Prosodic Conditions for Epenthetic Nasals

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ABSTRACT

This paper investigates prosodic conditions for the epenthetic /n/ in Korean. It has been claimed that an epenthetic /n/ appears across prosodic words (Han 1994 Lee 1996). However, using acoustic data as well as aerodynamic data, I argue that the epenthetic /n/ does not always surface across all prosodic words, but that its appearance is prosodically restricted. I further demonstrate that it appears only across prosodic words within an accentual phrase. This finding provides empirical support for the intonation-based model of Korean prosodic structure studies.

Keywords: epenthetic nasals, accentual phrase, Korean prosody, prosody

1. Introduction

In this paper, I argue that the occurrence of epenthetic nasals in Korean is prosodically conditioned. Specifically, based on nasal traces and pitch tracks, I claim that the accentual phrase is the environment for this phonological process in Korean.

In section 2, I briefly review differnt models for Korean prosodic structure. In section 3, I discuss the assertion raised by previous studies (Han 1994, Lee 1996) that we should view *n*-epentheis as a process which applies across prosodic words. In section 4, I present aerodynamic data to show that an *n* is not always epenthesized across all prosodic words, but that its occurrence is prosodically restricted. In section 5, using acoustic data as well as aerodynamic data, I further demonstrate that the process occurs across prosodic words *within an accentual phrase*. In section 6, I conclude that an intonation-based approach to prosodic structure properly characterizes the domain of application of *n*-epenthesis in Korean.

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2. Prosodic Structure

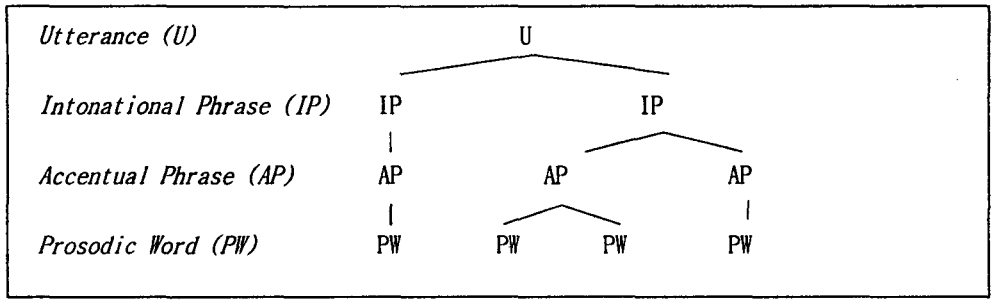
In broad strokes, approaches to defining phrasal constituents have been either syntactically based (Nespor & Vogel 1986; Selkirk 1984, 1986) or intonationally based (Beckman & Pierrehumbert 1986; Jun 1993, 1998; Pierrehumbert & Beckman 1988)

Syntax-based phrasing assumes that utterances are comprised of prosodic constituents projected from syntactic structure. It thus builds independent prosodic constituents on the basis of the edges of lexical or phrasal categories (End-based theory, Selkirk 1986) or the relation between a head and its complements (Relation-based theory, Nespor & Vogel 1986). On the other hand, intonation-based phrasing defines prosodic units larger than a word on the basis of surface phonetic properties (i.e. intonation and final lengthening). For example, Beckman & Pierrehumbert (1986) found that in English and Japanese certain prosodic constituents are defined phonologically by such intonational features as pitch accent and boundary tones. Similary, Jun (1993) proposes that in Korean, systematic tonal contours function to delimit a prosodic gouping of words. In short, the syntactic approach relates phonological aspects of prosody to syntax, while the intonational approach associates phonetic aspects of prosody to phonology. Moreover, the former focuses on how to predict a prosodic boundary by looking at the syntactic structure in a given sentence, while the latter concentrate on how to detect a prosodic boundary in produced sentences (Jun 1998: 190)

The prediction that the syntactic approach makes is that sentences of the same structure would have the same phonological phrasing since the syntactic structure of a sentence is not variable. However, it is not possible to predict all phonological phrasings only based on syntactic information. It is well recognized that non-syntactic factors such as focus, speech rate or the length of the sentence influence phrasing. The intonational approach, as implemented by Jun, has been successful in accurately characterizing the domain of a number of postlexical segmental rules in Korean which varies depending on different phrasings.

The prosodic hierarchy developed by Jun (1993, 1998) is as follows in (1), where "Accentual Phrase", and "Intonational Phrase" are tonally-marked prosodic levels higher than a prosodic word.

(1) Prosodic Structure of Korean



The accentual phrase, located between a PW and an IP, plays a crucial role as a domain for several phonological rules in Korean such as Lenis Stop Voicing (Jun 1993), Post Obstruent Tensing and Vowel Shortening (Jun 1998). According to Jun, the underlying tonal pattern of the accentual phrase in Seoul Korean, is Low-High-Low-High (LHLH) or High-High-Low-High (HHLH), wherein the laryngeal feature of the phrase-initial segment determines the accentual phrase-initial tone. That is, the accentual phrase begins with a H tone when the first segment of the phrase is either aspirated or tense; otherwise it begins with a L tone. All of the underlying tones, LHLH or HHLH, are realised on the surface when an accentual phrase has more than four syllables. But when it has fewer than four syllables, a few different surface tonal patterns are realized depending on the degree of undershoot of the initial H or the following L tones.

3. Phonological Aspects of *N*-epenthesis

A coronal nasal /n/ is epethesized stem-initially in stems beginning with *i* or *y* that are preceded by a stem or prefix ending in a consonant (Choi 1955, Huh 1965, Kim 1970, Kim-Renaud 1974, Chung 1980, Han 1994, Lee 1996). Furthermore, the epethesized *n* triggers nasalization of the preceding obstruents. In general, *n*-epenthesis occurs in free stem compounds or prefixed compounds, as seen in (2).

(2) a. Free stem compounds

puək^h + il	[puəŋnil]	'kitchen+work → cooking'
pat^h + ilaŋ	[panniraŋ]	'the ridge of a field'

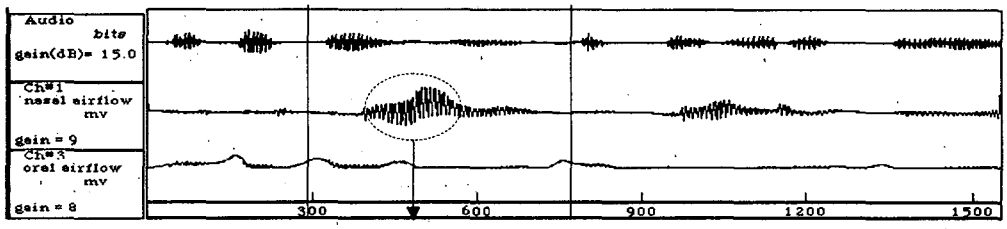
b. Prefixed compounds

nic + yəɨlim	[ninnyəirim]	'late summer'
hot^{h} + ipul	[honnibul]	'single+comforter→unlined comforter'
təs + yaŋmal	[tənnyaŋmal]	'oversocks

The nasal airflow traces in Figure 1 demonstrate the occurrence of *n*-epentheis in *puək^{h} il* in (1a) and *nic yəlim* in (1b). The words were produced within the carrier phrase, *kesok* _____ *tʃi akke malhaseyo 'Please keep saying* ____.

