PROSODIC DISAMBIGUATION OF SYNTACTICALLY AMBIGUOUS PHRASES IN KOREAN*

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1 Introduction

Often in spoken language, syntactic ambiguity is resolved by the use of prosody. Identical surface forms with different underlying syntactic structures are distinguishable by different prosodic patterns. This reconfirms the widely acknowledged idea that prosody is, at least to some degree, grounded in syntax. In Korean, a complex DP such as (1) is syntactically ambiguous, as the relative clause (CP) can modify either NP1 or NP2. If it modifies NP1, it is attached to the syntactic structure at a lower position, leading to a low attachment reading as in (1a). If it modifies NP2, it is attached at a higher position, yielding a high attachment reading as in (1b).

(1) [*pucilenha-n*]$_{CP}$ [*nam-haksayng-uy*]$_{NP1}$ [*nuna*]$_{NP2}$
diligent-COMP male-student-POSS older.sister

a. low attachment: [[[*pucilenha-n*]$_{CP}$ [*nam-haksayng-uy*]$_{NP1}$]$_{DP1}$ [*nuna*]$_{NP2}$]$_{DP2}$
'the older sister of the diligent male student'

b. high attachment: [[*pucilenha-n*]$_{CP}$ [[*nam-haksayng-uy*]$_{NP1}$ [*nuna*]$_{NP2}$]$_{DP}$]$_{DP}$
'the diligent older sister of the male student'

Previous research on such complex DPs in Korean found that a high attachment reading is preferred in comprehension and that the edge of the relative clause often shows a stronger prosodic boundary than that of NP1 (Jun and Kim, 2004). However, the precise link between different readings and prosodic patterns has not been systematically investigated.

This study aims to examine prosodic disambiguation of syntactic ambiguity in Korean and provide an account based on a direct syntax-prosody mapping. The rest of this section introduces a theory on syntax-prosody mapping (section 1.1) and makes prediction for Korean complex DPs

*WE WOULD LIKE TO THANK ANONYMOUS REVIEWERS AND THE AUDIENCE OF WAFL 13. WE ARE ALSO GRATEFUL TO ELLEN BROSELOW, JOSÉ ELÍAS-ULLOA, AND SEUNGHUN LEE FOR THEIR HELPFUL COMMENTS.

based on the introduced theory (section 1.2). Section 2 describes a production experiment and analysis of its data. Section 3 reports experiment results and discusses their theoretical implication. Section 4 concludes and suggests possible directions for future research.

1.1 Syntax-prosody mapping

Use of prosody to resolve syntactic ambiguity demonstrates that prosody is more grounded in syntax than had been previously considered. This motivated frameworks of prosodic theories to be revised so as to account for a stronger faithful relation between syntax and prosody. This relation has been represented for example as an edge-based constraint ALIGN or a phrase-based constraint WRAP (Selkirk, 2000, Truckenbrodt, 1995, 1999). More recently in the framework of Match Theory, the mapping between syntax and prosody has been formalized as a set of Match constraints (Selkirk, 2009, 2011, Selkirk and Lee, 2015). Analogous to input-output faithfulness constraints in Optimality Theory (Prince and Smolensky, 2004), Match constraints, as defined in (2), call for a faithful mapping between each level of syntactic categories and each level of prosodic categories. For example, MATCH(phrase, ϕ), as in (2b), requires correspondence between edges of a maximal projection of a phrase in syntax and edges of a phonological phrase in phonology.

(2) a. MATCH(clause, ι)
The left and right edges of a clause in syntactic representation must correspond to the left and right edges of an Intonational Phrase (ι) in phonological representation.

b. MATCH(phrase, ϕ)
The left and right edges of a maximal projection of a phrase (XP) in syntactic representation must correspond to the left and right edges of a Phonological Phrase (ϕ) in phonological representation.

c. MATCH(word, ω)
The left and right edges of a word (X) in syntactic representation must correspond to the left and right edges of a Prosodic Word (ω) in phonological representation.

Unlike in other theories on intonational phonology where prosodic domains are posited to be *strictly layered* (Nespor and Vogel, 1986, Selkirk, 1984), the direct mapping between syntax and phonology in Match theory allows recursive occurrence of prosodic constituents. For instance, as maximal phrases can be recursively embedded in other maximal phrases in syntax, the direct mapping of their edges leads to recursive prosodic categories in prosody as well. Recursivity of prosodic constituents derived from recursive syntactic constituents is illustrated in Figure 1. Evidence for recursivity in prosodic structure has been reported in recent studies including Ito and Mester (2007).

