

## **Morpho-phonological processes in Korean**<sup>1</sup>

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### **Summary**

It has been an ongoing issue within generative linguistics how to properly analyze morpho-phonological processes. Morpho-phonological processes typically have exceptions, but

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In the use of abbreviations, I follow the Leipzig Glossing Rules, with the addition of the following: SE = Sentence Ender, HORT = HORTative, RELE = RELative clause Ender, PROS = PROSpective, NFS = Noun Forming Suffix, INT = INTerrogative. In addition, I use angled brackets < > to represent orthographic spellings.

nonetheless they are often productive. Such productive, but exceptional, processes are difficult to analyze since grammatical rules or constraints are normally invoked in the analysis of a productive pattern whereas exceptions undermine the validity of the rules and constraints. In addition, productivity of a morpho-phonological process may be gradient, possibly reflecting the relative frequency of the relevant pattern in the lexicon. Simple lexical listing of exceptions as suppletive forms would not be sufficient to capture such gradient productivity of a process with exceptions. It is then necessary to posit grammatical rules or constraints even for exceptional processes as long as they are at least in part productive. Moreover, the productivity can correctly be estimated only when the domain of rule application is correctly identified. Consequently, a morpho-phonological process cannot be properly analyzed unless we possess both the correct description of its application conditions and the appropriate stochastic grammatical mechanisms to capture its productivity.

The same issues arise in the analysis of morpho-phonological processes in Korean, in particular, n-insertion, sai-siot and vowel harmony. Those morpho-phonological processes in Korean have many exceptions and variations, which make them look quite irregular and unpredictable. However, they have at least a certain degree of productivity. Moreover, the variable application of each process is still systematic in that various factors, phonological, morpho-syntactic, socio-linguistic, and processing, contribute to the overall probability of rule application. Crucially, grammatical rules and constraints, which have been proposed within generative linguistics to analyze categorical and exceptionless phenomena, may form an essential part of the analysis of the morpho-phonological processes in Korean.

For an optimal analysis of each of the morpho-phonological processes in Korean, the correct conditions and domains for its application need to be identified first, and its exact productivity can then be measured. Finally, the appropriate stochastic grammatical mechanisms need to be found or developed in order to capture the measured productivity.

## **Keywords**

variation, exception, Korean morphophonology, n-insertion, sai-siot, vowel harmony

## **1. Introduction**

Morpho-phonological processes refer to phonological processes with the following characteristic properties.

- (1) Characteristic properties of morpho-phonological processes
  - a. may be subject to morphological and lexical conditions.
  - b. may have exceptions.
  - c. not sensitive to speech rate and style.<sup>1</sup>

d. may be phonologically unnatural.

English velar softening (e.g. electri[k] vs. electri[s]-ity) is an example of the morpho-phonological process, as discussed by Pierrehumbert (2006): (a) it applies only before a certain limited set of derivational suffixes, mainly –ity, –ism and –ist; (b) it has exceptions (e.g. Yor[k]-ist); (c) it applies regardless of speech rate and style; and (d) it cannot simply be characterized as the result of coarticulation or reduction. It has been an issue for a long time how to properly analyze such morpho-phonological processes within generative linguistics. Morpho-phonological processes typically have exceptions, varying in productivity. Productive processes can plausibly be formulated as synchronic rules or constraints. In contrast, for unproductive processes, it is usually difficult to justify linguistic rules. It might then be reasonable to assume that the relation between alternants involved is simply suppletive, in particular when the processes are phonetically unnatural.

However, productivity of a process may be gradient, reflecting, arguably, the relative frequency of the relevant pattern in the lexicon (Zuraw 2000, 2002, 2007, 2010; Bybee 2001; Albright, Andrade & Hayes 2001; Albright 2002a, b; Albright & Hayes 2003; Ernestus & Baayen 2003; Hayes & Londe 2006; Becker 2009; Jun & Lee 2007; Jun 2010, 2015; Jun & Albright 2017; and others). Thus, simple lexical listing of exceptions as suppletive forms would not be sufficient to capture such gradient productivity of a process with exceptions. It is necessary to posit grammatical rules or constraints even for exceptional processes as long as they are (in part) productive. Moreover, the productivity can correctly be estimated only when the domain of rule application is correctly identified. Consequently, a morpho-phonological process cannot be properly analyzed unless we possess both the correct description of its application conditions and the appropriate stochastic grammatical mechanisms to capture its (possibly, gradient) productivity. (See Coetzee & Pater (2011) for a review of such stochastic Optimality-Theoretic (OT) approaches.)

Given this background, this article explores the following morpho-phonological processes in Korean by providing an in-depth review of relevant previous studies.

## (2) Morpho-phonological processes in Korean

- a. n-insertion
- b. sai-siot
- c. vowel harmony

All these processes are much discussed in the literature on Korean phonology and morphology. They have on the one hand a large number of exceptions, but on the other hand they have at least a certain degree of productivity. For each of the three processes, issues involving the application conditions, the productivity and the optimal formal analysis need to be addressed.

The organization of this chapter is as follows. The next section introduces phoneme inventories and some productive phonological processes in Korean. Following sections (sections

2-4) discuss n-insertion, sai-siot and vowel harmony in this order. These three sections have almost identical structures: (i) basic pattern, (ii) conditioning factors, (iii) productivity and (iv) analysis. The final section (section 5) concludes this study.

### 1.1 Phonemes in Korean

Throughout this article, I use the following consonant and vowel phoneme inventories of a dialect of Korean spoken in the Seoul-Gyeonggi area (henceforth, Seoul Korean).

#### (3) Seoul Korean phoneme inventory

##### a. Consonant (C<sup>h</sup> = aspirated, C' = tense or glottalized)

	<i>labial</i>	<i>coronal</i>	<i>velar</i>	<i>glottal</i>
stop	p, p <sup>h</sup> , p'	t, t <sup>h</sup> , t'	k, k <sup>h</sup> , k'	
affricate		c, c <sup>h</sup> , c'		
fricative		s, s'		h
nasal	m	n	ŋ	
liquid		l		
glide	w	j		

##### b. Vowel

	front		back	
	unround	round	unround	round
high	i	y	ɨ	u
mid	e	ø		o
	ɛ		ʌ	
low			a	

There is general agreement on the consonant inventory of Seoul Korean. In contrast, the vowel inventory is much more controversial. Controversies include whether front round vowels /y, ø/ are simple vowels or diphthongs, and whether /e/ and /ɛ/ are merged completely or not. (See Cho (2016) for relevant discussion.) I adopt a conservative option, shown in (3), with no theoretical commitment to it.