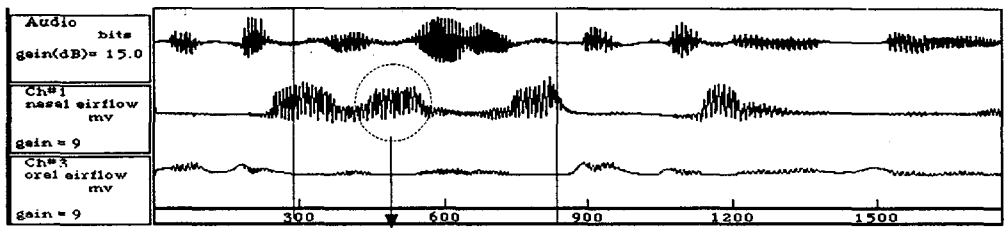
Figure 1. Nasal airflow traces demonstrating the occurrence of *n*-epenthesis

a. *puək^{h} il 'cooking'*



[p u ə ŋ n i l]

b. *nic yəlim 'late summer'*



[n i n n y ə ɾ i m]

As seen in Figure 1, the presence of nasalization (circled), which has occurred across the two free stems in Figure (1a) and across a prefix and a free stem in Figure (1b), indicates that *n* is epenthesized and that it triggers the nasalization of the preceding consonant.

In Korean, a free stem or a prefix constitutes a prosodic word (Kang 1992). Thus, the data in (2) consist of two prosodic words. Based on this fact, Han (1994) argues that *n*-epenthesis must refer to the prosodic word, and formulates the rule in (3).

(3) *n*-epenthesis

$\varnothing \rightarrow n$ / [...C]$_{Prwd}$ [_i ...]$_{PrWd}$

Furthermore, Lee (1996) claims that not only does *n*-epenthesis occur across two prosodic words which form compounds, as shown in (2), but it also applies across prosodic words which do not form compounds. Examples are given in (4).

(4) a. os ipta [onnibda] 'to wear clothes'
clothes wear
b. ha-n il [hannil] 'thing which is done'
do-COMP thing

In (4a), *n* is inserted between /s/ and /i/; in (4b) where the first prosodic word ends with /n/, we get a geminate *n*.

If an */n/* is epenthesized freely across prosodic words that do not form compounds as Lee claims, this would indicate that the domain of *n*-epenthesis is bounded only by the utterance. My investigation of *n*-epenthesis focuses on the claim that *n*-epenthesis may occur across any prosodic words within an utterance. In the sections that follow, I examine whether *n*-epenthesis is unrestricted within an utterance or whether further prosodic considerations govern its application. Using nasal airflow data combined with pitch tracks, I show that *n*-epenthesis is best defined as an accentual rule by the intonation-based model of Korean prosody.

4. Experiment 1: Testing *N*-epenthesis as an Utterance-Span Rule

4.1. Stimuli

In the first experiment, I investigate whether *n*-epenthesis occurs across any prosodic words in the utterance, i.e. whether *n*-epenthesis is an utterance-span rule or whether *n*-epenthesis is prosodically governed. Two sentences containing the sequence *os ipta* in (5), where Lee (1996) claims that *n*-epenthesis should occur, were recorded.

(5) a. əsə os ip-ə
right away clothes wear-IMP
'Get dressed right away.'
b. ki os ip-tʃimalko i os ip-əla
those clothes wear-IMP(Neg.) these clothes wear-IMP
'Do not wear those clothes, but wear these clothes.'

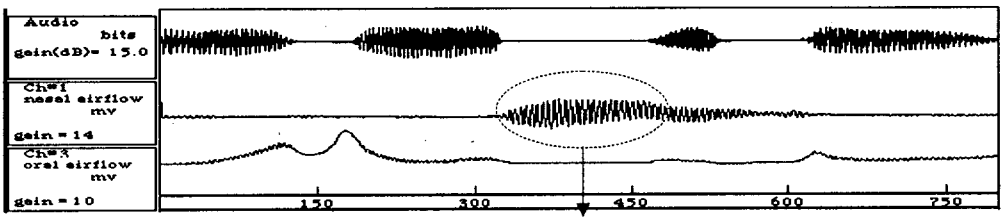
Ten repetitions of each sentence were recorded for six subjects (four females F1, F2, F3, F4 and two males M1, M2). The sentences were randomized with two other dummy sentences and presented to the subjects in Korean orthography. Subjects were asked to read each sentence without pausing to inhale. The presence or the absence of nasal activity across /s/ and /i/ was observed.

4.2. Results and Implications

If *n* is inserted between *os* and *ip-* in both sentences in (5), we would expect to observe nasal activity across these two prosodic words. However, my aerodynamic data do not exactly correspond to Lee' s claim. For sentence (5a), nasal activity indicative of *n*-epenthesis was observed in most of the subjects, as shown in Figure (2a). F1 and F3 showed the opposite pattern: no nasal activity coincident with the */s-i/* sequence was observed, as demonstrated in Figure (2b). Since unreleased consonants are not allowed in coda position in Korean, the /s/ is neutralized to [t] in the surface form.

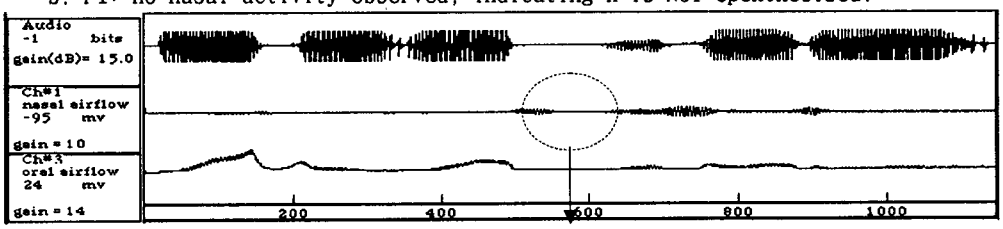
Figure 2. Nasal and oral traces of əsə os ipəla *' Get dressed right away. '*

a. F4: nasal activity observed, indicating *n* is epenthesized.



[ə s ə o n n i b ə]

b. F1: no nasal activity observed, indicating *n* is NOT epenthesized.