When multiple levels of a prosodic category occur recursively, they can be categorized into maximal and minimal categories, as in (3) (Ito and Mester, 2013). For instance, in a structure with more than one levels of ϕ, a ϕ is minimal (ϕ_{min}) when it does not dominate any other ϕ, i.e., when it is the lowest level of ϕ. If it dominates one or more levels of ϕ, it is non-minimal ($\phi_{\text{non-min}}$).

(3) a. maximal (projection of) $\alpha =_{\text{def}} \alpha$ not dominated by α

b. minimal (projection of) $\alpha =_{\text{def}} \alpha$ not dominating α

Figure 1: Recursivity in syntactic and prosodic structure

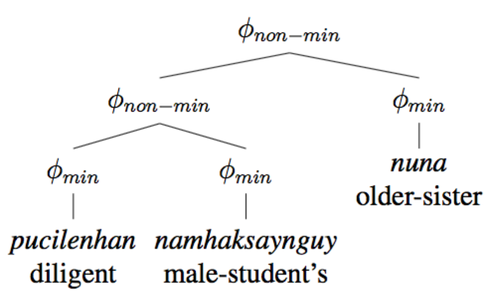
The distinction between minimal and non-minimal prosodic categories is crucial because it affects their prosodic realization. Previous studies have found that left or right edges of $\phi_{\text{non-min}}$ are associated with a distinct tonal pattern or a stronger degree of prosodic pattern than edges of ϕ_{min}. For instance, in Connemara Irish, a phrase-initial LH accent is associated only with the left edge of $\phi_{\text{non-min}}$ but not that of ϕ_{min} (Elfner, 2012, 2015). Similarly in Lekeitio Basque, the left edge of $\phi_{\text{non-min}}$ triggers pitch reset while that of ϕ_{min} does not (Elordieta, 2015).

1.2 Prediction

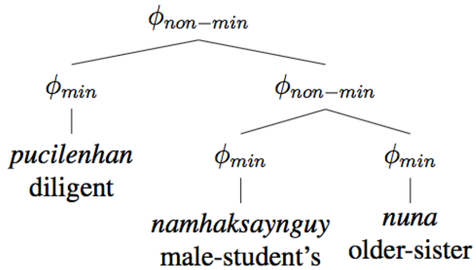
Given the different behavior of ϕ_{min} and $\phi_{\text{non-min}}$ in languages, it is expected that in Korean as well a left or right edge of a $\phi_{\text{non-min}}$ has a prosodic effect that is distinct from that of a ϕ_{min}. Despite little association with syntax, a previous study on Korean complex phrases found distinct boundary tones, pitch reset, and pause appearing in some of the phrasal boundaries (Jun and Kim, 2004). Thus, this study hypothesized that a left or right edge of a $\phi_{\text{non-min}}$ is associated with a stronger prosodic boundary, marked by either i) a distinct boundary tone, ii) pitch reset, or iii) pause, than edges of a ϕ_{min}.

Different readings of complex DPs such as (1) result from different phrasing in syntactic structure. Consequently, the direct mapping between syntactic phrase edges and edges of ϕ derives different structures in prosody as well. Tree diagrams in (4a-b) show prosodic structure of each reading, where edges of ϕ are corresponding to edges of XP in (1a-b), respectively.

(4) a. low attachment reading



b. high attachment reading



The two structures have edges of $\phi_{\text{non-min}}$ in different word boundaries. In the low attachment reading (4a), there is a right edge of $\phi_{\text{non-min}}$ between the two NPs. In the high attachment reading (4b), on the other hand, there is a left edge of $\phi_{\text{non-min}}$ between CP and NP1. Therefore, we expect a stronger prosodic boundary between CP and NP1 in the high attachment reading than in the low attachment reading, as well as between NP1 and NP2 in the low attachment reading than in the high attachment reading.

2 Methods

In order to test our hypotheses, a production experiment was conducted to elicit prosodic disambiguation of complex DPs in Korean. Speakers were given paraphrases of different readings and were asked to produce target phrases to convey the given meaning.

2.1 Materials

Target phrases were six syntactically ambiguous phrases consisting of a relative clause and two noun phrases. They were categorized into three syntactic types. In Type A, both noun phrases consisted of a head noun only. In Type B, the first NP contained a one-word CP modifying N1, while in Type C, the second NP contained a one-word CP modifying N2. The phrases are listed in Table 1.