### 1.2 Phonological processes in Korean

In (4), I introduce some productive phonological processes in Korean which are relevant to the discussion in the following sections:

(4) Productive phonological processes in Korean

- a. coda neutralization: coda obstruents are neutralized into homorganic unreleased lenis stops (e.g. /nac<sup>h</sup>/ [nat] ‘face’).
- b. obstruent nasalization: obstruents become nasal before a nasal (e.g. /kuk-mul/ [kuŋmul] ‘soup (soup-water)’).
- c. post-obstruent tensing: a lenis obstruent becomes tense after an obstruent (e.g. /mʌk-ca/ [mʌk<sup>c</sup>a] ‘eat-HORT’).
- d. consonant place assimilation: coronal and labial non-continuants optionally assimilate in place to the following non-coronals and velars, respectively (e.g. /pan-mal/ [pammal]~[panmal] ‘impolite speech (half-language)’).

These are all neutralizing processes, and they are mostly reflected in the broad phonetic transcription adopted in this study. In contrast, most automatic non-neutralizing changes such as inter-sonorant voicing (e.g. /ipul/ [ibul] ‘blanket’) are not reflected in the transcription unless they are relevant to the discussion at hand. (For details of phonological and phonetic processes in Korean, see Cho (2016).)

## 2. n-insertion

### 2.1 Basic pattern: n-insertion

In Seoul Korean (and other dialects of Korean including Kyungsang Korean), a coronal nasal is inserted at the juncture of two morphemes: e.g. /com-jak/ [com<sup>n</sup>jak] ‘mothball (moth-medicine)’. As shown in (5), this consonant epenthesis may occur in a variety of multi-morphemic forms, but only when the morpheme preceding the insertion site, which I call M<sub>1</sub>, ends in a consonant and the morpheme following it, which I call M<sub>2</sub>, begins with high front vocoids /i, j/:

(5) Examples of Korean n-insertion

a. pre-/i/ insertion

- |                 |                          |                         |   |
|-----------------|--------------------------|-------------------------|---|
| i. compound     | /som-ipul/               | [som <sup>n</sup> ipul] | ‘cotton sheet (cotton-blanket)’                     |
| ii. prefix-stem | /hot <sup>h</sup> -ipul/ | [ho <sup>n</sup> ipul]  | ‘unlined comforter (onefold-blanket)’               |
| iii. phrase     | /ha-n#il/                | [ha <sup>n</sup> il]    | ‘thing that (someone) has done (do-RELE.PST#thing)’ |

b. pre-/j/ insertion

- |                 |              |                           |   |
|-----------------|--------------|---------------------------|---|
| i. compound     | /kiʌp-jesan/ | [kiʌm <sup>n</sup> jesan] | ‘corporation budget (corporation-budget)’             |
| ii. prefix-stem | /tʌs-jaŋmal/ | [tʌŋ <sup>n</sup> jaŋmal] | ‘anklet socks (outer-sock)’                           |
| iii. phrase     | /mʌk-il#jʌs/ | [mʌkiʌʎ <sup>n</sup> ʌt]  | ‘taffy that (someone) will eat (eat-RELE.PROS#taffy)’ |

This nasal epenthesis has been called n-insertion in the traditional literature under the assumption that epenthesis of an alveolar nasal /n/ is followed by automatic application of allophonic palatalization.<sup>2</sup> The consonant at the end of M<sub>1</sub>, which I call C<sub>1</sub>, is mostly a nasal at the surface level mainly due to obstruent nasalization as can be seen in (5a.ii) and (5b.i-ii), except when M<sub>1</sub> ends in a liquid. As can be seen in (5b.iii), a liquid at the end of M<sub>1</sub> forms a palatalized geminate lateral with the epenthetic /n/ which is subject to both lateralization and palatalization.<sup>3</sup>

## 2.2 Conditioning factors: n-insertion

The basic conditions for application of n-insertion, presented in the previous section, are not enough to determine when to apply and when not to apply n-insertion. Many previous studies have attempted to properly restrict the domain of application of n-insertion. However, none of the conditions proposed thus far clearly separate words undergoing n-insertion from those not undergoing it since there are usually exceptions to each of the proposed conditions. To illustrate this point, let us consider some of the main proposals.

First, many previous studies argue that n-insertion (at least in native Korean words) occurs only when M<sub>2</sub> is a stem or root which can be an independent word (Huh 1984: 267; Ki 1990: 95-6, 130-1; Han 1993: 124-5, 1994: 131; Ko 1992: 32; Kim et al. 2002: 44; and Hong 2006: 400; and Cho 2016). However, it turns out that this stem/root requirement is neither a sufficient nor a necessary condition for the occurrence of n-insertion. As exemplified in (6), not all /i, j/-initial M<sub>2</sub> stems trigger n-insertion (Kim-Renaud 1974/1991: 151; Im 1981: 7; Huh 1984: 268; Ki 1990: 90; Ko 1992: 32; Kwack 1992; Kim et al. 2002: 46-53; Bae 2003: 241-2; and others).

(6) Exceptional blocker: /is/ ‘exist’

- |                 |                          |                              |
|-----------------|--------------------------|------------------------------|
| a. /mas-is’-ta/ | *[maŋɲitt’a], [masitt’a] | ‘delicious (taste-exist-SE)’ |
| b. /mʌs-is’-ta/ | *[mʌɲɲitt’a], [mʌsitt’a] | ‘stylish (style-exist-SE)’   |

On the other hand, certain (/j/-initial) M<sub>2</sub> suffixes may trigger n-insertion.

(7) Exceptional triggers

- |  |             |                                    |
|--|-------------|------------------------------------|
| a. Sino-Korean suffixes (Ko 1992: 38; Kim et al. 2002) |             |                                    |
| i. /pisaŋ-jon/   | [pisaŋɲjon] | ‘for emergency’ (/j-on/ ‘for use’) |

<sup>2</sup> With palatalization, the triggering palatal glide is completely or significantly reduced (Kang 2003: 460; Lee & Lee 2006).

<sup>3</sup> The liquid phoneme in Korean is realized as a lateral [l] except when it is a single onset which is realized as a flap, transcribed as [r] in the traditional literature. The coronal nasal /n/ occurring after the liquid becomes a lateral (lateralization), and the resulting geminate lateral palatalizes before high front vocoids (palatalization).

- ii. /kwancal-jam/ [kwancalɭjam] ‘arthritis’ (/jam/ ‘infection’)
- b. Native-Korean polite sentence ender /-jo/ (Bae 2003: 243; Oh 2006: 119)
  - i. /camsi-man-jo/ [camsimanɳjo] ‘Wait a moment (moment-only-SE)’
  - ii. /kilam-jo/ [kilamɳjo] ‘Of course (yes-SE)’

Thus, the stem/root requirement cannot be an absolute condition for application of n-insertion although it probably holds for the majority of words undergoing it.