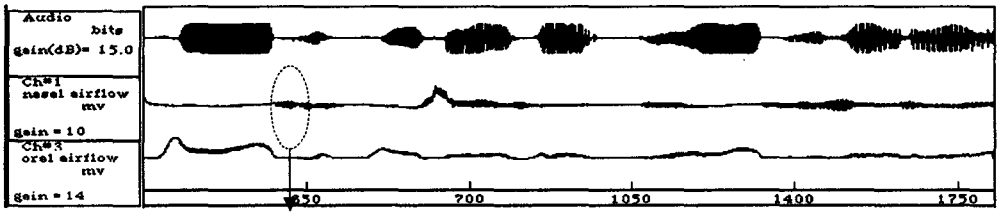


[ə s ə o t i b ər a]

For its part, sentence (5b) displays no nasal activity corresponding to the */s-i/* sequence, indicating that *n*-epenthesis does not occur. All the subjects showed this nasal pattern. Subjects F1 and F3 who showed a different pattern from the

other subjects in sentence (5a) behave the same way as the other subjects in the sentence (5b). A representative nasal flow trace from F4 is shown in Figure 3.

Figure 3. Nasal trace of *ki os iptʃimalko i os ipəla 'Don't wear those clothes, but wear these clothes.'*



[k i o t̲ i b dʒ i m a l g o i o t i b ə ɾ a]

The following table shows the number of tokens where nasal activity is present as an indication of *n*-insertion and where nasal activity is absent, for sentences (5a & b).

Table 1. Number of tokens in which *n* is epenthesized or not

Sentences / Subjects	(5a) əsə os ipəla *'Get dressed right away.'*		(5b) ki os iptʃimalko i os ipəla *'Do not wear those clothes, but wear these clothes.'*	
	n inserted	*n NOT inserted*	*n inserted*	*n NOT inserted*
F1		10		10
F2	10			10
F3		10		10
F4	10			10
M1	10			10
M2	10			10
Total	*40*	*20*	*0*	*60*

In Table 1, we observe that nasal activity as evidence of *n*-epenthesis is present in (5a). However, the complete set of tokens in (5b) does not show nasal activity. This contradicts Lee's claim that *n*-epenthesis always occurs across prosodic words, and suggests that the domain of *n*-epenthesis should be prosodically governed. Table 1, furthermore, illustrates that the application of *n*-epenthesis is consistent within speakers, but varies across speakers. All the speakers show the same pattern for each sentence; the patterns of F1 and F3 are different from the other subjects in (5a).

As we observe in Table 1, if *n*-epenthesis is prosodically restricted, what is the domain of *n*-epenthesis? We are going to ask whether its prosodic domain can be characterized by a syntax-based or an intonation-based approach to prosodic structure.

5. Experiment 2: *N*-epenthesis as an Accentual Phrase Rule

The second experiment was carried out to examine whether *n*-epenthesis can be best defined via syntax-based or intonation-based models of prosody. In § 5.1, I describe the data (e.g. potential environments where *n*-epenthesis would occur, such as a consonant followed by the vowel *i* or *y*) and the procesure of the experiment. In § 5.2, I examine *C-i* sequences which different models predict will be divided by a phrase boundary. In § 5.3, I investigate cases where *C-i* sequences are within the same phrases projected by different models. In § 5.4, I look at cases where syntax-based and intonation-based models produce different phrase boundaries with respect to *C-i* sequences.

5.1. Experimnetal Setup and Stimuli

The data were collected and analyzed using Macquirer system for Macintosh. Macquirer hardware containing 16-bit A/D Converter for the DC channels is connected to a transducer box, which provides low pass filtering for the channels. Separate oral and nasal masks are connected through tubes to the transducer box. The oral mask comes with a built-in condenser microphone that feeds into the microphone input of the Macquirer hardware. The nasal mask is attached to the head by straps which provide a tight seal, while the oral mask is held tightly against the face while speaking. In the data here, the transduced signal was sampled at 800 Hz for nasal flow and 7 kHz for the audio signal.

Nine sentences which contain a potential environment for *n*-epenthesis were recorded, in addition to the sentences in (5). The first prosodic word ends with /s/, /t^h/, /k/ or /n/, and the second prosodic word begins with the vowel *i* or the semivowel *y*. The prediction is that if /n/ is inserted across a prosodic word ending with the consonants other than /n/ and a prosodic word beginning with /i/, we would observe nasalization of the consonants triggered by the inserted *n*. Similarly, if *n* is inserted between /n/ and /i/, we would obtain a geminate *n*. I call the first group (i.e. consonants other than /n/ followed by *i*) *C-i* sequences

the second group (i.e. /n/ followed by *i*) as *n-i* sequences since I treat them differently. The list of sentenes used in this experiment is provided in Appendix.

The sentences, written in Korean, were randomly ordered and given to each subject (F1, F2, F3, F4, M1 and M2). Ten repetitions of each sentence were recorded, totaling 540 tokens (6 subjects* 9 sentences* 10 repetitions). Measurements were made depending on segmental differences in the target sequences. The presence or absence of nasal activity was investigated in the *C-i* sequences. If *n*-epenthesis occurs across prosodic words containing the *C-i* sequences, we expect to observe nasal activity correlated to consonants as evidence of the application of *n*-epenthesis. However, the presence of nasal activity cannot be a determinant in the *n-i* sequence, since this sequence already carries a nasal consonant. Therefore in the *n-i* sequences, the duration of the nasal consonant was measured. If *n* is inserted between *n* and *i*, this means that we would obtain a geminate *n*. As a result, a geminate *n* generated by the application of *n*-epenthesis in the *n-i* sequences should display longer duration than an *n* in the *n-i* sequences which do not undergo *n*-epenthesis.

I discuss the results of the experiment for the *C-i* sequences in § 5.2 and the *n-i* sequences in § 5.3.

5.2. *C-i* sequences

In § 5.2.1, I examine cases where *C-i* sequences are projected to be within the same phrase by different phrasing models. In § 5.2.2, I investigate cases where a phrase boundary falls across *C-i* sequences by different phrasing models. In § 5.2.3, I show that the application of *n*-epenthesis varies depending on different phrasings.

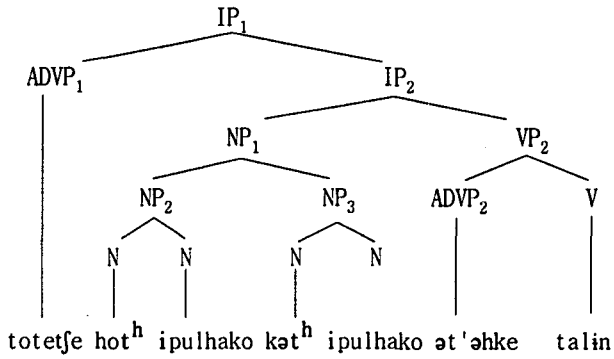
5.2.1. Within the same phonological or accentual phrase.

We begin with a consideration of sentence (6), where the *C-i* sequence is predicted to be within the same phonological or accentual phrase.

(6) totetʃe hot^{h} ipul-hako kət^{h} ipul-hako ət'əhke talini?
in the world unlined comforter-and comforter-and how different
'How in the world is an unlined comforter different from a comforter?'

The syntactic structure of the sentence and its phrasings by the different models are presented in (7).

