An Optimality Theoretic Analysis of Phonetically Motivated /n/-insertion*

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Kim, Hyung-Sun, Kim, Baegseung & Oh, Mira. 2007. An Optimality Theoretic Analysis of Phonetically Motivated /n/-insertion. *The Linguistic Association of Korea Journal, 15*(2), 187-205. /n/-insertion takes place after a consonant followed by /i, j/ in Korean. Previous studies on /n/-insertion have not systematically investigated the reason why it occurs. Thus the first aim of this paper is to answer the questions why /n/-insertion occurs and furthermore why /n/ is inserted. The second aim is to provide an Optimality Theoretic analysis of /n/-insertion. There are three points we make throughout this paper. Firstly, /n/-insertion is motivated on perceptual grounds: to strengthen the morphemic boundaries and help smoother transition in morphemic concatenation. Secondly, it is /n/ that is the least salient consonant before /i/. We conduct a phonetic experiment comparing F1 and F2 transition of /i/ after /n/ and /l/ to prove that /n/ as opposed to /l/ is the least salient consonant before /i/. Thirdly, the faithfulness constraint, Dep (salient), which has a gradient nature, plays a crucial role in the Optimality Theoretic account for /n/-insertion.

Keywords: /n/-insertion, phonetic motivation, strengthening, formant transition, degree of saliency

1. Introduction

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Korean /n/-related phenomena include both insertion and deletion. From a rule-governed perspective, /n/-deletion is explained by the Initial Law that deletes sonorant onsets such as /l, n/ preceding /i, j/. In this paper we focus on /n/-insertion as opposed to /n/-deletion. /n/-insertion rule is formalized as in (1).

(1) /n/-insertion: ∅ → n / $[...C]_{pw}$ $[\_\_\_[i, j]...]_{pw}$ (Han 1994; Lee 2004)

/n/-insertion takes place between the coda and /i, j/ across a prosodic word boundary. The examples in (2) demonstrate /n/-insertion.

(2) Examples of /n/-insertion

a. Native Korean words

pom+jʌrɨm	[pomnjʌrɨm]	'spring and summer'
som+ibul	[somnibul]	'cotton comforter'
sak+il	[saŋnil]	'day labor'
mak+il	[maŋnil]	'manual labor'
mæn+ip	[mænnip]	'bare-mouthed' (Park 2005)

b. Sino-Korean words

kiʌp+jesan	[kiʌmnjesan]	'company budget'
saŋin	[saŋin] *[saŋnin]	'merchant' (Oh 2006a)

c. Compounds

ɨnhæŋ+ip	[ɨnhæŋnip]	'gingko leaf'
ʧ^{h}ʌt+insaŋ	[ʧ^{h}ʌdinsaŋ]	
	*[ʧ^{h}ʌnninsaŋ][1]	'first impression' (Oh 2006a)

The process of /n/-insertion differs depending on morphological categories (Park 2005). For native Korean words, insertion takes place both in derived words and compound words. For Sino-Korean words, the context of /n/-insertion is restricted to /j/ as opposed to /i/. In

1) [ʧ'hʌnninsaŋ] is selected as the optimal output in Gyeongsang dialect, which is beyond the scope of this paper.

case of compound words, /n/-insertion is decided based on the morphological category of the second part: before /i, j/ where the second word is a native Korean word, and before /j/ where the second word is a Sino-Korean word (Oh 2006a). That is to say, /n/-insertion is triggered by the interaction between morphological structure of a word and its phonetic environment. However, this paper focuses on proving the phonetic motivation of /n/-insertion and further application of the finding to the analysis within the Optimality Theoretic (henceforth OT) framework.[2)]

The previous studies on /n/-phenomena usually centered on the context for insertion and the relationship between /n/-insertion and deletion. On the contrary, why the segment chosen for insertion is exclusively /n/ has not been sufficiently covered. This paper aims to investigate an answer to the question as well as its phonetic motivation. (3) summarizes the previous studies which are the cornerstone of our study.