Second, some previous studies argue that n-insertion is more widespread before /j/ than before /i/. Some studies (Lee & Lee 2006: 422-4; Hong 2006: 397; Ahn 2009: 263) even deny the existence of pre-/i/ insertion in Korean. They analyze words with pre-/i/ insertion as having underlying, not epenthesized, /n/ at the beginning of M<sub>2</sub>. They attribute the word-initial absence of M<sub>2</sub>-initial /n/ to (historical) word-initial n-deletion which occurred before high front vocoids /i, j/. Some others, who confirmed the existence of pre-/i/ insertion in native Korean words, excluded Sino-Korean words from the domain of pre-/i/ n-insertion (Han 1994: 77; Kim et al. 2002: 51; Park 2005: 324, 334; and Oh 2006: 123-4). However, according to the results of previous survey and experimental studies on Korean n-insertion, Korean speakers do apply n-insertion to Sino-Korean words with /i/-initial M<sub>2</sub>, as shown in (8).

(8) Rates of n-insertion (%) for some Sino-Korean words (selected from Kim 2003 where the rate is calculated by dividing the number of subjects who produced the inserted form by the total number of participants in the experiment)

a.	/sun-iik/	[sunɳiik]	23.71	‘net profit (pure-profit)’
b.	/sun-ilon/	[sunɳilon]	34.57	‘notionality (pure-theory)’
c.	/seŋ-ipjal/	[seŋɳipjal]	24.29	‘parting (raw-parting)’
d.	/pul-iik/	[puɭɳiik]	43.14	‘disadvantage (not-advantage)’
e.	/jan-wal-il-si/	[janwalɳilsɿ]	44.00	‘date (year-month-day-hour)’
f.	/mol-ihe/	[molɳihe]	48.86	‘lack of understanding (lack-understanding)’

Thus, it seems that the domain of n-insertion defined for existing Korean words is not severely restricted for pre-/i/ insertion, compared to pre-/j/ insertion. Nonetheless, it is probably true, as mentioned by Lee (1996: 168)<sup>4</sup>, Bae (2003: 241), and Oh (2006: 125-9, based on Kim 2003), that pre-/j/ insertion is in general more frequent or more naturally occurring than pre-/i/ insertion. This stochastic preference for pre-/j/ over pre-/i/ insertion is confirmed in a more systematic and wide-scale investigation by Jun (2015).

Third, it has been argued that the sonorancy of the final consonant of M<sub>1</sub> is the condition for the occurrence of n-insertion at least in a certain subset of Korean lexicon. Oh (2006: 121-2), followed by Ahn (2008: 384-5), argues that in Sino-Korean words consisting of monosyllabic

<sup>4</sup> Lee (1996: 168) states that pre-/i/ n-insertion is blocked with a short pause whereas pre-/j/ n-insertion is blocked across a long pause.

roots, n-insertion occurs only after a sonorant, not after an obstruent, taking the words in (9) as illustrative examples:<sup>5</sup>

(9) Words consisting of monosyllabic Sino-Korean roots

a. sonorant-final M<sub>1</sub>

i. /kʌm-jʌl/ [kʌmɲjʌl], \*[kʌmjʌl] ‘censorship (examine-count)’

ii. /cʌŋ-jʌm/ [cʌŋɲjʌm], \*[cʌŋjʌm] ‘passion (love-fire)’

b. obstruent-final M<sub>1</sub>

i. /pɛk-jʌl/ \*[pɛɲjʌl], [pɛkjʌl] ‘white heat (white-heat)’

ii. /hjaɸ-jak/ \*[hjaɸɲjak], [hjaɸjak] ‘agreement (harmony-promise)’

In addition, a similar asymmetry involving the C<sub>1</sub> sonorancy can be found in the description of Korean n-insertion by Cho (1995: 610-611) and Cho & Iverson (1997: 702) that are not confined to Sino-Korean words: n-insertion applies obligatorily after a sonorant and optionally after an obstruent. The results of previous survey and experimental studies show that n-insertion is often possible after an obstruent, regardless of the word origin, thus refuting the claim that n-insertion applies only after a sonorant. It is also shown that n-insertion can be optional even after a sonorant, contrary to the claim that n-insertion is obligatory after a sonorant. In fact, optionality of n-insertion has been mentioned in a number of previous studies on Korean n-insertion (Kim-Renaud 1974/1991: 150; Ko 1992: 32; Kwack 1992: 84; Han 1993: 124-5, 1994: 76; Cho & Sells 1995: 126; Lee 1996: 167-71; Hong 1997: 175; Cho & Iverson 1997: 701; Kim et al. 2002: 46; Bae 2003: 240-3; Oh 2006: 119; Ahn 2009: 279, citing Kim 2000). Thus, the sonorancy of C<sub>1</sub> cannot be an absolute condition for the occurrence of n-insertion. However, several previous studies suggest that the sonorancy of C<sub>1</sub> still affects the probability that n-insertion applies. Han (1994: 76) argues that n-insertion is more likely to occur after a sonorant, especially /l/, than after an obstruent. This preference of n-insertion after sonorant, as opposed to obstruent, C<sub>1</sub> consonants was confirmed by experimental and survey studies by Hwang (2008) and Jun (2015), which additionally reported that the velar nasal is an exception in that they are less likely to trigger n-insertion than the rest of the sonorant consonants.

Fourth, and finally, the morphological (or prosodic) status of M<sub>1</sub> has been adopted as a condition for the occurrence of n-insertion in some previous studies. The key observation is that n-insertion occurs when M<sub>1</sub> is a prefix or the first stem of a compound (see examples in (5i,ii)) whereas it is blocked when M<sub>1</sub> is a (Sino-Korean) bound root (e.g. /min-jo/ [minjo], \*[minɲjo] ‘folk song (people-song)’; /il-joil/ [iljoil], \*[ilɲjoil] ‘Sunday (sun-day)’).<sup>6</sup> This restriction has been analyzed by formulating n-insertion as a prosodic/phonological word (or stem) juncture rule (Kwak 1992: 84-5; Han 1993: 126, 1994: 132; Cho 1995: 610-11; cf. Kim 2000: 126), based on a hypothesis that a prefix as well as the first stem of a compound may form a

<sup>5</sup> Lee (2006: 635-6, (24) vs. (27)) presents the same type of data in the description of Kyungsang Korean n-insertion.

<sup>6</sup> Kyungsang Korean is different from Seoul Korean in that n-insertion applies even after a root M<sub>1</sub> (Han 1994: 132).



prosodic/phonological word of its own whereas a (Sino-Korean) bound root cannot. Putting aside how to properly categorize the triggering (or blocking)  $M_1$  classes in prosodic terms, notice that there are not a few exceptions to the restriction under consideration. As can be seen in (9a), words with Sino-Korean bound root  $M_1$ 's may undergo n-insertion. On the other hand, the results of previous survey and experimental studies on Korean n-insertion (for instance, Kim 2003) show that many prefixed and compound words meeting the basic conditions for application of n-insertion do not always undergo n-insertion.