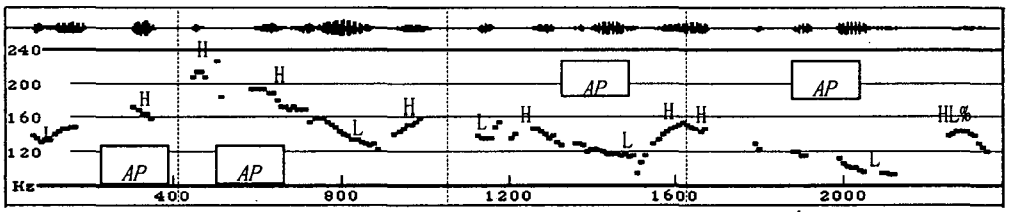
(7)



a. End-based:	PP	PP	PP	PP
b. Relation-based:	PP	PP	PP	PP
c. Intonation-based:	AP	AP	AP	AP

The different models project the same phrasing for the sentence. End-based phrasing aligns phrase boundaries with the ends of maximal projections ($ADVP_1$, NP_2, NP_3, and $ADVP_2$). Relation-based phrasing predicts the same phrasing as the end-based phrasing. Each of the branching maximal projections (NP_2 and NP_3) constitutes a phonological phrase. The head V forms a phonological phrase with the adjacent $ADVP_2$ within its maximal projection. The remaining $ADVP_1$ forms its own phonological phrase. Intonation-based phrasing generates the same phrasing as the syntax-based phrasing. The complete set of tokens produced by the subjects displayed the intonational pattern in (7c), which is exemplified by a representative pitch track from M1 in Figure 4.

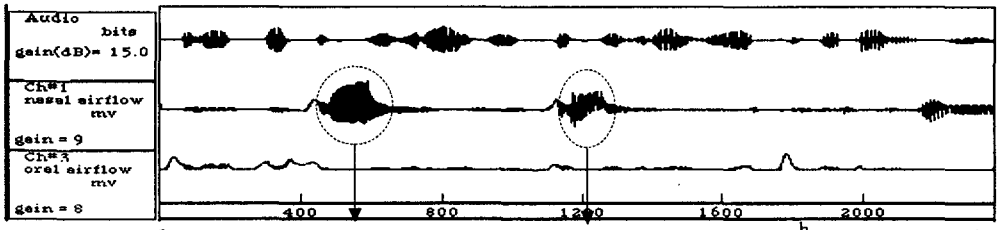
Figure 4. Pitch track of *totetʃe hot^h ipulhako kət^h ipulhako ət'əhke talini*
'How in the world is an underlined comforter different from a comforter?'



[t o d e ʃ e h o n n i b u l h a g o k ə n n i b ul h a g o ə t'ə k^h e d a ɾ i n i]

Each accentual phrase (indicated by dotted vertical lines) is demarcated by the final rising. Notice, here, that the *C-i (/t^h-i/)* sequence is within the same accentual phrase as it is in the syntax-based models. Figure 5 shows the nasal airflow trace of the sentence produced by this phrasing.

Figure 5. Nasal flow trace of *totetʃe hot^{h} ipulhako kət^{h} ipulhako ət'əhke talini*
' How in the world is an unlined comforter different from a comforter?'



[t o d eʃ e h o nn i bul h a g o k ənn i bulh a goə t'ək^{h}e da ɾi n i]

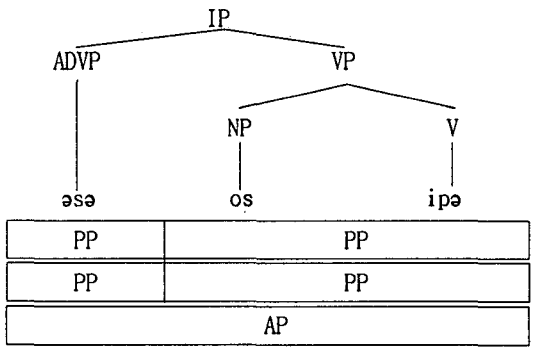
Here, we observe the presence of nasal activity corresponding to the underlying /t^{h}/. This is clear evidence of *n*-epenthesis when the *C-i* sequence is within the same phonological phrase under the phrasing of the syntax-based models, or the same accentual phrase by the intonation-based model.

Next, consider another sentence in (8).

(8) əsə os ip-ə
right away clothes wear-IMP
'Get dressed right away.'

The syntactic structure of the sentence and its phrasings by the different models are presented in (9).

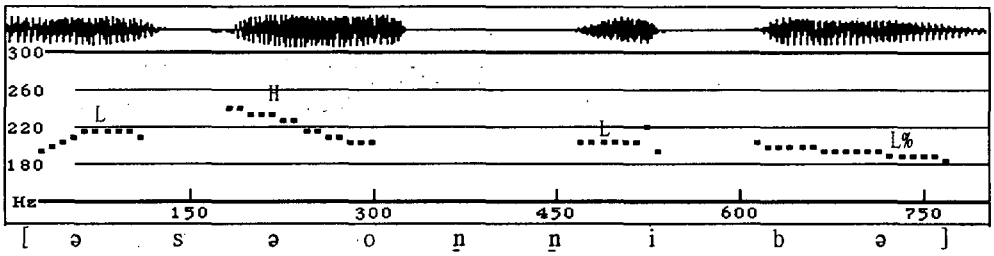
(9)



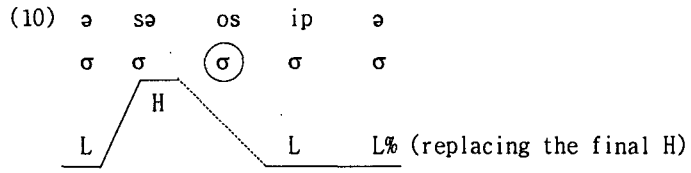
End-based phrasing in (9a) predicts two phonological phrases by aligning their boundaries with the left ends of maximal projections (ADVP and NP). Relation-based phrasing in (9b) projects the same phrasing as the end-based phrasing. The head V, *ipə*, combines with the closest NP, *os*, within its maximal projection VP. (9c) shows the phrasing determined by the intonation-based model. No boundary was detected in

neutral speaking of the sentence by four subjects (F2, F4, M1 and M2). The entire sentence was produced within an accentual phrase. This is seen by a representative pitch track from F4 in Figure 6.