(3) a. /n/-insertion occurs to strengthen the perception of morphemic boundaries (Oh 2006b).
b. Inserted segments should both distinguish the preceding elements from the following ones and help create smooth transitions in production; they should be insalient to the listener (Howe and Pulleyblank 2003; Lee 2004; Oh 2006b).

Based on these previous studies, we make two claims as given in (4).

(4) a. A phonetic experiment reveals that /ni/ has a pattern more similar to /i/, null insertion, than /li/ has to /i/ in terms of F1 and F2 formant transitions.

2) Oh (2006b) demonstrates the asymmetry between /i/ and /j/ in case of /n/-insertion in suffixation as in /san+i/ → [sani] 'mountain (nominative)' and /san+jo/ → [sannjo] 'mountain (polite)' and explains "...The application of n-insertion ... is then not determined by the prosodic wordhood but by the following segment..." This paper only deals with native Korean words in the Seoul Korean.

b. Dep (salient), which is phonetically motivated, plays a crucial role in the OT analysis of /n/-insertion.

We will prove the claim in (4a) through a phonetic experiment. Based on the phonetic experimental results, we analyze /n/-insertion within the OT framework. This paper is presented as follows: in section 2, the previous studies will be critically reviewed. In section 3, through the phonetic experiment, we will investigate the first and second formant (F1 and F2) differences between the starting and mid points of the vowel /i/ in three forms /Vi/, /Vnni/, and /Vlli/. We will argue that the F1 and F2 of /nni/ have a smoother transition than those of /lli/ and that /ni/ be more similar to /i/. In section 4, /n/-insertion is analyzed within the framework of Optimality Theory. We will conclude our research in Section 5.

2. Literature Review on /n/-insertion

Park (2005) argues for a constraint-based analysis in contrast to a rule-governed one for /n/-insertion relying on positional markedness constraints. He contends that the same segment /n/ becomes either marked in the word-initial position or unmarked in the word-medial position as in (5).

(5) (Park 2005)

i	[∅i]	*[ni]	'tooth'
alɛtni	*[-∅i]	[-ni]	'lower tooth'

When we see /n/-insertion as rule-governed transmission (deletion rule → insertion rule) which is inviolable, we are misled to insert /n/ after syllables without codas. On the other hand, a constraint transmission account (word-initial markedness → word-medial unmarkedness) in which deletion is followed by a later presumably restorative insertion makes use of the interaction between faithfulness constraints and markedness constraints. Park (2005; 2006) made an

attempt to analyze /n/-insertion within the constraint-based OT framework. He divides the faithfulness constraint, Dep, into markedness and unmarkedness constraints[3] in accordance with the segment inserted and the environment for insertion. As to the reason why /n/[4] is exclusively selected instead of other coronal segments /l, s, t/, he explains again that markedness in word-initial position is transmitted into unmarkedness in word-medial position.

Park's (2006) account has four weaknesses. Firstly, it is not plausible that /n/ is inserted by the transmission just because it is /n/ that was deleted. In fact, /l/ is also deleted by the Initial Law, but is not similarly inserted. Secondly, it is doubtful that a speaker processes his utterance through a complex analogy based on historically affected phonology.[5] Moreover, considering that children acquire language through exposure to adult contemporary language use, the phonetic motivation-based account is more appropriate than the diachronic analogy-based one to account for this phenomenon. Finally, he assumes that /n/ is marked word-initially but unmarked in word-medial position, but he does not provide enough evidence for why one segment differs in markedness depending on its position.

Meanwhile, Lee (2004) proposes that /n/-deletion and insertion, which operate in opposite ways, occur to strengthen the perceptual domain. He explains that /n/-deletion is a way to prohibit high sonority consonants at word-initial position in Korean, and connects it with the tendency of strengthening the left edge in a prosodic unit. Strengthening between syllables is achieved by sonority decreases (Jakobson 1962). Lee (2004) extends such strengthening to upper

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3) Park (2005) explains that the insertion of /t, s/ before /i, j/ and the insertion of /n, l/ before other vowels all constitute the violation of the markedness Dep C, while the insertion of /n, l/ before /i, j/ is the violation of the unmarkedness Dep C.