2.2 Participants

Twelve Korean speakers (7 males, 5 females) participated in the experiment. The participants were living near Stony Brook University campus at the time of their participation, but all of them reported that they spoke Seoul Korean as their native language and that they had lived in the Seoul Capital area for at least 10 years.

2.3 Procedure

Each participant was seated in front of a computer screen. Each slide presented one of the target phrases embedded in a carrier sentence. Below the sentence were given two contexts, eliciting its high attachment reading (High condition) and low attachment reading (Low condition). The participants were asked to read aloud the given sentence twice, each time according to one of the given contexts. The order between the two conditions were counter-balanced across participants. 12 speakers $\times$ 3 syntactic types $\times$ 2 target phrases $\times$ 2 conditions yielded 144 utterances.

Type A	**[V]**$_{CP}$	**[**	**N1]**$_{NP1}$	**[**	**N2]**$_{NP2}$
	pucilunha-n		*nam-haksayng-uy*		*nuna*
	diligent-COMP		male-student-POSS		older.sister
	coyongha-n		*tongney-uy*		*kongwen*
	quiet-COMP		town-POSS		park
Type B	**[V]**$_{CP}$	**[[V]**$_{CP}$	**N1]**$_{NP1}$	**[**	**N2]**$_{NP2}$
	yumyengha-n	*olaytoy-n*	*nolay-uy*		*cakkokka*
	famous-COMP	old-COMP	song-POSS		composer
	yamcenha-n	*alumtawu-n*	*yeca-uy*		*nam-tongsayng*
	quiet-COMP	beautiful-COMP	woman-POSS		younger-brother
Type C	**[V]**$_{CP}$	**[**	**N1]**$_{NP1}$	**[[V]**$_{CP}$	**N2]**$_{NP2}$
	camca-nun		*aki-uy*	*kanyeli-n*	*emma*
	sleep-COMP		baby-POSS	slender-COMP	mother
	kongpuha-nun		*yeca-uy*	*tacengha-n*	*oppa*
	study-COMP		woman-POSS	kind-COMP	older.brother

Table 1: Target phrases in three syntactic types

2.4 Analysis

After running the experiment, prosodic boundaries of CP-NP1 as well as NP1-NP2 were investigated. Each boundary was labeled as either a regular or a strong boundary. They were labeled as a *regular boundary* if there was an H boundary tone on the preceding phrase, which usually designates a right edge of a word in Korean (Jun, 1998). They were labeled as a *strong boundary*, if there were one or more of the following patterns: pause between words, phrase-final lengthening in the preceding word with a boundary tone other than H, such as HL or LH, or pitch reset in the following word.

For example, Figure 2 is a pitch contour of an actual production of a stimulus Type C ([*camcanun* 'sleeping']$_{CP}$ [*akiuy* 'baby's']$_{NP1}$ [*kanyelin* 'slender' *emmaka* 'mom']$_{NP2}$) produced in Low attachment condition. At the boundary between CP and NP1, the preceding word *camcanun* has an H boundary tone with no other relevant prosodic pattern, and thus it was labeled as a regular boundary. At the boundary between NP1 and NP2, there is an HL boundary tone in the preceding word *akiuy*, pause between the two words, as well as pitch reset in the following word *emmaka*, breaking the chain of downstep. Therefore, this boundary was labeled as a strong boundary. Figure 3 is a pitch contour of the same phrase produced by the same speaker but in High attachment condition. In this contour, the boundary between CP and NP1 displays all the three patterns marking a strong boundary, while the boundary between NP1 and NP2 shows an H boundary tone in the preceding word *akiuy*, thus marking a regular boundary.

All speech analyses were done with Praat (Boersma and Weenink, 2016). After labeling the boundaries, the frequency of strong boundary was calculated and compared across conditions. Differences in the frequency of strong prosodic boundary across conditions were statistically analyzed by Fisher's exact test using R (R Core Team, 2014).