(10) Tendencies in Seoul Korean n-insertion (from Jun 2015: 433, (12))

- a. Syllabicity effect  
Insertion is more likely before /j/ than before /i/.
- b. Obstruency effect  
Insertion is less likely after an obstruent  $C_1$ .
- c. Velar nasal effect  
Insertion is less likely after a velar nasal  $C_1$ .
- d. Height effect  
Insertion is more likely before /j/ if it is followed by a high vowel.
- e. Length effect  
Insertion is more likely with a longer  $M_1$ .

It seems that morphological, phonological, etymological and processing factors interact to give rise to tendencies involving n-insertion although none of them are absolute conditions for the occurrence of n-insertion.

### 2.3 Productivity: n-insertion

As shown in (11), some previous studies report that Korean speakers may apply n-insertion in the production of loanwords and English phrases (Park 2005: 324; Oh 2006: 128-9).

(11) n-insertion in novel words

- a. loanwords
  - i. /k'alk'imha-n # junipom/ [k'alk'imhəŋjʊnipʰom]  
'neat uniform (neat-RELE.PST#uniform)'
  - ii. /(nɛ-ka) ka-l # itʰɛli/ [(nɛka) kaʌʌitʰɛli]  
'Italy that I'm going to visit (1SG-NOM go-RELE.PROS#Italy)'
- b. English phrases
  - i. [kʰæŋjʊ] 'can you'
  - ii. [kʰiʌʌju] 'kill you'

A systematic investigation on the productivity of Korean n-insertion has been conducted in experimental and survey studies with loan and nonce words by Hwang (2008) and Jun (2015). Their results indicate that Korean n-insertion is productive under certain conditions. Specifically, phonological tendencies found from the distribution of n-insertion in existing Korean words were mostly mirrored in novel words. Only pre-/j/, not pre-/i/, insertion turned out to be productive, confirming the syllabicity effect. (But, see Kim (2000) for phrasal application of pre-/i/ n-insertion.) In addition, both obstruency and velar nasal effects were confirmed. The remaining two effects, height and length, cannot be examined with Hwang’s test results, due to the lack of relevant items. Jun’s survey results confirmed only height effect, not length effect. Consequently, at least pre-/j/ n-insertion is clearly productive in Seoul Korean, and speakers of Seoul Korean learned many statistical tendencies in the lexicon.

#### 2.4 Analysis: n-insertion

What drives n-insertion in Korean? Many previous analyses assume that n-insertion is motivated to align morpheme and syllable boundaries (Kim-Renaud 1974/1991: 148-9; Chung 1980: 57; Im 1981: 7; Ki 1990: 85, section 3.5; Shin 1997: 211; Park 2005: 330; Lee 2006; Lee & Lee 2006; Hwang 2008; Ahn 2009; Jun 2015: 434; and Lee 2016). This analysis is illustrated in (12).

(12) Forms with no n-insertion (‘J’ indicates the right edge of M<sub>1</sub>.)

	a. resyllabification	b. alignment	c. n-insertion
/som-ipur/	so.m]i.pul	som.]i.pul	som.] <b>pi</b> .pul
/com-jak/	co.m]jak	com.]jak	com.] <b>ɲ</b> jak

If /n/ is not inserted, C1 consonants at the end of M<sub>1</sub> would be either resyllabified into the onset of M<sub>2</sub>-initial syllable as in (12a) or be aligned with the end of the M<sub>1</sub>-final syllable as in (12b). In OT terms, the forms with resyllabification and alignment violate the alignment constraint (‘The right edge of a morpheme coincides with the right edge of a syllable.’) and an optimal syllable structure constraint, respectively, whereas the form with n-insertion in (12c) satisfy both constraints at the cost of violating the constraint militating against insertion of a segment, i.e. DEP.

Constraints on optimal syllable structure violated by aligned forms with /i/-initial M<sub>2</sub> in (12b) include ONSET (‘Syllables have an onset.’) and NOCODA (‘Syllables do not have codas.’). The same constraints would be violated by those with /j/-initial M<sub>2</sub> in (12b) if /j/ is syllabified as part of a nucleus. On the other hand, if /j/ is syllabified as an onset, forms with /j/-initial M<sub>2</sub> would violate a constraint prohibiting a bad onset, i.e. VOCOID-NUCLEUS (‘Every [-consonantal] segment must be in the nucleus.’) (Jun 2015). Some alternative analyses treating /j/ as an onset adopt a constraint on syllable contact that militates against rising sonority over a syllable boundary (Shin 1997: 210; Chung 2001; Lee 2004; Park 2005: 330; and Lee & Lee 2006). The

concept of syllable contact has already been invoked in Kim's (1981) pre-OT rule-based analysis of n-insertion. (But, see Ko (1992: 37), Ahn (2008: 372) and Lee (2016: 642-6) for the criticism on the use of syllable contact in the analysis of Korean n-insertion.) To summarize, a consonant needs to be inserted at the beginning of M<sub>2</sub> to obey the alignment and syllable structure constraints (possibly, along with the syllable contact constraint).

Why do Korean speakers insert a coronal nasal /n/, not other consonants? Jun (2015) answers this question by arguing that /n/ in Korean is perceptually weak in the context of n-insertion, i.e. before high front vocoids. In contrast, in Ko's (1992) analysis, the choice of /n/ as the epenthetic segment would be a byproduct of a diachronic change. Ko proposes a rule-inversion account of n-insertion in which word-initial n-deletion has been reanalyzed as a word-medial n-insertion rule. Ko's proposal has been criticized by Kim et al. (2002: 58) and Park (2005: 327) who point out that the rule contexts of n-insertion and n-deletion are not perfectly complementary since n-insertion is confined to a post-consonantal position. (See also Cho & Iverson (1997: 702) for a similar argument against the account based on diachronic rule inversion.)

Finally, Jun provides an analysis of the variable tendencies involving n-insertion, presented in (10), within the framework of the maximum entropy (maxent) OT grammar (Goldwater & Johnson 2003; Hayes & Wilson 2008).

### 3. Sai-siot

#### 3.1 Basic pattern: *sai-siot*

In traditional Korean phonology and morphology, *sai-siot* phenomena refer to morpho-phonological processes marking the juncture of a compound consisting of two nouns, which I will call N<sub>1</sub> and N<sub>2</sub>. The junctural processes include obstruent tensing and nasal gemination. Let us begin with the basic application conditions for each of the two processes and their illustrative examples.

As stated in (13), compound tensing occurs when N<sub>2</sub> begins with a lenis obstruent.

(13) Compound tensing rule:  $\begin{bmatrix} -\text{sonorant} \\ +\text{lenis} \end{bmatrix} \rightarrow [+constricted\ glottis] / ]_{N_1+N_2}[ \_$

Compound tensing is attested with all types of N<sub>1</sub> final segments, as shown in (14).

