/ Nilsun-eykey/ Thomi-ka/ tenci-n/ paykwukong-ul/ (nallyephakey | Hansu-eykey)/ kalochay-cwu-ess-ta.
(Romping) Pippi-NOM/ Nilsson-DAT/ Tommy-NOM/ throw-REL/ volleyball-ACC/ (swiftly | Hans-DAT)/ snatch-BEN-PST-DECL.
'(Romping) Pippi (swiftly) snatched (for Nilsson | Hans) the volleyball that Tommy threw (at Nilsson).

5. (Kaykwuli Cwungsa) Khelolo-ka/ Nala-eykey/ Mina-ka/ ponay-n/ phyenci-lul/ (khunsolilo | Wucwu-eykey)/ ilk-e-cwu-ess-ta.
(Sergeant Frog) Keroro-NOM/ Nala-DAT/ Mina-NOM/ send-REL/ letter-ACC/ (loudly | Wucwu-DAT)/ read-L-BEN-PST-DECL.
'(Sergeant Frog) Keroro (loudly) read (Nala | Wucwu) the letter that Mina sent (to Nala).'

6. (Milay Sonyen) Khonan-i/ Phopi-eykey/ Lana-ka/ pillye-cwu-n/ pomwulcito-lul/ (hwaksilhakey | Theyla-eykey)/ inkyeyhay-ss-ta.
(Future Boy) Khonan-NOM/ Phopi-DAT/ Lana-NOM/ lend-BEN-REL/ treasure map-ACC/ (definitely | Theyla-DAT)/ hand over-PST-DECL.
'(Future Boy) Khonan (definitely) handed over (to Phopi | Theyla) the treasure map that Lana lent (to Phopi).'

*7. (Unha Chelto) Sencang-i/ Cheli-eyeky/ Meytheyl-i/ cisiha-n/ yehayng-ul/ (kankyelhakey| Halok-eykey)/ yoyakhay-cwu-ess-ta.
(The Galaxy Express) Captain-NOM/ Cheli-DAT/ Meytheyl-NOM/ assign-REL/ journey-ACC/ (briefly | Halok-DAT)/ summarize-BEN-PST-DECL.
'(The Galaxy Express) Captain (briefly) summarized (for Cheli | Halok) the journey that Meythel assigned (to Cheli).'

*8. (Choycong Pyengki) Chisey-ka/ Syuci-eykey/ Akheymi-ka/ kulye-cwu-n/ kulim-ul/ (caseyhakey | Noli-eykey)/ myosahay-ss-ta.
(Ultimate Weapon) Chisey-NOM/ Syuci-DAT/ Akheymi-NOM/ draw-BEN-REL/ picture-ACC/ (minutely | Noli-DAT)/ describe-PST-DECL.
'(Ultimate Weapon) Chisey (minutely) described (to Syuci | Noli) the picture that Akheymi drew (for Syuci).'

9. (Pangkwi Taycang) Ppwungppwungi-ka/ Chichi-eykey/ Ppwungswuni-ka/ cwumwu-nha-n/ wuyu-lul/ (helttekkelimye | Ppikppiki-eykey)/ paytalhay-ss-ta.
(Great Farter) Ppwungppwungi-NOM/ Chichi-DAT/ Ppwungswuni-NOM/ order-REL/ milk-Acc/ (pantingly | Ppikppiki-DAT)/ deliver-PST-DECL.
'(Great Farter) Ppwungppwungi (pantingly) delivered (to Chichi | Ppikppiki) the milk that Ppwungswuni ordered (to Chichi).'

*10. (Ppalkan Mangtho) Chacha-ka/ Ttwuttwu-eykey/ Chingching-i/ peyphwu-n/ senhayng-ul/ (sangseyhakey | Pingping-eykey)/ pokohay-ss-ta.
(Red Cloak) Chacha-NOM/ Ttwuttwu-DAT/ Chingching-NOM/ give-REL/ favor-ACC/ (thoroughly | Pingping-DAT)/ report-PST-DECL.
'(Red Cloak) Chacha (thoroughly) reported (to Ttwuttwu | Pingping) the favor that Chingching gave (to Ttwuttwu).'