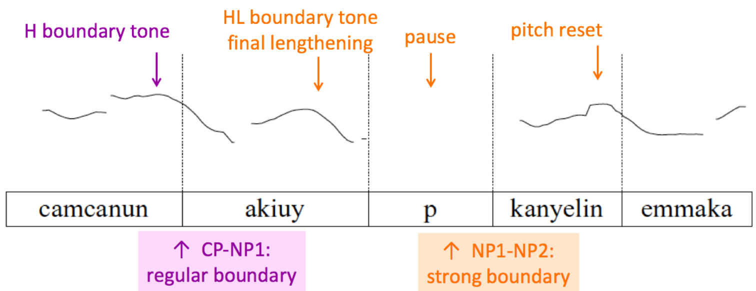


Figure 2: Example pitch contour: Type C, Low attachment

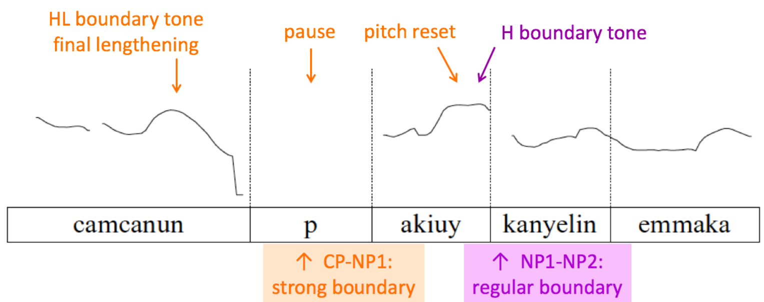


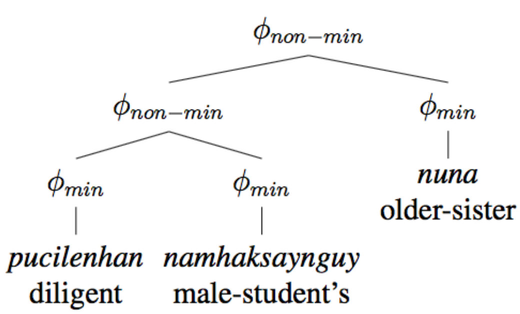
Figure 3: Example pitch contour: Type C, High attachment

3 Results and Discussion

3.1 Type A: [V]$_{CP}$ [N1]$_{NP1}$ [N2]$_{NP2}$

(5) is a copy of (4), which illustrates two prosodic structures of stimuli of type A, where both nouns consisted of a head noun only. In the low attachment reading, there is a right edge of $\phi_{\text{non-min}}$ between the two NPs. In the high attachment reading, there is a left edge of $\phi_{\text{non-min}}$ between CP and NP1. Thus, it was predicted that the low attachment reading would have a strong prosodic boundary between NP1 and NP2, while the high attachment reading was predicted to have a strong boundary between CP and NP1.

(5) a. low attachment reading



b. high attachment reading

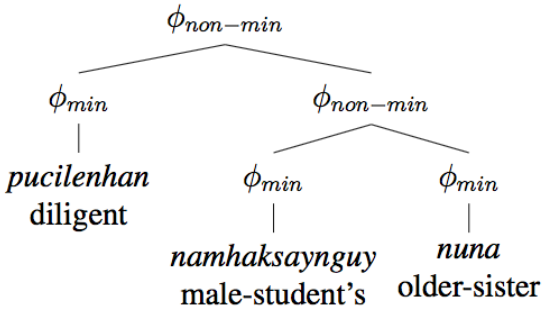


Table 2 shows the number of edges of $\phi_{\text{non-min}}$ and the frequency of strong prosodic boundary at each word boundary for each reading. The boundary between CP and NP1 was realized as a strong prosodic boundary more frequently in the high attachment reading, where it was associated with a left edge of $\phi_{\text{non-min}}$, than in the low attachment reading, where there was no $\phi_{\text{non-min}}$ edge. The difference was statistically significant ($p < .001$). The boundary between NP1 and NP2 was realized as a strong boundary more often in the low attachment reading, where it was associated with a right edge of $\phi_{\text{non-min}}$, and the difference was also statistically significant ($p < .001$).