Figure 6. Pitch track of *əsə os ipəla 'Get dressed right away.'*



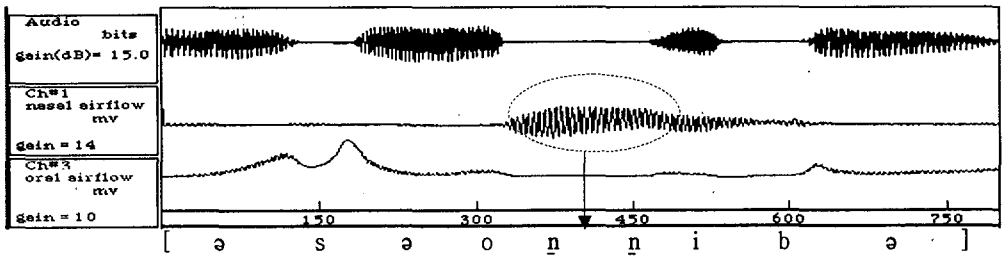
As explained in Section 2, the accentual phrase is characterized by the tonal pattern of LHLH (or HHLH). All of the tones are realized on the surface when an accentual phrase has more than four syllables, while some of them (i.e. the initial H, L or HL) do not surface when it has fewer than four syllables. When an accentual phrase is longer than four syllables, the syllables between the third and the antepenult of the accentual phrase get their surface tones by interpolating the H on the second syllable and the L tone on the penult syllable (Jun 1998: 194) The accentual phrase containing five syllables in Figure 6 is expected to have the following schematic tonal mapping:



The first two tones of the tonal melody (LHLH) are associated with syllables from the left and the last tow tones (LHLH) are mapped from the right. The third syllable *os* (circled) which is not assigned to any phonological tones get its surface tone by interpolating the adjacent H and L tones. The final H tone of the accentual phrase is replaced by the boundary tone (L%) of the intonational phrase. This is what we see in Figure 6: pitch rises toward the second syllable '*sə*', then gradully decreases toward the penult syllable '*ip*'.

Notice, here, that the target *C-i* sequence is within the same phrase. Figure 7 shows the nasal airflow traces of the sentence produced by F2.

Figure 7. Nasal and oral traces of *əsə os ipəla 'Get dressed right away.'*



Here, the presence of nasal activity is observed, indicating that *n* is epenthesized between /s/ and /i/ and that the inserted *n* further nasalizes /s/. Table 2 shows the number of tokens where nasal activity is present corresponding to */s-i/* and */t^h-i/* sequences in the sentences (6 & 8).

Table 2. Number of tokens where *n* is epenthesized for (6 & 8)

	(6) /t^h-i/		*(8) /s-i/*	
	n epenthesized	*n NOT epenthesized*	*n epenthesized*	*n NOT epenthesized*
F1	10			10
F2	10		10	
F3	10			10
F4	10		10	
M1	10		10	
M2	10		10	
Total	*60*	*0*	*40*	*20*

We can make a few observations in Table 2. First, nasal activity indicative of the application of *n*-epenthesis in the *C-i* sequences is observed in the complete sets of the tokens in (6) and 40 tokens in (8). Second, the application of *n*-epenthesis is consistent across subjects for (6), but varies for (8). Third, the application of *n*-epethesis is consistent within subjects.

In summary, *n*-epenthesis occurs where the *C-i* sequence is within the same phonological phrase by the syntax-based models, or the same accentual phrase by the intonation-based model.

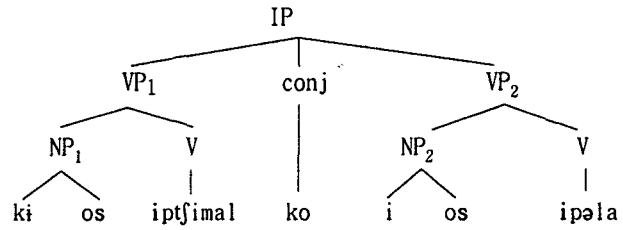
5.2.2. Separated by the phonological or accentual phrase boundary

Next, let us consider a case where the *C-i* sequence is divided into different phonological or accentual phrases.

(11) ki os iptʃimalko i os ipəla
those clothes wear-IMP(Neg.) these clothes wear-IMP
'Do not wear those clothes, but wear these clothes.'

The syntactic structure of the sentence and its phrasings by the different models are presented in (12).

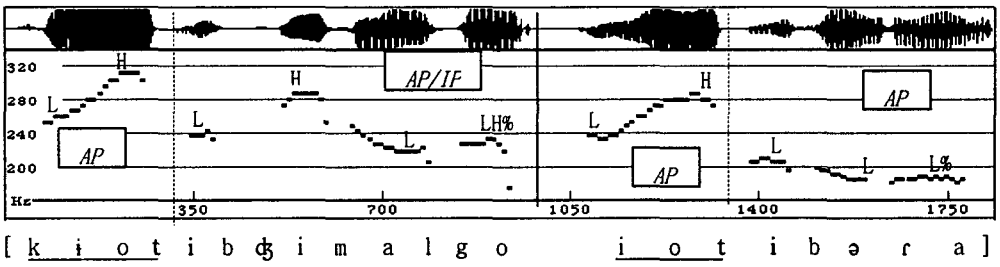
(12)



a. End-based:	PP	PP	PP	PP
b. Relation-based:	PP	PP	PP	PP
c. Intonation-based:	AP	AP	AP	AP

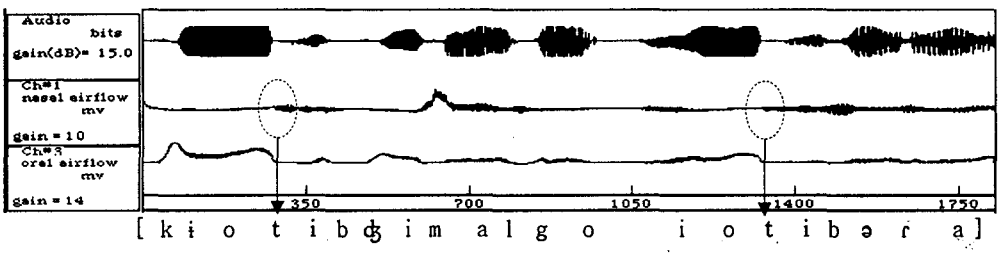
The different models make the same predictions with respect to the phrase boundary of two */s-i/* sequences here. End-based phrasing aligns phonological phrase boundaries with the left ends of maximal projections (NP_1, and NP_2), producing two major phonological phrases. Then, each major phrase is broken down into two minor phrases. The */s-i/* sequences are separated by the minor phrase boundaries, as seen in (12a). Relation-based phrasing in (12b) predicts the same phrasing as the end-based phrasing does. The branching maximal projections (NP_1 and NP_2) form phonological phrases. The unphrased V forms its own phrase. Intonation-based phrasing in (12c) shows the same phrasing as the syntactic models do. All the tokens produced by the subjects displayed this pattern. A representative pitch track from F1 in Figure 8 exemplifies the phrasing in (12c).

Figure 8. Pitch track of *ki os iptʃimalko i os ipəla* '*Do not wear those clothes, but wear these clothes.*'



In the sentence above, *ki os* 'those clothes' and *i os* 'these clothes' (underlined) are contrastively focused. This is reflected in the phrasing of the sentence: both form their own accentual phrase, indicated by the rising tone corresponding to *os[ot]* in Figure 8. These accentual phrase boundaries separate the */s-i/* sequences into different accentual phrases. The underlying /s/ is neutralized into the unreleased [t] in coda position. A pause after the second accentual phrase implies the existence of the intonational phrase boundary. The following is the nasal airflow trace of the sentence with the phrasing shown in Figure 9, produced by F1.