## (14) Compound tensing examples

	N <sub>1</sub> final	N <sub>2</sub> initial	N <sub>1</sub>	N <sub>2</sub>	phonetic form
a.	vowel	lenis obstruent	/hɛ/	/pic <sup>h</sup> /	[hɛp <sup>h</sup> it] 'sun light'
b.	liquid		/kai/	/pi/	[kai <sup>h</sup> p <sup>h</sup> i] 'autumn rain'
c.	nasal		/pom/	/pi/	[pom <sup>h</sup> p <sup>h</sup> i] 'spring rain'
d.	obstruent		/pok/	/cumʌni/	[pok <sup>h</sup> umʌni] 'lucky bag'

When N<sub>1</sub> ends with an obstruent as in (14d), however, N<sub>2</sub>-initial lenis obstruents are supposed to undergo automatic post-obstruent tensing. There is then no way to see whether compound tensing applies or not for compounds with obstruent-final N<sub>1</sub>. For this reason, in many previous studies on sai-siot, compounds with obstruent-final N<sub>1</sub> are excluded from the investigation. However, in her survey on Yanbian Korean speakers, Ito (2014) reports responses where tensing does not apply in compounds with obstruent-final N<sub>1</sub>. Kim's (2016) survey on Seoul Korean compound tensing is no different from Ito's in that tensing does not always apply in the context of post-obstruent tensing. Although this may indicate that some participants made erroneous judgments in those previous surveys, it is also possible that post-obstruent tensing does not apply all the time. Previous phonetic experimental studies (for instance, Jun 1993) on Korean post-obstruent tensing in fact report that it does not always apply even for the same word or phrase, attributing such cases to the prosodic restrictions on the rule application domain which may differ depending on the speech rate. Moreover, as will be discussed below, there exist cases in which compounds with different meanings behave differently with respect to compound tensing even when they consist of identical segmental strings. Crucially, such cases include compounds with obstruent-final N<sub>1</sub>: e.g. /cuŋkuk-cip/ [cuŋkuk<sup>h</sup>ip] 'a Chinese restaurant (China-house)' vs. [cuŋkukcip] 'a Chinese house (China-house)' (Cho & Sells 1995: 123). All this indicates that N<sub>2</sub>-initial lenis obstruents do not always undergo tensing, whether compound tensing or post-obstruent tensing, after N<sub>1</sub>-final obstruents, and that compounds with a potential target of post-obstruent tensing should not be excluded from the investigation of the sai-siot phenomena.

The second type of compound juncture marking process, i.e. nasal gemination, occurs only when N<sub>1</sub> ends in a vowel, and N<sub>2</sub> begins with a nasal, as stated in (15).

$$(15) \text{ Nasal gemination rule: } \emptyset \rightarrow \left[ \begin{array}{c} C_i \\ +\text{nasal} \end{array} \right] / V \_ ]_{N_1+N_2} \left[ \begin{array}{c} C_i \\ +\text{nasal} \end{array} \right]$$

Example words of nasal gemination are shown below.

(16) Nasal gemination examples

	N <sub>1</sub> final	N <sub>2</sub> initial	N <sub>1</sub>	N <sub>2</sub>	phonetic form
a.	vowel	nasal	/mʌli/ 'head'	/mal/ 'language'	[mʌlimmal] 'preface'
b.			/i/ 'tooth'	/mom/ 'body'	[immom] 'gum'

It is generally assumed that no junctural marking processes, whether tensing or nasal gemination, apply when N<sub>2</sub>-initial segments are laryngeally marked obstruents, vocoids or /h/.

### 3.1.1 The origin of sai-siot

The term *sai-siot* is a compound consisting of /sai/ [sai] 'between' and /sios/ [sioŋ] 'the letter /s/'. It refers to the letter denoting the sound /s/ which is suffixed to N<sub>1</sub> as a compound juncture marker in modern Korean orthography. As illustrated in (17), it is supposed to be used in compounds with vowel-final N<sub>1</sub> if they show compound tensing or nasal gemination:

(17) sai-siot <s> in modern Korean orthography

	N <sub>1</sub>	N <sub>2</sub>	phonetic form	spelling	
a.	/hɛ/	/pic <sup>h</sup> /	[hɛp'it]	<hɛ-s-pic <sup>h</sup> >	'sun light (sun-light)'
b.	/i/	/mom/	[immom]	<i-s-mom>	'gum (tooth-body)'

The use of sai-siot <s> in standard Korean orthography is inconsistent and does not always reflect speakers' pronunciation of relevant words which often shows variation, as will be discussed in section 3.2.

Historically, sai-siot <s> used to be a genitive case marker in Middle Korean (Lee 1954/1955; Jun 1967; An 1968; and others). As will be discussed in section 3.2, this historical origin is reflected at least in the overall tendency among words with sai-siot in Contemporary Korean. Sai-siot frequently applies to "genitive" compounds whereas it rarely does to "non-genitive" compounds.

### 3.1.2 The nature of sai-siot

Most previous synchronic accounts of sai-siot derive compound tensing and nasal gemination by positing a segmental (or featural) compound juncture marker in the underlying representation or through the application of the epenthesis rule. For instance, suppose that a genitive marker /-s/ in Middle Korean has been morphologized as an affix marking the compound juncture in Contemporary Korean. As shown in (18a), when the juncture marker /s/ is placed before a lenis

obstruent, it would trigger post-obstruent tensing (POT), possibly preceded by coda neutralization, i.e. /s/ → [t].

- (18) a. /pom-s-pi/ →<sub>POT</sub> [pomsp'i] →<sub>CS</sub> [pomp'i] 'spring rain (spring-rain)'  
b. /i-s-mom/ →<sub>ON</sub> [inmom] →<sub>PA</sub> [immom] 'gum (tooth-body)'.

The marker [s], or its neutralized [t], is then deleted due to cluster simplification (CS). As in (18b), when the juncture marker /s/ is placed before a nasal, it would first become an alveolar [n] through obstruent nasalization (ON), possibly preceded by coda neutralization. The resulting [n] would further undergo place assimilation (PA) if N<sub>2</sub>-initial nasal is not coronal. Notice that the phonological processes adopted here, in particular post-obstruent tensing and obstruent nasalization, are independently justified in Korean phonology. (See section 1.2 for their brief descriptions.) Consequently, both compound tensing and nasal gemination can be plausibly derived by inserting the juncture marker /s/ between compound members.

But notice that a coronal fricative [s] never appear phonetically at the internal juncture of the compound (Kim-Renaud 1974/1991: 170; Cook 1991: 3; and Labrune 2016: 207). Thus, there is no direct evidence that the underlying form of the compound juncture marker is /s/. Thus far, a variety of different phonological elements have been proposed as the compound juncture marker, as listed in (19).