Condition		CP-NP1 boundary	NP1-NP2 boundary
Low attachment	$\phi_{\text{non-min}}$ edge:	none	1 right edge
	strong boundary:	12.5%	79.2%
High attachment	$\phi_{\text{non-min}}$ edge:	1 left edge	none
	strong boundary:	50.0%	16.7%

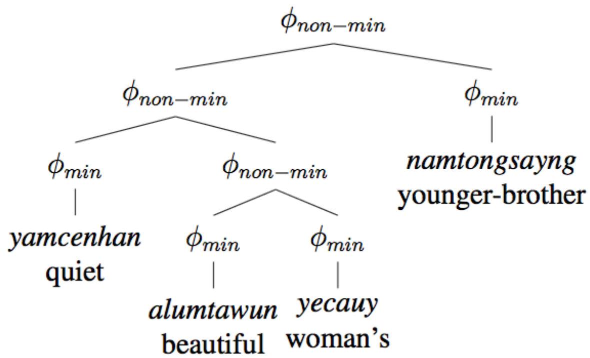
Table 2: Number of $\phi_{\text{non-min}}$ edges and frequency of strong boundary: Type A

These results suggest that both left and right edges of $\phi_{\text{non-min}}$ are associated with a strong prosodic boundary more frequently than edges of ϕ_{min}. It supports our prediction that edges of $\phi_{\text{non-min}}$ are realized as a stronger prosodic boundary than edges of ϕ_{min}.

3.2 Type B: [V]$_{\text{CP}}$ [[V]$_{\text{CP}}$ N1]$_{\text{NP1}}$ [N2]$_{\text{NP2}}$

Tree diagrams in (6) show two prosodic structures of stimuli of type B, where the first noun is modified by an additional relative clause. In the low attachment reading, there is a left edge of $\phi_{\text{non-min}}$ between CP and NP1, and two right edges are coinciding between NP1 and NP2. In the high attachment reading, two left edges of $\phi_{\text{non-min}}$ are coinciding between CP and NP1, and there is one right edge between the two NPs.

(6) a. low attachment reading



b. high attachment reading

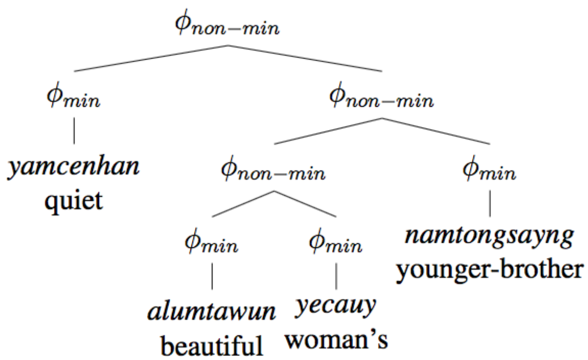


Table 3 shows the number of $\phi_{\text{non-min}}$ edges and the frequency of strong prosodic boundary at each word boundary for each reading. The boundary between CP and NP1 was realized as a strong boundary more often when two left edges of $\phi_{\text{non-min}}$ were co-occuring (high attachment reading) than when there was a single left edge of $\phi_{\text{non-min}}$ (low attachment reading), but the difference was not found to be significant. The boundary between NP1 and NP2 was realized as a strong boundary more frequently when two right edges of $\phi_{\text{non-min}}$ were co-occurring (low attachment reading) than when there was a single right edge (high attachment reading). The difference was statistically significant ($p < .001$).

Condition		CP-NP1 boundary	NP1-NP2 boundary
Low attachment	$\phi_{\text{non-min}}$ edge:	1 left edge	2 right edges
	strong boundary:	50%	91.7%
High attachment	$\phi_{\text{non-min}}$ edge:	2 left edges	1 right edge
	strong boundary:	62.5%	29.2%

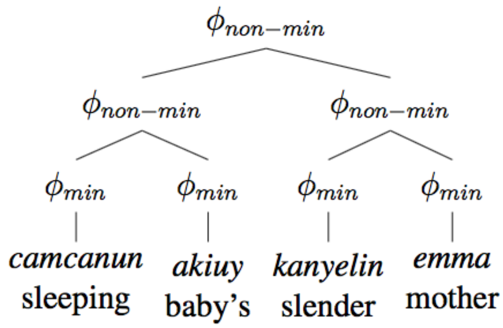
Table 3: Number of $\phi_{\text{non-min}}$ edges and frequency of strong boundary: Type B

These results indicate a cumulative effect of edges of $\phi_{\text{non-min}}$. That is, more than one edges of $\phi_{\text{non-min}}$ coinciding at the same position have a greater prosodic effect than one edge, being associated with a stronger prosodic boundary. The cumulative effect of $\phi_{\text{non-min}}$ edges, however, was found to be significant for its right edges but not for its left edges.