Figure 9. Nasal flow trace of *ki os iptʃimalko i os ipəla* '*Do not wear those clothes, but wear these clothes.*'



Here, we do not observe any sign of nasalization corresponding the */s-i/* sequence. Figure 9 demonstrates that *n*-epenthesis does not occur when the *C-i* sequence is divided into separate phonological or accentual phrases. Table 3 shows the number of tokens where nasal activity is absent for the sentence (11) in which *C-i* sequences are separated into different phrasing units by different models.

Table 3. Number of tokens where *n* is epenthesized for (11)

Sentence / Subjects	*(11) ki os iptʃimalko i os ipəla' Do not wear those clothes, but wear these clothes.'*	
	n epenthesized	*n NOT epenthesized*
F1		10
F2		10
F3		10
F4		10
M1		10
M2		10
Total	*0*	*60*

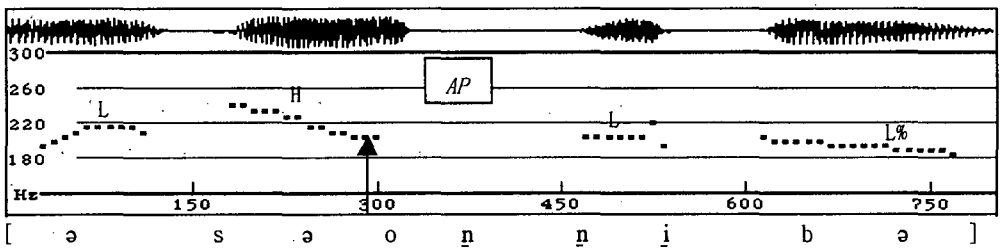
As seen in Table 3, none of the tokens display nasal activity corresponding to the */s-i/* sequences, indicating that *n*-epethesis does not occur.

In summary, *n*-epenthesis does not occur when a *C-i* sequence straddles different phrases projected either by the syntax-based models or by the intonation-based model.

5.2.3. Implication of variable phrasings

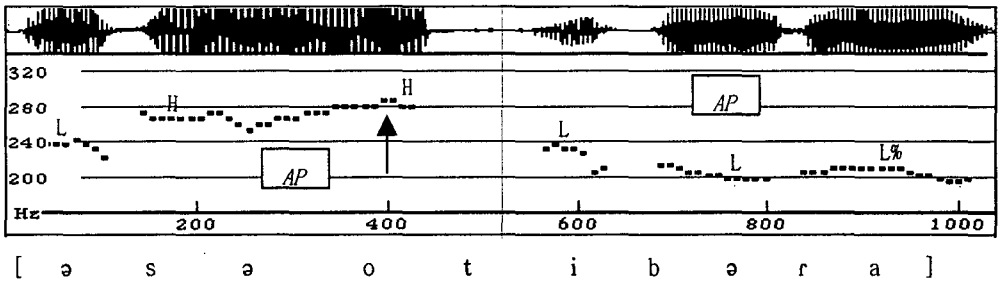
As mentioned in § 5.2.1, the subjects F1 and F3 show a different phrasing from the other subjects for sentence (6), *əsə os ipə ' Get dressed right away'* . Four subjects (F2, F4, M1 and M2) produced the entire sentence within an accentual phrase. A pitch track exemplifying this phrasing is shown again in Figure 10.

Figure 10. Pitch track of *əsə os ipə 'Get dressed right away'*, where the */s-i/* sequence is within an AP



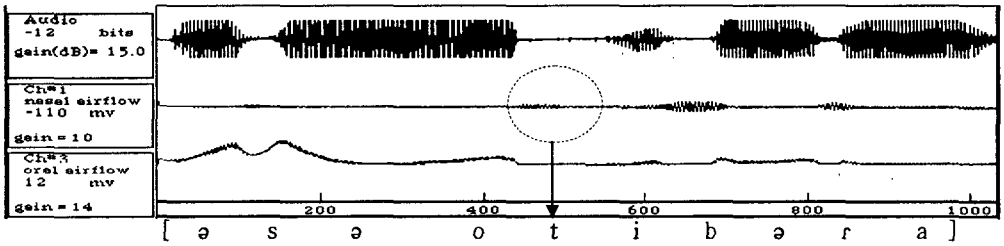
By contrast, F1 and F3 show a different phrasing: they produced an accentual phrase boundary between /s/ and /i/.

Figure 11. Pitch track of *əsə os ipə 'Get dressed right away'*, where the */s-i/* sequence is separated by the AP boundary



Comparing the two pitch tracks in Figure 10 and 11, we observe the different implementations of f0 in the third syllable */os/*, as indicated by arrows. Pitch decreases in the third syllable after the initial rising in Figure 10, while pitch rises for the final rising of the accentual phrase in Figure 11. This final rising functions as the accentual phrase boundary, splitting the *C-i* sequence. Remember that nasal activity coincident with the *C-i* sequence was observed in the sentence with the phrasing in Figure 10, where the *C-i* sequence is within the same accentual phrase. By contrast, the following nasal airflow trace shows that no nasal activity is observed when the accentual phrase boundary falls across the *C-i* sequence.

Figure 12. Pitch track of *əsə os ipəla 'Get dressed right away'*, where an accentual phrase boundary is produced across *C-i* sequence



Here, we see that *n*-epenthesis does not occur when the *C-i* sequence is separated into different accentual phrases. Table 4 shows the number of tokens where nasal activity is absent for the subjects F1 and F3.

Table 4. Number of tokens where nasal activity is absent for (6) when the *C-i* sequence is separated by the accentual phrase boundary

sentence / subjects	*(6) əsə os ipəla*	
	n epenthesized	*n NOT epenthesized*
F1		10
F3	1	9
Total	1	19

Here, no nasal activity is observed in 19 out of 20 tokens. Importantly, the different pattern of *n*-insertion is not predicted by the syntax-based models, but predicted by the intonation-based model which allows variable phrasings.

In the next section, I look at *n*-epenthesis in *n-i* sequences.

5.3. *n-i* sequences

In § 5.3.1, I begin with cases where different models predict a phrase boundary between *n* and *i*. In § 5.3.2, I investigate cases where *n-i* sequences are projected to be within the same phrase by different phrasing models.

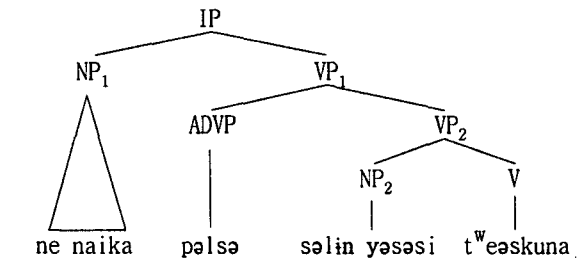
5.3.1. Separated by the phonological or accentual phrase boundary

Sentence (13) contains a */n-y/* sequence. If *n*-epenthesis occurs in the */n-y/* sequence, we would expect to acquire a geminate *n* in this case.