11. (Sonyen Myengthamceng) Khonan-i/ Seymo-eykey/ Mwungchi-ka/ kenney-cwu-n/ cungkemwul-ul/ (kanglyekhakey | Alum-eykey)/ yokwuhay-ss-ta.
(Young Detective) Khonan-NOM/ Seymo-DAT/ Mwungchi-NOM/ transfer-BEN-REL/ exhibit-ACC/ (emphatically | Alum-DAT)/ ask-PST-DECL.
'(Young Detective) Khonan (emphatically) asked (Seymo | Alum) for the exhibit that Mwungchi transferred (to Seymo).'

*12. (Tulcangmi Sonye) Khaynti-ka/ Niil-eykey/ Ansoni-ka/ mwul-e-po-n/ cilmwun-ul/ (kekcengsulepkey | Alpetu-eykey) / toymwul-e-ss-ta.
(Wild Rose Girl) Candy-NOM/ Neal-DAT/ Anthony-NOM/ ask-L-try-REL/ question-ACC/ (uneasily | Albert-DAT) / ask again-L-PST-DECL.
'(Wild Rose Girl) Candy (uneasily) asked (Neal | Albert) the question again that Anthony asked (Neal).'

13. (Nalunun) Hoppangmayn-i/ Lolppang-eykey/ Sikppangmayn-i/ sokayha-n/ chicu-lul/ (cekkukcekulo | Khaleyppang-eykey)/ chwuchenhay-ss-ta.
(Flying) Hoppangmayn-NOM/ Lolppang-DAT/ Sikppangmayn-NOM/ introduce-REL/ cheese-ACC/ (strongly | Khaleyppang-DAT)/ recommend-PST-DECL.
'(Flying) Hoppangmayn (strongly) recommended (Lolppang | Khaleyppang) the cheese that Sikppangmayn introduced (to Lolppang).'

14. (Chenpangcichwuk) Hani-ka/ Unay-eykey/ Hongtwukkay-ka/ naypichi-n/ sokmaum-ul/ (sayngkakepsi | Changswu-eykey)/ ttetul-e-tay-ss-ta.
(Impulsive) Hani-NOM/ Unay-DAT/ Hongtwukkay-NOM/ intimate-REL/ intention-ACC/ (indifferently | Changswu-DAT)/ jabber-L-repeat-PST-DECL.
'(Impulsive) Hani (indifferently) jabbered (to Unay | Changswu) the intention that Hongtwukkay intimated (to Unay).'

15. (Talpich Chensa) Lwuna-ka/ Phwulmwun-eykey/ Meylloni-ka/ ceyanha-n/ keyim-ul/ (panpokhayse | Thatho-eykey)/ selmyenghay-cwu-ess-ta.
(Moonlight Angel) Lwuna-NOM/ Phwulmwun-DAT/ Meylloni-NOM/ suggest-REL/ game-ACC/ (repeatedly | Thatho-DAT)/ explain-BEN-PST-DECL.
'(Moonlight Angel) Lwuna (repeatedly) explained (to Phwulmwun | Thatho) the game that Meylloni suggested (to Phwulmwun).'

*16. (Wucwu Sonyen) Athom-i/ Along-eykey/ Lopitha-ka/ penyekhay-cwu-n/ oykwuksi-lul/ wunchiisskey | Seyen-eykey)/ ulph-e-cwu-ess-ta.
(Astroboy) Athom-NOM/ Along-DAT/ Lopitha-NOM/ translate-BEN-REL/ foreign poem-ACC/ (elegantly | Seyen-DAT)/ recite-L-BEN-PST-DECL.
'(Astroboy) Athom (elegantly) recited (for Along | Seyen) the foreign poem that Lopitha translated (for Along).'

*17. (Pangka Pangka) Haymtholi-ka/ Phaynte-eykey/ Nyamnyami-ka/ call-a-cwu-n/ chicu-lul/ (nallyephakey | Yuna-eykey)/ mwul-e-ta-cwu-ess-ta.
(Hi Hi) Haymtholi-NOM/ Paynte-DAT/ Nyamnyami-NOM/ slice-L-BEN-REL/ cheese-ACC/ (nimly | Yuna-DAT)/ take in his mouth-L-intensifier-BEN-PST-DECL.
'(Hi Hi) Haymtholi (nimbly) took (for Paynte | Yuna) the cheese in his mouth that Nyamnyami sliced (for Paynte).'