3.3 Type C: [V]$_{CP}$ [N1]$_{NP1}$ [[V]$_{CP}$ N2]$_{NP2}$

Tree diagrams in (7) are two prosodic structures of stimuli of type C, where the second noun is modified by an additional relative clause. In the low attachment reading, a left edge and a right edge of $\phi_{\text{non-min}}$ are co-occurring between NP1 and NP2. In the high attachment reading, there is one left edge of $\phi_{\text{non-min}}$ in each of the two boundaries.

(7) a. low attachment reading



b. high attachment reading

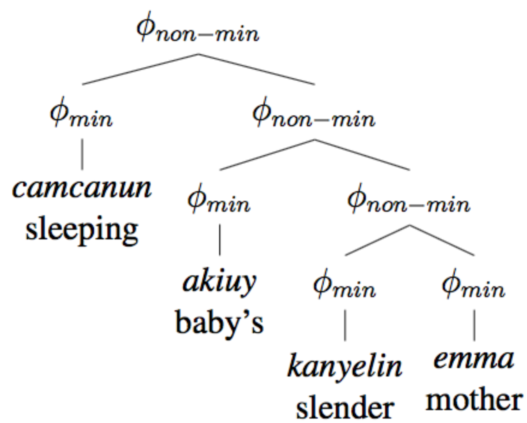


Table 4 shows the number of $\phi_{\text{non-min}}$ edges and the frequency of strong prosodic boundary at each word boundary for each reading. The boundary between CP and NP1 was realized as a strong prosodic boundary more often when there was a left edge of $\phi_{\text{non-min}}$ (high attachment reading) than when there was no $\phi_{\text{non-min}}$ edge (low attachment reading). The boundary between NP1 and NP2 was realized was a strong prosodic boundary more frequently when a left and a right edge of $\phi_{\text{non-min}}$ are co-occurring (low attachment reading) than when there was only a left edge (high attachment reading). Both differences were statistically significant ($p < .001$).

The results confirm our previous results from Type A that a left edge of $\phi_{\text{non-min}}$ is associated with a stronger prosodic boundary than ϕ_{min} edge. Furthermore, it shows the cumulative effect of $\phi_{\text{non-min}}$ edges, whether left or right, as coinciding multiple $\phi_{\text{non-min}}$ edges were realized as a stronger prosodic boundary than a single $\phi_{\text{non-min}}$ edge.

Condition		CP-NP1 boundary	NP1-NP2 boundary
Low attachment	$\phi_{\text{non-min}}$ edge:	none	1 left, 1 right edge
	strong boundary:	12.5%	91.7%
High attachment	$\phi_{\text{non-min}}$ edge:	1 left edge	1 left edge
	strong boundary:	66.7%	25.0%

Table 4: Number of $\phi_{\text{non-min}}$ edges and frequency of strong boundary: Type C

3.4 General Discussion

Overall, the results of the experiment showed the effects of $\phi_{\text{non-min}}$ edges on prosody. First, it was found that left and right edges of $\phi_{\text{non-min}}$ are both realized as a stronger prosodic boundary than edges of ϕ_{min}. This is consistent with previous research results that edges of $\phi_{\text{non-min}}$ have a distinct tonal pattern or a stronger degree of prosodic pattern than edges of ϕ_{min} in other languages (Elfner, 2015, Elordieta, 2015). In the current study, $\phi_{\text{non-min}}$ edges were found to be associated with phonetically strong word juncture, including distinct boundary tones, pause, and pitch reset. It supports the argument that in prosodic structure with recursive prosodic domains, it is necessary to make a distinction between minimal and non-minimal domains (Ito and Mester, 2007).

Second, it was shown that multiple coinciding edges of $\phi_{\text{non-min}}$ are associated with a stronger prosodic boundary more frequently than a single edge. The cumulative effect of prosodic domain edges has also been discussed in previous studies. For instance, Lekeitio Basque has a three-way distinction between cases with a) no left edge of $\phi_{\text{non-min}}$ at a boundary, b) one left edge of $\phi_{\text{non-min}}$ aligned with a boundary, and c) two left edges of $\phi_{\text{non-min}}$ aligned with a boundary (Elordieta, 2015). The higher number of left edge of $\phi_{\text{non-min}}$ is correlated with a higher degree of pitch reset. Also, in Japanese, every ϕ has an initial rise %LH (i.e., Low left boundary tone followed by phrasal High tone), and when two left edges of ϕ occur recursively, the initial rise is significantly larger than the initial rise at the left edge of single ϕ (Ito and Mester, 2013).