(13) ne nai-ka pəlsə səlin yəsəs-i t^{w}e-əs-kuna
my age-TOP already thirty-six-NOM become-PST-DEC
'I already turned thirty-six years old.'

The syntactic structure of the above sentence and its phrasings by the different models are given in (14).

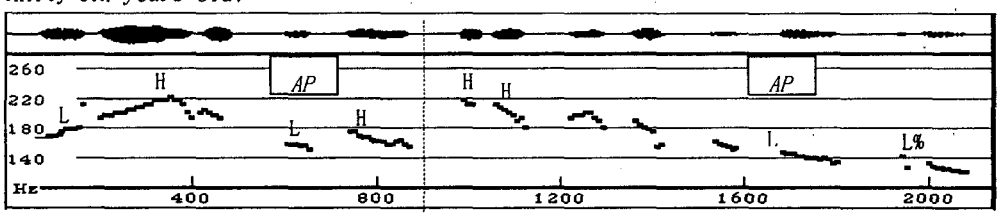
(14)



a. End-based:	PP	PP	PP	
b. Relation-based:	PP	PP	PP	
c. Intonation-based:	AP		AP	AP

Despite the discrepancy in overall phrasing of the sentence between the syntax-based models and the intonation-based model, the */n-y/* sequence still falls within the same phrase, as seen in (14). The dotted line in (14c) indicates an optional accentual phrase boundary. A representative pitch track from M1 in Figure 13 exemplifies the most common phrasing produced by the subjects in neutral speech.

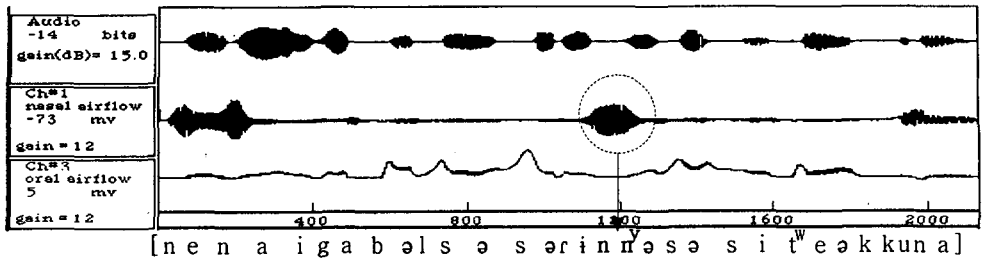
Figure 13. Pitch track of *ne naika pəlsə səlin yəsəsi t^weəskuna 'I already turned thirty-six years old.'*



[n e n a i g a b əl s ə s ə r i nʸ ə s ə s i t^we ə kkun a]

As seen in Figure 13, two accentual phrases are detected in the sentence. The first accentual phrase is mapped to the underlying LHLH pattern, while the second accentual phrase beginning with the fricative /s/ is associated with the HHLH pattern. By this phrasing, the */n-y/* sequence is located within the same accentual phrase. Figure 14 shows a representative nasal flow trace of the sentence from M1.

Figure 14. Nasal flow trace *ne naika pəlsə səlin yəsəsi t^{W}eəskuna 'I already turned thirty-six years old.'*



However, as mentioned earlier, the presence of nasal activity in Figure 14 cannot be a litmus test for the application of *n*-epenthesis in the */n-y/* sequence, since the sequence already carries the nasal consonant *n*. Thus, to investigate whether *n* is inserted in the */n-i/* sequence, the duration of the nasal consonant was measured using spectrographic displays, assuming that a geminate *n* generated by the application of *n*-epenthesis in the *n-i* sequences should be longer than an *n* in the *n-i* sequences which do not undergo *n*-epenthesis. Figure 15 demonstrates the measurement points between the offset of the vowel preceding /n/ (i.e. the onset of the geminate *n*) and the onset of the vowel (i.e. the offset of the geminate *n*).

Figure 15. A sample showing measurement points

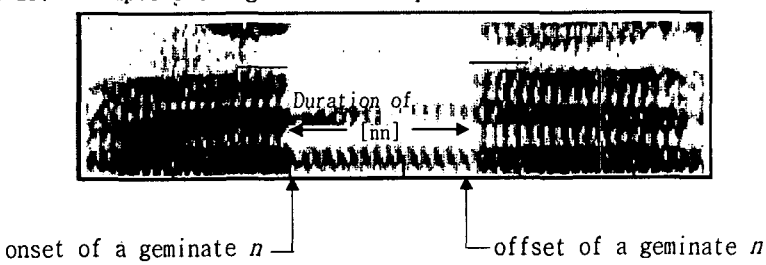


Table 5 provides the mean duration of geminate *n* produced in the sentence (13) and two similar sentences where *n-i* sequences are projected to be within the same phrase by the different models.

Table 5. Mean duration of geminate *n* from sentence (13) & two similar sentences (25 ≤ n ≤30)

	mean	*std.dev.*	*std.error.*
F1	85.67	7.40	2.47
F2	94.20	4.76	2.13
F3	111.63	5.40	1.91
F4	91.85	12.15	1.51
M1	110.80	13.19	5.90
M2	89.13	10.40	1.33

The mean duration of a geminate *n* ranges from about 85 milliseconds to 120 milliseconds. In the following section, these means will be compared with the duration of an *n* in the *n-i* sequences where *n*-epenthesis does not occur.

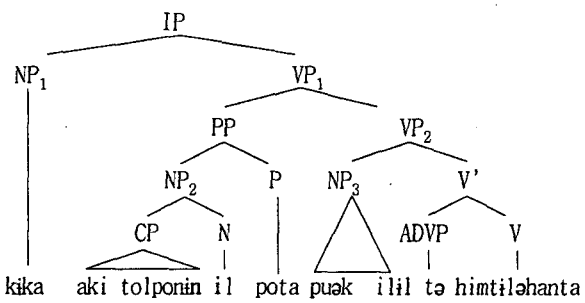
5.3.2. Within the same phonological or accentual phrase

Sentence (15), contains an *n-i* sequence where different models predict either a phonological or accentual phrase between them.

(15) ki-ka aki tolponin il-pota puək il-il tə himtiləhanta
he-NOM baby-sitting-than cooking-ACC feel harder
'He feels cooking is harder than baby-sitting.

The syntactic structure of the sentence and its phrasings by the different models are presented in (16).