4) As Korean /ln/ cluster is always realized as [ll], /n/-insertion in the case of /solip/ is seemingly realized as /l/-insertion (/solip/ → [solnip] → [sollip]).

5) Both etymologic /n/ and nonetymologic /n/ undergo /n/-insertion as given in (i).

(i) (Cho 1995: 54)

a. etymologic /n/:	əkum+ni → əkumni	'molar'
b. nonetymologic /n/:	pam+il → pamnil	'night work'

prosodic units such as phonological words and phonological phrases. /n/ is relatively high in sonority and its deletion causes the edge in prosodic units to be strengthened. As for the reason why /n/ is deleted before /i, j/, it is simply because the vowels [+high, +front] and coronal sonorants share the [cor] feature. Lee (2004) claims that /n/-deletion results from the interaction between the constraint that avoids the repetition of sounds sharing same features, and the one which avoids sonorants appearing in word-initial position (Hume 1992).

Lee (2004) also explains /n/-insertion in terms of domain-initial strengthening. The left boundary is most likely subject to strengthening since it is the starting point which is important for the hearer's perception. While /n/-insertion occurs with some exceptions at the lexical level, it always takes place at the post-lexical level where the distinction between constituents is more obvious than at lexical level. This asymmetry makes the assumption of domain-initial strengthening for better perceptibility more plausible. When it comes to inserted segments, Lee suggests, quoting Howe and Pulleyblank (2003), that it is desirable for them to be less salient in order to help the hearer's natural perception.

Under Optimality Theory, markedness constraints usually determine the segments to be inserted. However, Lee (2004) employs faithfulness constraints to control the distance between null insertion and inserted segments using a saliency hierarchy. A certain segment differs in saliency based on the environment in which it appears (Steriade 1997), and a less-sonorant consonant is less salient at the left edge of a prosodic unit. These explanations solve the problem that default segments are not exclusively inserted.

Lee (2004) attributes /n/-insertion to the Syllable Contact Law where sonority of the onset in a syllable should not be higher than that of the coda in a preceding syllable (Davis and Shin 1999). In his analysis, /n/ is chosen rather than other coronal /l, r, s, t/ because /n/ satisfies the Syllable Contact Law and the requirement that an inserted segment should be insalient in the context in question.

There are two critical drawbacks to Lee's (2004) proposal. One is

that it is difficult to explain why only /n/ is inserted as opposed to /l/ through the Syllable Contact Law. In the case of /toklip/ [toŋnip] 'independence', /l/ is realized as [n], then in turn, /k/ is nasalized, satisfying the Syllable Contact Law (Oh 2006b). By the same token, once /l/-insertion causes the violation of the Syllable Contact Law, a subsequent phonological process will be triggered to meet the law. After all, the Syllable Contact Law cannot exclude /l/-insertion as shown in (6).

(6) /pat+irɨm/ [pannirɨm] *[pallirɨm] 'the name of field'

If /l/-insertion occurs in /patirɨm/, it would result in [patlirɨm], then in turn, the /tl/ would turn into [ll] to meet the Korean phonotactic constraint which will be given in (8c): *[pallirɨm]. In addition, the Syllable Contact Law is for between consonants but the context of /n/-insertion is between a consonant and a vowel producing a consonant cluster only as a result, which makes the explanation using the Syllable Contact Law less plausible (Kim et al. 2002). Another problem arises when considering the inserted environment, before /i, j/. As English /r/-insertion is associated with the succeeding vowel /ɑ, ə, ɔ/ because they share the feature [pharyngeal] (Bakovic 2000), /n/-insertion can be better explained in relation to the succeeding vowel.

We aim to show that /n/ and /i, j/ share certain features which contribute to the smooth transition on boundaries.[6] For the purpose, we conduct a phonetic experiment in section 3.

3. Phonetic Experiment

3.1 Experimental Design

6) The vowel [+high, +front] and a coronal consonant share the feature [cor] (Hume 1992).

The phonetic experiment aims to prove a phonetic motivation to explain why only /n/ can be inserted, even though both /n/ and /l/ are legitimate candidates, considering either its degree of saliency in terms of the sonority hierarchy or its phonetic similarity to vowels. We will test the validity of the hypothesis in (7).