When it comes to the effect of a single edge, both left and right edges of $\phi_{\text{non-min}}$ were found to be active. When it comes to the cumulative effect of multiple edges, however, only right edges were shown to be active. Previous findings showed that languages differ in terms of *prosodic activeness* of left versus right edges of prosodic domains (Richards, 2016). The results of the current study suggest that in Korean a right edge of $\phi_{\text{non-min}}$ is more active than its left edge. The activeness of right edges of prosodic domains in Korean has been also discussed in literature, for example with High boundary tone at the right edge of accentual phrases in Korean (Jun, 1998).

One of the three components of a strong prosodic boundary associated with $\phi_{\text{non-min}}$ edges was pitch reset. There are two possible analyses on the occurrence of pitch reset in Korean. One analysis is to posit a prosodic domain called *intermediate phrase* (ip), which is larger than Accentual Phrase (AP) and smaller than Intonation Phrase (IP) (Jun, 2005). For example, in a syntactically ambiguous phrase in (8), pitch reset often occurs between the relative clause and the first noun. The ip-based argument, illustrated in (8a), is that the first two words and the last two words respectively form an ip, and that the boundary between the two ip's triggers pitch reset, as represented by the upward arrow. By positing an additional intermediate prosodic category in the prosodic hierarchy, this analysis follows Strict Layer Hypothesis, in which neither skipping nor recursion of prosodic category is allowed (Nespor and Vogel, 1986, Selkirk, 1984).

(8) [*pyengwen-ey ipwenha-n*]$_{CP}$ [*tonglyo-uy*]$_{NP1}$ [*puin-eykey*]$_{NP2}$
hospital-LOC hospitalized-COMP colleague-POSS wife-DAT

a. Analysis with ip
((*pyengwen-ey*)$_{AP}$ (*ipwenha-n*)$_{AP}$)$_{ip}$ ↑((*tonglyo-uy*)$_{AP}$ (*puin-eykey*)$_{AP}$)$_{ip}$

b. Analysis with recursive ϕ
((*pyengwen-ey*)$_{\phi_{min}}$ (*ipwenha-n*)$_{\phi_{min}}$)$_{\phi_{non\text{-}min}}$ ↑((*tonglyo-uy*)$_{\phi_{min}}$ (*puin-eykey*)$_{\phi_{min}}$)$_{\phi_{non\text{-}min}}$

An alternative analysis of pitch reset in Korean is to posit recursive prosodic categories as argued in the current study. According to this analysis, as in (8b), there are edges of $\phi_{non\text{-}min}$ between the relative clause and NP1, and pitch reset is triggered by these edges. By allowing recursive layering of a prosodic domain, $\phi_{non\text{-}min}$, this analysis explains the occurrence of pitch reset on the basis of syntax-prosody mapping. The two analyses are independently motivated and reasonable in their own ways. However, positing recursive prosodic categories provides a link between syntax and prosody and thus explains the occurrence of pitch reset with regard to prosodic resolution of syntactic ambiguity.

4 Conclusion

The present study examined the prosodic disambiguation of syntactic ambiguities in Korean with regard to syntax-prosody mapping. The results of the study showed the direct mapping between syntactic and prosodic categories, particularly between maximal phrases (XP) in syntax and phonological phrases (ϕ) in prosody. As a consequence of the direct mapping, ϕ was shown to occur recursively in Korean prosodic structure. In production of syntactically ambiguous phrases, $\phi_{non\text{-}min}$ edges were found to be associated with strong prosodic boundaries, marked by distinct boundary tones, pause, and pitch reset. Moreover, co-occurrence of more than one $\phi_{non\text{-}min}$ edges led to a higher frequency of strong prosodic boundaries, showing a cumulative effect.

There still are remaining questions to be answered in future research. First, the current study found that $\phi_{non\text{-}min}$ is associated with strong prosodic boundary in Korean, phonetically realized with one or more prosodic patterns (boundary tones, pause, pitch reset). However, it has not scrutinized the individual occurrence of each pattern, which could lead to a significant result. Second, the present study only investigated prosody in the production of ambiguous phrases. However, as prosody is also a primary acoustic cue used in speech perception, the effect of such prosodic patterns must also be examined in perceptual disambiguation. Third, this study showed the recursive occurrence of ϕ by looking at syntactically ambiguous complex DP structure. As prosodic hierarchy also includes other smaller or larger prosodic domains such as prosodic word (ω) and intonation phrase (ι), it is necessary to see whether they also occur recursively, and if so, how they behave.

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