- (19) Previous proposals on the nature of the compound juncture marker
- a. /s/ (Choy 1971: 707; C. Kim 1984; Moon 1997; Sohn 1999: 244)
  - b. /t/ (Ryu 1963; Kim 1970; C. Lee 1972; Kim-Renaud 1974/1991: 163; Huh 1985: 287; Kang 1989, 2003: 504-7)
  - c. /ʔ/ (Martin 1954; Cho 1967; Kim 1974: 137; Oh 1988: 188)
  - d. C-slot (Kim 1986: 178; Ko 1992: 45-6; Han 1997: 274)
  - e. C-slot associated with [+coronal, -continuant] (Ahn 1985: 71)
  - f. X-slot associated with [+constricted glottis] (Sohn 1987: 249; Kim 1992: 154; Kim 2001, Ha 2006: 157)
  - g. floating [tense] feature (Ito 2014; Kim 2016)

The majority of the previous studies assume, in line with standard Korean orthography, that the compound juncture marker is a coronal consonant. Some of those studies (19a, b) adopt /s/ or /t/ as the marker. Other studies (19e, f) adopt an underspecified segment or a skeletal slot for the marker, but most of them posit a default mechanism which derives [t] from the marker. The crucial evidence for the 'coronality' of the marker comes from the data where the marker is pronounced as [t] or [n], as shown in (20).

- (20) Words with [t] or [n] at the compound juncture
- a. /c<sup>h</sup>o-pul/ [c<sup>h</sup>otp'ul] 'candlelight (candle-light)'

- |    |            |            |                                   |
|----|------------|------------|-----------------------------------|
| b. | /nɛ-ka/    | [nɛtk'a]   | 'shore of a stream (stream-edge)' |
| c. | /mɔli-mal/ | [mɔlinmal] | 'preface (head-language)'         |
| d. | /i-mom/    | [inmom]    | 'gum (tooth-body)'                |
| e. | /u-os/     | [utot]     | 'top (upper-clothes)'             |
| f. | /u-ɔlin/   | [utɔlin]   | 'senior (upper-adult)'            |

Previous studies (19a, b, e) adopting a full, or underspecified, coronal consonant marker, attribute compound tensing and nasal gemination to automatic post-obstruent tensing and obstruent nasalization, respectively, as illustrated in (18). In contrast, the studies (19f) adopting a skeletal slot associated with [+constricted glottis] as the compound juncture marker, analyze compound tensing as the result of feature spreading from the juncture marker to the following N<sub>2</sub>-initial lenis obstruent. And, nasal gemination is derived by nasal spreading from N<sub>2</sub>-initial nasal onto the preceding skeletal slot of the juncture marker. Thus, these latter studies differ from those adopting a lenis coronal consonant marker in that sai-siot has nothing to do with automatic processes in Korean such as post-obstruent tensing and obstruent nasalization. Still, they are no different in assuming that the compound marker may surface as a coronal consonant, [t] or [n], as shown in (20).

The coronal hypothesis, i.e. that the compound juncture marker is a coronal consonant, whether underspecified or not, has been criticized by some previous studies. If the forms with [t] or [n] at the compound juncture in (20a-d) are attested, in addition to those without it such as [c<sup>h</sup>op'ul] 'candlelight', [nɛk'a] 'shore of a stream', [mɔlinmal] 'preface' and [inmom] 'gum', they can form strong evidence for the coronal juncture marker. But, Jun (1979: 90-1), Lee (1983), Cook (1987: 599), Moon (1989: 43) and Ko (1992: 41) argue that the pronunciation forms with [t] or [n] at the compound juncture in (20a-d) are not possible in natural speech, and, if possible, they must be spelling pronunciations. Words in (20e, f), which are cited as the examples with the compound juncture marker [t] in intervocalic contexts, are also considered inadequate by some of the previous studies. Ko points out that there exist only a very small number of such compounds, which is difficult to understand, given that sai-siot processes are productive (see section 3.3 for relevant discussion). Moreover, it is possible either that such words are synchronically not decomposable, or, as mentioned explicitly by Ko and assumed by Cho (2016: (27c)), that they are prefixed, not compound, words. Thus, it seems that a systematic experimental investigation on Korean speakers' natural production of words with sai-siot is required to verify the coronal hypothesis.

In the studies (19d) adopting an empty C as the juncture marker, compound tensing is the result of melody spreading from the N<sub>2</sub>-initial lenis obstruent to the preceding C slot, followed by addition of the feature [tense] to the geminate obstruent. Compound nasal gemination can be derived similarly via melody spreading from the N<sub>2</sub>-initial nasal to the preceding C slot. This type of analysis is crucially based on the 'geminate' hypothesis that tense (and aspirated) consonants in Korean are geminates (Martin 1954; Kim 1986; You 1989; Ko 1992; Jun 1994; Han 1996, 1997; Choi & Jun 1998 and others). A similar analysis is provided by Jun (1979)

although he does not explicitly posit an empty skeletal slot as the compound juncture marker. The success of such approaches based on the geminate hypothesis heavily depends on the empirical validity of the hypothesis which needs to be explored. (See Cho (2011) for an in-depth criticism of the geminate hypothesis.)

Almost all the previous approaches provide a unified analysis of the two processes involved in sai-siot. They attempt to derive both tensing and nasal gemination from a single underlying form of the compound juncture marker. But, this is probably not true for the studies adopting a floating [tense] feature as the juncture marker (19g). If the floating [tense] feature is associated to N<sub>2</sub>-initial lenis obstruent, compound tensing would be easily derived. But, it is not clear how to derive nasal gemination from the [tense] feature when N<sub>2</sub> begins with a nasal.

Before leaving this section, note that some previous studies (for instance, Ahn (1985: 71) and Zuraw (2011)) assume that n-insertion and sai-siot are both compound juncture marking processes. But, as mentioned in section 2.1, n-insertion applies in various multi-morphemic contexts, and it cannot be a compound juncture marking process. (See Ko (1992) for discussion of why the sai-siot phenomena should be considered distinct from n-insertion.)

### 3.2 Conditioning factors: sai-siot

Not all noun-noun compounds undergo sai-siot even when they meet the basic application conditions for sai-siot stated in (13) and (15). It has been pointed out in the literature (in particular, Im 1981: 1-2; Zuraw 2011) that the occurrence or non-occurrence of sai-siot is not phonologically predictable, as can be illustrated by the pairs of words in (21), each of which consists of two nouns with no essential phonological differences, one with sai-siot and the other without it.

(21) Variation in compound tensing across words with no crucial phonological differences

	N1 final	sai-siot	non-sai-siot
a.	vowel	/namu-pɛ/ [namu <b>p</b> 'ɛ] 'boat to transport wood (wood-boat)'	/namu-pɛ/ [namu <b>p</b> ɛ] 'wooden boat (wood-boat)'
b.	liquid	/mul-koki/ [mul <b>k</b> 'oki] 'fish (water-fish)'	/pul-koki/ [pul <b>k</b> oki] 'barbecued beef (fire-meat)'
c.	nasal	/pom-pi/ [pom <b>p</b> 'i] 'spring rain (spring-rain)'	/pom-kail/ [pom <b>k</b> ail] 'spring and fall (spring-fall)'

Notice that words in (21a) consist of the same stems, /namu/ and /pɛ/, although they have different meanings. Accordingly, most previous studies argue (or assume) that the occurrence or non-occurrence of sai-siot is determined by non-phonological factors. They attempt to characterize the set of Korean compounds undergoing sai-siot and those not undergoing it in terms of their morpho-syntactic, semantic, etymological, and processing properties. The table in (22) summarizes such non-phonological factors proposed in the literature (in particular, Chung 1980; Im 1981; Sohn 1999; Kang 2003; Ha 2006).