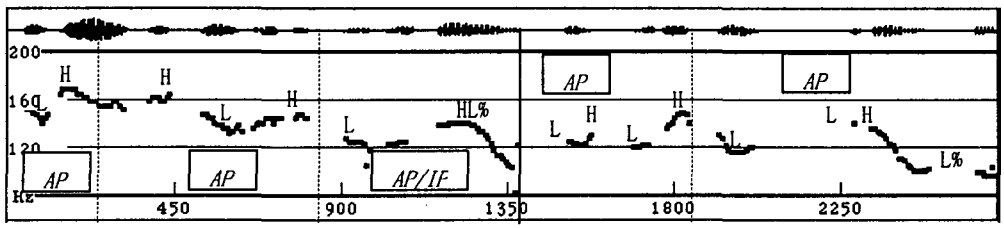
(16)



a. End-based:	PP	PP	PP	PP	PP
b. Relation-based:	PP	PP	PP	PP	PP
c. Intonation-based:	AP	AP	AP	AP	AP

End-based phrasing projects four phonological phrases by aligning their boundaries with the ends of maximal projections, NP_1{kika} CP{aki tolponin ilpota} NP_3{puək ilil} ADVP{tə himtiləhanta}. The second phrase is broken down into two pieces by binary branching, yielding {aki tolponin} {ilpota}, as seen in (16a). Relation-based phrasing predicts the same phrasing as the end-based phrasing model Applying the phonological phrasing algorithm from the bottom of the syntactic structure in (16), CP forms its own phonological phrase and ADVP forms a phonological phrase with the following V. At the higher nodes (NP_2 and NP_3), the unphrased N constitutes a phrase with P and the internally branching NP_3 forms a phrase. Finally, NP_1 forms its own phrase. Intonation-based phrasing, as exemplified in Figure 16, shows the same phrasings.

Figure 16. Pitch track of *kika aki tolponin ilpota puək ilil tə himtiləhanta 'He feels cooking is harder than baby-sitting.'*



As shown in Figure 16, the pitch rise associated with *-ponIn [bonIn]* in the second accentual phrase indicates a boundary, which splits the *n-i* sequence. Using the same methods described in the previous section, the duration of the nasal consonant was measured.

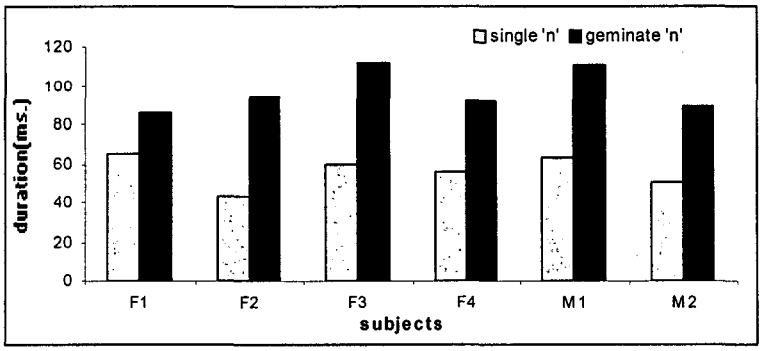
Table 6 provides the mean duration of *n* produced in the sentence (15) and two similar sentneces where *n-i* sequences are divided into different phrases by the different models.

Table 6. Mean duration of *n* from sentence (15) & two similar sentences (25 ≤n ≤30)

	mean	*std.dev.*	*std.error.*
F1	64.71	7.16	2.71
F2	43.40	4.16	1.86
F3	59.50	11.58	4.10
F4	55.50	2.59	1.06
M1	62.20	12.99	5.81
M2	50.29	7.32	2.77

The mean duration of *n* ranges from about 43 milliseconds to 64 milliseconds. This was compared with the mean duration of a geminate *n* given in Table 5, using bar-graphs.

Figure 17. Bar-graphs showing the duration difference between a single *n* and a geminate *n*



By comparing the dark bars, representing a geminate *n*, with the light bars representing a single *n*, we see that the former is noticeably longer than the latter. Not surprisingly, a two-factor ANOVA in Table 7, comparing *n* duration by speakers in two contexts (single *n* vs. geminate *n*) reveals that a geminate *n* is significantly longer than a single *n*.

Table 7. Two-factor ANOVA comparing *n* duration by speakers in a single *n* vs. a geminate n (α=.05)

	mean square	*F-value*	*P-value*
single n vs. geminate n	67232.04	8.82	.0001
6 speakers	1458.90	19.13	.0001

In short, we see that the duration of a *n-i* sequence projected by different models to be within the same phrase is longer than that of a *n-i* sequence divided into different phrases. This indicates that *n*-insertion occurs in the former, but it does not occur in the latter. This is another piece of evidence that *n*-insertion occurs across prosodic words within the same phrase, but it does not occur across prosodic words which belong to different phrases.

6. Conclusion

In this paper, I have examined prosodic conditions for the epenthetic /n/ in Korean. Previous studies claim that an epenthetic /n/ appears across prosodic words. However, I have argued that the epenthetic /n/ does not apply across all prosodic words, but its appearance is prosodially restricted. Using nasal airflow data combined with pitch tracks, I have shown that the rule applies across prosodic words *within an accentual phrase*.

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Appendix

a. totetʃe hot^{h} ipul-hako kət^{h} ipul-hako ət'əhke talɨni?
in the world unlined comforter-and comforter-and how different
'How in the world is an unlined comforter different from a comforter?'

b. əsə os ip-əla
right away clothes wear-IMP
'Get dressed right away.'

c. kɨ-ka puək il-pota aki tolponɨn il-ɨl tə himtɨləhanta
he-NOM cooking-than baby-sitting-ACC feel harder
'He feels baby-sitting is harder than cooking.'

d. kɨ os iptʃimalko i os ip-əla
those clothes wear-IMP(Neg.) these clothes wear-IMP
'Do not wear those clothes, but wear these clothes.'

e. onɨl ne os ip-tʃima
today my clothes wear-IMP(Neg.)
'Do not wear my clothes today.'

f. ne nai-ka pəlsə səlɨn yəsəs-i t^{W}e-əs-kuna
my age-TOP already thirty-six-NOM become-PST-DEC
'I already turned thirty-six years old.'

g. ne-ka ha-n il-i tʃənpu həsaka t^{W}e-əs-ta
I-NOM do-COM work-TOP all nothing become-PST-DEC
'Everything I did became nothing.'

h. tʃinaka-n il-tɨl-ɨl yekihesə m^{W}əha-ni
pass-COM thing-PL-ACC talk about not worth-Q
'It is not worth talking something that has passed.'

i. ki-ka aki tolponɨn il-pota puək il-ɨl tə himtɨləhanta
he-NOM baby-sitting-than cooking-ACC feel harder
'He feels cooking is harder than baby-sitting.'

j. kɨn il-pota tʃakɨn il-put$_{h}$ə tʃəntʃənhi hekyəlhe nakatʃa
big matter-than small matter-from slowly solve let's
'Let's begin to solve small matters before big matters.'

k. ne-ka itʃek'atʃi han il-pota ap^{h}ɨlo hal il-i tə tʃuŋyohata
I-NOM until now do work-than in the future do work-TOP more important
'What I will do is more important than what I have done.'

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