(7) Hypothesis: F1 and F2 transition degree from the preceeding segment to the following vowel can be ranked in the order of (l+l+vowel) > (n+n+vowel) > (vowel+vowel).

To compare three types of consecutive pairs, namely /vowel+vowel/, /n+n+vowel/, /l+l+vowel/, we created the word list in Table 1 for our experiment.

Table 1. Experimental word list

/vowel+vowel/	/n+n+vowel/	/l+l+vowel/
ai	anni	alli
əi	ənni	əlli
ui	unni	ulli
oi	onni	olli
ii	inni	illi

Vowels /a, ə, u, o, i/ before /i/ are used to see whether /i/ is affected by different preceding vowels. We examined intervocalic /nn/ and /ll/ since the prerequisite for /n/-insertion is the presence of a coda and those geminates will exclude the possibility that different codas could affect sound transition in different ways.

Three males and three females in their 20's to 40's read the randomly ordered words twice at a normal rate. The total number of tokens was 180 (6 speakers × 2 times × 15 words). The subjects were born and lived in Seoul until they moved to Gwangju in 2000. No subjects reported any problems in hearing and speaking. Recordings were made in the Phonetics Lab of Chonnam National University using a headset-mounted microphone and audio recording

interface and then uploaded to a computer for analysis. The words were analyzed through the Praat 4424. To compare the transitions from a segment in question to /i/, we compared the degree of saliency of /ni/ and /li/ to /i/. We calculated the difference between the starting point and stable point of the F1 and F2 of /i/.

3.2 Results and Discussion

3.2.1 F2 Transition

We examined the F2 transition difference values among (vowel+vowel), (n+n+vowel), and (l+l+vowel) through spectrograms and wave forms. Examples from female A's recordings of /ai, anni, alli/ are shown in Figures 1-3. The upper panel in Figure 1 shows the sound waves, and the lower panel the spectrogram. Axis x indicates time flow, and axis y indicates spectrum frequency in Hz. In all figures, the formants have been manually enhanced.

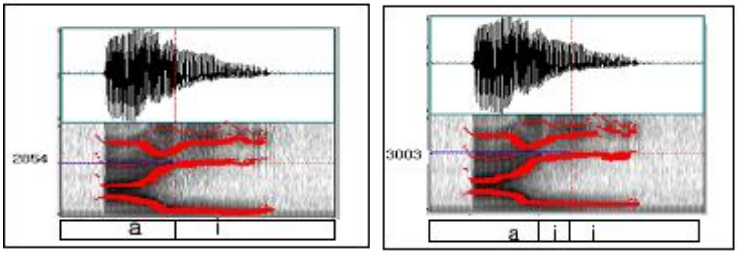

Figure 1a. Starting point of /i/ in /ai/ at 2854 Hz

b. Stable point of /i/ in /ai/ at 3003 Hz

Figure 1 shows that the F2 transition value of the vowel /i/ in /ai/ is 149 Hz (3003 Hz - 2854 Hz).

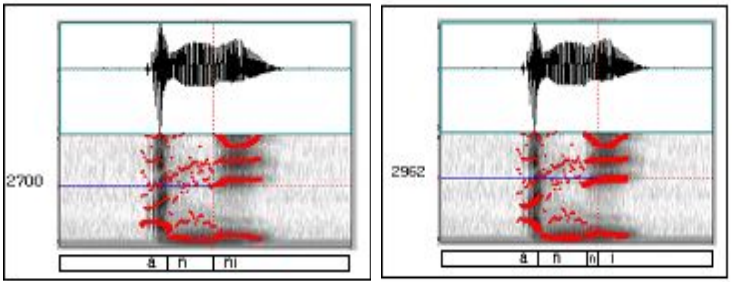

Figure 2a. Starting point of /i/ in /anni/ at 2700 Hz

b. Stable point of /i/ in /anni/ at 2962 Hz

Figure 2 indicates that F2 transition value of /anni/ is 262 Hz (2962 Hz - 2700 Hz).