*18. (Thaykwen Wang) Kangthaypwung-i/ Tochen-eykey/ Chenha-ka/ censwuha-n/ sinkiswul-ul/ (hwullyunghakey | Tomi-eykey)/ senpoye-ss-ta.
(Taekwondo King) Kangthaypwung-NOM/ Tochen-DAT/ Chenha-NOM/ impart-REL/ new technique-ACC/ (excellently | Tomi-DAT) / display-PST-DECL.
'(Taekwondo King) Kangthaypwung (excellently) displayed (for Tochen | Tomi) the new technique that Chenha imparted (to Tochen).'

*19. (Khwaykel Longmayn) Nalongi-ka/ Wukkya-eykey/ Swungswungi-ka/ kaluchye-cwu-n/ cengtap-ul/ (cipyohakey | Talpong-eykey)/ khaymwul-e-ss-ta.
(Righteous Longman) Nalongi-NOM/ Wukkya-DAT/ Swungswungi-NOM/ teach-BEN-REL/ answer-ACC/ (tenaciously | Talpong-DAT)/ pry-L-Pst-Decl.
'(Righteous Longman) Nalongi (tenaciously) pried (from Wukkya | Talpong) the answer that Swungswungi gave (to Wukkya).'

*20. (Khatu Khaypthe) Sakhwula-ka/ Kheylo-eykey/ Thakhasi-ka/ cakkokhay-cwu-n/ nolay-lul/ (hwullyunghakey | Litu-eykey)/ yencwuhay-poye-ss-ta.
(Card Capter) Sakhwula-NOM/ Kheylo-DAT/ Thakhasi-NOM/ compose-BEN-REL/ song-ACC/ (nicely | Litu-DAT) / play-show-PST-DECL.
'(Card Capter) Sakhwula (nicely) played (for Kheylo | Litu) the song that Thakhasi composed (for Kheylo).'

21. (Syupe Lwukhi) Sethaywung-i/ Thaysep-eykey/ Paykho-ka/ poye-cwu-n/ nongkwu-yelceng-ul/ (cinsimulo | Chiswu-eykey)/ chingchanhay-ss-ta.
(Super Rookie) Sethaywung-NOM/ Thaysep-DAT/ Paykho-NOM/ show-BEN-REL/ passion for the basketball-ACC/ (sincerely | Chiswu-DAT)/ praise-PST-DECL.
'(Super Rookie) Sethaywung (sincerely) told (Thaysep | Chiswu) good things about Paykho who showed (Thaysep) his passion for the basketball.'

22. (Chensa Sonye) Saylomi-ka/ Ppochi-eykey/ Yuli-ka/ pwul-e-cwu-n/ phwungsen-ul/ (cayppalukey | Naykha-eykey)/ mwukk-e-cwu-ess-ta.
(Angel Girl) Saylomi-NOM/ Ppochi-DAT/ Yuli-NOM/ inflate-L-BEN-REL/ balloon-ACC/ (quickly | Naykha-DAT)/ tie-L-BEN-PST-DECL.
'(Angel Girl) Saylomi (quickly) tied (for Ppochi | Naykha) the balloon that Yuli inflated (for Ppochi).'

*23. (Kkoma Mapepsa) Leymi-ka/ Meyi-eykey/ Pola-ka/ allye-cwu-n/ yoli-lul/ (cengsengsulepkey | Salangi-eykey)/ mantul-e-cwu-ess-ta.
(Young Magician) Leymi-NOM/ Meyi-DAT/ Pola-NOM/ inform-BEN-REL/ food-ACC/ (earnestly | Salangi-DAT)/ prepare-L-BEN-PST-DECL.
'(Young Magician) Leymi (earnestly) prepared (for Meyi | Salangi) the food that Pola informed (Meyi) of.'

24. (Iwuscip) Thotholo-ka/ Meyi-eykey/ Khantha-ka/ kkulye-cwu-n/ lamyen-ul/ (coshimsulepkey | Sachukhi-eykey)/ tel-e-cwu-ess-ta.
(Neighbor) Thotholo-NOM/ Meyi-DAT/ Khantha-NOM/ cook-BEN-REL/ noodle-ACC/ (carefully | Sachukhi-DAT)/ serve-L-BEN-PST-DECL.
'(Neighbor) Thotholo (carefully) served (Meyi | Sachukhi) the noodle that Khantha cooked (for Meyi).'

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