## (22) Conditioning factors for the occurrence and non-occurrence of sai-siot

	sai-siot	non-sai-siot
a. degree of cohesion of compound members	intermediate	either high or low
b. compound type	genitive (with inanimate N <sub>1</sub> ), sub-compound (modifier-head)	genitive (with animate N <sub>1</sub> ), non-genitive, coordinative or co-compound, argument-predication
c. N1 denotation	time, location, origin, purpose of use	shape, material, ingredient
d. etymology	native Korean	Sino-Korean (in particular, with multisyllabic N <sub>2</sub> )

Descriptive categories in (22) are often impressionistically defined, and thus category membership is not always clear-cut for some words. Moreover, each of the proposed conditions has exceptions. This point can be illustrated by the pairs of words in (23) consisting of one with sai-siot and the other without, which show no crucial difference in most conditioning factors for sai-siot.

## (23) Variation in sai-siot across words with no crucial differences in conditioning factors

	sai-siot	non-sai-siot
a.	/pipim-pap/ [pipim <b>p</b> 'ap] 'rice mixed with vegetables and beef (mixing-rice)'	/pipim-kuksu/ [pipim <b>k</b> uks'u] 'spicy noodle (mixing-noodle)'
b.	/k <sup>h</sup> oŋ-kuk/ [k <sup>h</sup> oŋ <b>k</b> 'uk] 'bean soup (bean-soup)'	/k <sup>h</sup> oŋ-pap/ [k <sup>h</sup> oŋ <b>p</b> ap] 'rice with beans (bean-rice)'
c.	/an-paŋ/ [an <b>p</b> 'aŋ] 'main room (inner-room)'	/salaŋ-paŋ/ [salaŋ <b>p</b> aŋ] 'reception room for male guests (outer room-room)'
d.	/ton-paŋsɔk/ [ton <b>p</b> 'aŋsɔk] 'a pile of money (money-sitting mat)'	/panil-paŋsɔk/ [panil <b>p</b> aŋsɔk] 'a bed of nails (needle-sitting mat)'
e.	/p <sup>h</sup> anca-cip/ [p <sup>h</sup> anca <b>c</b> 'ip] 'shack (board-house)'	/kiwa-cip/ [kiwa <b>c</b> ip] 'house roofed with tiles (roof tile-house)'
f.	/pɔl-cip/ [pɔl <b>c</b> 'ip] 'hive (bee-house)'	/sɛ-cip/ [sɛ <b>c</b> ip] 'birdhouse (bird-house)'
g.	/ton-pɔl-i/ [ton <b>p</b> 'ɔli] 'money making (money-earn-NFS)'	/non-kal-i/ [non <b>k</b> ali] 'rice field plowing (rice field-plow-NFS)'

In addition to variation across words, considerable variation occurs within a word, across speakers, generations and dialects. According to the Standard Korean Dictionary (Kwuklip kwuke yenkwuwen 1999) and most previous studies, the words in (24) do not undergo sai-siot, but their variants with sai-siot can often be observed in natural speech.

(24) Variation in sai-siot within a word

- a. /salaŋ-paŋ/ [salaŋpaŋ] ~ [salaŋ**p**'aŋ] 'reception room for male guests (outer room-room)'
- b. /kiwa-cip/ [kiwacip] ~ [kiwa**c**'ip] 'house roofed with tiles (roof tile-house)'
- c. /sai-sios/ [saisiot] ~ [sais'**i**ot] 'sai-siot (between-letter s)'

Thus, it is obvious that none of the factors stated in (22) can clearly separate words undergoing sai-siot from those not undergoing it. This is in line with the statement from many previous studies (to name just a few: Choy 1971: 708-9; Kim-Renaud 1974/1991: 168; Chung 1980: 60; Lee 1983: 140-1; Cook 1987: 596, 1991: 5; Kim 1992: 160-1; Ko 1992: 36; O 2000: 103; Labrune 2016: 208) that sai-siot is extremely irregular and largely unpredictable.

However, although the probability of sai-siot varies across words and speakers, there exist tendencies which may be explained by the interaction of phonological, morpho-syntactic, etymological and processing factors such as word origin, stem length, branching structure, features of segments involved and presence of tense consonants. These factors might contribute to the overall probability of the occurrence of sai-siot. This possibility has been explored initially by Zuraw (2011) and subsequently by Ito (2014) and Kim (2016) both of whom focus on phonological factors.

Consequently, sai-siot is no different from n-insertion in that its (non-)occurrence cannot be predicted with absolute certainty from a single factor, phonological or not, but various factors interact to increase (or decrease) the probability of (non-)occurrence.

### 3.3 Productivity: sai-siot

Most previous studies on sai-siot phenomena (notably, Kim-Renaud 1974/1991: 168; and Ko 1992: 41; but cf. Choi 2003: 144) seem to assume, implicitly or explicitly, that sai-siot is synchronically productive although their data are the pronunciation of existing Korean words, obtained mainly through the author's intuition as a native speaker of Korean. Studies not relying on the author's native speaker intuition make use of either the dictionary pronunciations (Ha 2006; Zuraw 2011) or the results of the judgment survey on native Korean speakers (Ito 2014; Kim 2016). English loanwords with sai-siot, which can be considered as more direct evidence for its productivity, have been reported as shown in (25).

(25) Sai-siot in loanwords (slightly adapted from Kim-Renaud 1974/1991: 168)

- a. /pata-pilausi/ [patap'**p**ilausi] 'blouse for beach (sea-blouse)' (N<sub>2</sub> = loanword)
- b. /radio-sok/ [radios'**s**ok] 'radio inside (radio-inside)' (N<sub>1</sub> = loanword)

Further evidence for the productivity of sai-siot can be found in Ito (2014) who conducted wug tests on speakers of Yanbian Korean. Results of her wug tests showed that most of the tendencies observed in existing compounds were mirrored in nonce compounds. In order to ensure and

confirm the productivity and distribution of sai-siot in other dialects of Korean including Seoul Korean, tests with nonce words need to be conducted on native speakers of such Korean dialects.

### *3.4 Analysis: sai-siot*

As discussed in section 3.1.2, most previous approaches to sai-siot posit a compound internal juncture marker, such as a full segment /t/, a floating feature [tense] or an empty skeletal slot. The juncture marker is argued either to be present in the underlying representation or inserted by epenthesis rules or constraints. Depending on the type of the compound juncture marker posited, different mechanisms are adopted in the analysis of sai-siot phenomena.