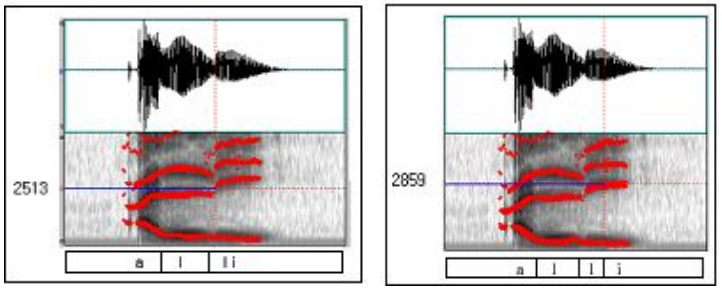

Figure 3a Starting point of /i/ in /alli/ at 2513 Hz

b. Stable point of /i/ in /alli/ at 2859 Hz

Figure 3 illustrates that the F2 transition value of /i/ in /alli/ is 346 Hz (2859 Hz - 2513 Hz).

Table 2 summarizes F2 transition mean values for the following vowel /i/ in a context with the preceding vowels /a, ə, u, o, i/.

Table 2. F2 transition mean values for the following vowel /i/ in a context with the preceding vowels /a, ə, u, o, i/

Experimental words			F2 transition mean values (Hz)
Preceding vowel	Structure	words	
a	vowel + vowel	'ai'	134
	nn + vowel	'anni'	179
	ll + vowel	′alli'	293
ə	vowel + vowel	'əi'	125
	nn + vowel	'ənni'	164
	ll + vowel	'əlli'	321
u	vowel + vowel	'ui'	78
	nn + vowel	'unni'	147
	ll + vowel	'ulli'	293
o	vowel + vowel	'oi'	118
	nn + vowel	'onni'	217
	ll + vowel	'olli'	313
i	vowel + vowel	'ii'	22
	nn + vowel	'inni'	185
	ll + vowel	'illi'	233

The means of the F2 transition values in table 2 vary according to the preceding vowels, because different preceding vowels affect the starting point for /i/. However, regardless of the different preceding vowels, the F2 transition values for the following vowel /i/ are ranked by slope as (l+l+vowel) > (n+n+vowel) > (vowel+vowel). It clearly supports the hypothesis given in (7). It is in line with Lee (2006) and Sproat and Fujimura (1993) in that /l/s involve a dorsal gesture as well as an apical gesture. Then it falls out that /l/ in Korean has lower F2 value than /n/, which in turn clarifies that the distance from /l/ to /i/ is farther than that from /n/ to /i/ in terms of F2 value.

To confirm the hypothesis that the degree of slope of the transition is ranked in the order of (l+l+vowel) > (n+n+vowel) > (vowel+vowel), and that (n+n+vowel) is closer to (vowel+vowel) than (l+l+vowel) is to (vowel+vowel), the mean and the standard deviation were calculated. In the set of (vowel+vowel), the mean F2 value of the transition between the starting point and the stable point of the vowel /i/ is

95.88 Hz. In the set of (n+n+vowel), it is 178.98 Hz. In the set of (l+l+vowel), it is 291 Hz. We conducted t-tests to see if there was a statistically significant difference between (n+n+vowel) and (l+l+vowel). The procedure is as follows: First, for all the samples, the difference (A) was calculated from the transition values between (n+n+vowel) and (vowel+vowel). The mean of A is 83.10 Hz. Second, for all the samples, the difference (B) was calculated from the transition values between (l+l+vowel) and (vowel+vowel). The mean of B is 195.11 Hz. Third, to see if A and B have a statistically significant difference, a t-test was conducted. The p-value is 1.3837E-08, indicating that the difference is significant. Table 3 shows that the hypothesis given in (7) is confirmed.

Table 3. Comparison of F2 transition values

F2 transition				A	B
	①(vowel+vowel)	②(n+n+vowel)	③(l+l+vowel)	(②-①)	(③-①)
Mean	95.8833	178.9833	291.0000	83.1000	195.1167
(standard deviation)	(71.9699)	(90.1251)	(150.5890)	(98.7626)	(129.4229)
				t = 6.580201, p=1.3837E-08	

3.2.2 F1 Transition

F1 values indicate the openness of mouth, and so high vocoids have low values, and low vocoids have high values. In all (vowel+vowel) contexts, F1 transition difference values in all 60 items were zero. Similarly, 48 out of 60 items in (n+n+vowel) had a value of zero. However, F1 values were conspicuously different in the (l+l+vowel) context. Only 17 out of 60 items were zero. These results clearly suggest that /ni/ is less different from null insertion /i/ comparing /li/ and /i/.

Table 4 summarizes F1 transition mean values of /i/ in different phonetic contexts.

Table 4. F1 transition mean values for the following vowel /i/ in a context with the preceding vowels /a, ə, u, o, i/

Experimental words			F1 transition mean values (Hz)
Preceding vowel	Structure	words	
a	vowel +vowel	'ai'	0
	nn+vowel	'anni'	-3
	ll+ vowel	'alli'	-32
ə	vowel + vowel	'əi'	0
	nn+vowel	'ənni'	-10
	ll+ vowel	'əlli'	-35
u	vowel + vowel	'ui'	0
	nn+vowel	'unni'	-6
	ll+ vowel	'ulli'	-33
o	vowel +vowel	'oi'	0
	nn+vowel	'onni'	-13
	ll+ vowel	'olli'	-42
i	vowel +vowel	'ii'	0
	nn+vowel	'inni'	-23
	ll+ vowel	'illi'	-29

The slopes of the transition differences can be ranked as (l+l+vowel)> (n+n+vowel) > (vowel+vowel). This result is also in line with the findings of the F2 analysis.

Table 5 demonstrates means, standard deviations, and t-tests of the F1 analysis.

Table 5. Comparison of F1 transition value (Hz)

F1 transition				A	B
	①(vowel+vowel)	②(n+n+vowel)	③(l+l+vowel)	(②-①)	(③-①)
Mean	0	-2.000	-34.0667	-2.2000	-34.0667
(standard deviation)	0	41.2318	28.5449	41.2318	28.5449
				t =-4.6434, p=1.9618E-05	

We conducted a t-test for A, the difference of (n+n+vowel) minus (vowel+vowel), and B, (l+l+vowel) minus (vowel+vowel). Table 5 shows that as for F1 the difference is statistically significant.

Through this phonetic experiment dealing with F1 and F2 measurements, we argue that an insalient segment /n/ be selected for insertion before /i/. On the other hand, F1 and F2 transitions of /l/ to /i/ were shown to exhibit a more radical change.

4. An OT Analysis of /n/-insertion

The phonetic experiment in section 3 showed that /n/ makes less salient transition to the following /i/ than /l/. Based on the experimental results, this section presents the OT-analysis introducing Dep (salient) which gradually constrains candidates according to the degree of saliency. Saliency is a relative and contextual property by definition, so the constraint on saliency can be reasonably applied in a gradual manner. We propose to establish a hierarchy within the constraint. /n/-insertion before /i, j/ across a morpheme boundary does not violate Dep (salient). However, /l/-insertion in the same context violates Dep (salient) once and other consonants such as /d/ violate Dep (salient) twice. Likewise, the Dep (salient) applies in gradual fashion. Strengthening constraint represents speakers' strategic process to avoid possible indistinctiveness resulting from the resyllabification of a coda at a morpheme boundary by inserting a segment before /i, j/.

(8) illustrates the constraints employed in this paper.

(8) a. Strengthening
The morpheme boundary between a preceding coda and following /i, j/ must be strengthened.

b. Dep (salient)
Consonant insertion before /i, j/ is prohibited gradually according to the saliency degree of the inserted segment.

c. Similarity (cf. Davis and Shin 1999)
The alveolar cluster of different manner of articulation is prohibited (*ln, *tl).
d. Max (lateral) (Davis and Shin 1999)
Input [lateral] must be realized as output.

The constraint ranking for /n/-insertion is given in (9).

(9) Similarity, Max (lat), Strengthening >> Dep (sal), Dep C

Tableau in (10) illustrates how the constraint ranking in (9) yields the optimal output, [somnibul], for /som+ipul/.

(10) /som+ipul/ → [somnibul] 'cotton comforter'

/som+ ipul/	Strength	Dep (sal)	Dep C
a. so.mi.bul	*!		
☞ b. som.ni.bul			*
c. som.li.bul		*!	*
d. som.di.bul		*!*	*

In (10), the resyllabified candidate (a) is ruled out since it fails to strengthen the morpheme boundary between a coda and /i/. Candidates (c) and (d) are ruled out as they violate Dep (salient). Candidate (b) is chosen optimal since it satisfies both Strengthening and Dep(sal).

Tableau in (11) shows the optimal output, [pamal], from /pam+al/.

(11) /pam+al/ → [pamal] 'chestnut'

/pam+ al/	Strength	Dep (Sal)	Dep C
☞ a. pa.mal			
b. pam.nal			*!
c. pam.lal			*!
d. pam.dal			*!

The case of /pamal/ in (11) does not meet the necessary context for /n/-insertion, before /i, j/, and the optimal output, [pamal], rather undergoes resyllabification. However, it violates neither Strengthening nor Dep (salient) since those constraints apply only before /i, j/. Candidates (b), (c), and (d) are all ruled out since they violate Dep C. Notice that /n/ preceding /a/ is not differentiated from other coronals unlike when /n/ precedes /i, j/.

Tableau in (12) demonstrates how the optimal output [sollip] is chosen from /sol+ip/.

(12) /sol+ip/ → [sollip] 'pine needle'

/sol+ ip/	Similar	Max(lat)	Strength	Dep(sal)	Dep C
a. so.rip			*!		
b. sol.nip	*!				*
c. son.nip		*!			*
☞ d. sol.lip				*	*
e. sol.dip				**!	*

In (12), candidate (a) violates Strengthening and candidate (b) violates Similarity which prohibits the cluster of /ln/. Candidate (c) violates Max (lateral) which forces the realization of /l/ in its output. Candidates (d) and (e) violate Dep (salient), but still the hierarchy within the constraint selects out candidate (d) as the optimal output over candidate (e) since the former violates the constraint only once, while the latter commits double violations.

To summarize, the optimal analysis of /n/-insertion heavily relies on Dep (salient) which applies gradually depending on phonetic properties of the inserted segments and phonetic contexts.

5. Conclusion

We have discussed the phonetic motivation for /n/-insertion and the reason why /n/ is exclusively inserted. /n/-insertion is a phonological process which enhances listeners' word recognition through the morpheme initial segment strengthening. Insertion occurs to strengthen morpheme boundaries or the left edge of prosodic unit since those positions play a critical role in recognition of the unit (Smith 2002; Lee 2004). /n/-insertion may be taken as a strategic process for a speaker to prevent possible indistinctiveness between boundaries. The fact that it occurs at the lexical level with some exceptions but without exceptions at the post-lexical level which maintain farther distance between units supports the explanation.

The phonetic experiment conducted in this paper proves that /n/ is distinctive enough to distinguish the preceding and following segments yet less salient so that the transition through those segments can be smooth for the sake of pronunciation. The degree of salience depends on the phonetic context, so the inserted segment is not necessarily an unmarked one. /n/ which meets both the distinctiveness and non-salience requirement is optimally inserted before /i, j/. In other words, /l/ and /n/ are both sonorant alveolars, but the phonetic experiment demonstrates that /n/ is less salient before /i/ compared with /l/.

Based on the results of the phonetic experiment, we analyzed /n/-insertion within the OT framework. In the optimal analysis of /n/-insertion, Dep (salient) which applies in a varying degree of violation according to the concerned phonological context plays a crucial role.

As stated throughout the paper, our aims were to prove the phonetic motivation of /n/-insertion through the phonetic experiment and to apply the phonetic results to the OT analysis of /n/-insertion. The data were confined to native words. The variations on /n/-insertion according to different dialects and morphological categories were not covered in this paper. We leave those issues for further study.

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