In the previous approaches adopting a segmental marker such as /t/ or /s/, the presence of the marker triggers the application of some automatic phonological processes in Korean, as shown in (18). Specifically, when N<sub>2</sub>-initial segment is a lenis obstruent, the marker induces its tensing due to post-obstruent tensing. When N<sub>2</sub>-initial segment is a nasal, the marker undergoes nasalization due to obstruent nasalization. Approaches adopting an under- or less-specified segment as the juncture marker follow this line of analysis, as long as it is assumed that the marker may trigger tensing of the following lenis obstruent and undergoes nasalization before a nasal. In these approaches, rules or constraints adopted for the analysis of automatic processes in Korean would play a major role in the analysis of sai-siot phenomena.

In the approaches adopting an empty skeletal slot marker, the marker forms a geminate with the following N<sub>2</sub>-initial segment through melody spreading, yielding an obstruent geminate when N<sub>2</sub>-initial segment is a lenis obstruent, and a nasal geminate when it is a nasal. The obstruent geminate is realized as a tense consonant, under the geminate hypothesis that tense consonants in Korean are geminate. Under these approaches, the analysis of sai-siot phenomena consists of autosegmental rules or constraints which are responsible for melody spreading from the N<sub>2</sub>-initial consonant to the preceding skeletal slot marker.

Finally, in the approaches adopting a floating feature marker such as [tense], tensing of the N<sub>2</sub>-initial obstruent is analyzed as the spreading of the floating [tense] onto it. In OT analyses, the interaction of faithfulness constraint demanding the realization of a morphemic element (e.g. REALIZEMORPHEME: ‘A floating [tense] feature in the input must be realized in the output.’ (Ito 2014: 371)), faithfulness constraint for featural identity (especially, in the initial segment of the second member of a compound) and markedness constraint militating against floating features in the output would form the main part of the analysis. But, as mentioned in section 3.1.2, in this approach, analysis of nasal gemination is in principle unavailable.

For the formal analysis of tendencies found in the distribution of sai-siot, probabilistic grammar models are needed. See Ito (2014) and Kim (2016) for the maxent OT analyses of compound tensing.

## 4. Vowel harmony

### 4.1 Basic pattern: vowel harmony

In Seoul Korean and other dialects of Korean, vowel harmony occurs in verbal inflection and ideophones. Since the topic of the present study is morpho-phonological processes, this section is mainly concerned with verbal inflection although harmony patterns in ideophones will be discussed when they are relevant to the discussion at hand.<sup>8</sup>

In Korean, all verb forms are suffixed, and verb stems never occur in isolation. Verbal suffixes may be classified into the following four types, based on Choi (1985) and Kang (2006).

(26) Four types of verbal suffix in Korean

- a. V(owel)-initial suffix: -a/ə ‘IMP’ and many other meanings.
- b. C(onsonant)-initial suffix: e.g. -ca ‘HORT’, -ko ‘PROG’. (/i/ is not inserted even when the stem ends in a consonant.)
- c. (i)C-initial suffix: e.g. -(i)mjən ‘if’. (/i/ is present only when the stem ends in a consonant other than /l/.)
- d. (Ci)C-initial suffix: e.g. -(si)p ‘addressee honorific’. (Ci is present only when the stem ends in a consonant other than /l/.)

In Korean verbal paradigm, all V-initial inflectional suffixes have two basic allomorphs, a- and ʌ-initial, as illustrated in (27).

(27) Allomorphs of some V-initial inflectional suffixes<sup>9</sup>

a ~ ʌ	‘DECL.IND’, ‘INT.IND’, ‘IMP’, and ‘ADV’
as’ ~ ʌs’	‘PST’
asʌ ~ ʌsʌ	‘and then’
ala ~ ʌla	‘IMP’

The choice of the allomorphs depends on the quality of the last stem vowels. As illustrated in (28), a-initial forms are chosen when the last stem vowel is either /a/ or /o/ whereas ʌ-initial forms are chosen for the rest of the vowels.

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<sup>8</sup> Adjectives in Korean are not distinct from verbs in many morpho-syntactic and phonological properties, crucially including vowel harmony patterns. Thus, for simplicity’s sake, the inflection of verbs and adjectives is referred to as verbal inflection.

<sup>9</sup> Kang (2012: 3, (3)) reports that NIKL (The National Institute of Korean Language) frequency data contain 16 harmonizing V-initial suffixes including three rarely used ones.

(28) Korean verbs and adjectives suffixed with -a/Λ

stem V	suffix V	stem	suffixed form	
Λ	Λ	/mΛk/	mΛk-Λ	‘eat’
e		/se/	se-Λ	‘count’
ε		/mεc/	mεc-Λ	‘bear’
i		/mil/	mil-Λ	‘push’
ɨ		/tɨl/	tɨl-Λ	‘lift’
u		/sum/	sum-Λ	‘hide’
∅		/t∅/	t∅-Λ	‘become’
y		/hy/	hy-Λ	‘bend’
o	a	/c’oc <sup>h</sup> /	c’oc <sup>h</sup> -a	‘chase’
a		/mac/	mac-a	‘correct, be hit’

This vowel harmony in verbal inflection is local in that it holds only between the last stem vowel and the initial vowel of the immediately following suffix (Sohn 1987: 196; Hong 2008: 408; Han 2009: 342, footnote 2; Kang 2012: 2). Note first that even when a V-initial suffix is multisyllabic, only its initial vowel is subject to harmony: e.g. /cap-*A*la/ [cap*a*la] ‘grab-IMP’ and /mΛk-*A*la/ [mΛk*Λ*la] ‘eat-IMP’ where the symbol *A* is used for the underlying form of the alternating vowel. Second, when a stem is followed by more than one V-initial suffix, vowel harmony targets only the first one (Kim-Renaud 1976/1986: 68; Lee 1992: ch. 4; Cho 1994: 132; Kang 2012: 2). The remaining V-initial suffixes are realized as *Λ*-initial forms, regardless of the quality of the last stem vowel: e.g. /cap-*As*’-*A*/ [cap-*as*’-*Λ*] ‘grab-PST-DECL.IND’. Finally, the choice of V-initial suffix allomorphs depends only on the last vowel of a stem (Hong 2008: 408): e.g. /k’ocip-*A*/ [k’ocip*Λ*] \*[k’ocipa] ‘pinch-IMP’.

The basic patterns of vowel harmony in Korean verbal inflection are summarized as below:

(29) Summary: Basic patterns of vowel harmony in Korean verbal inflection

- a. The initial vowel of V-initial suffixes is [a] if the following conditions are met:
  - i. The last stem vowel is /a/ or /o/.
  - ii. There is no intervening suffix between the stem and the target suffix.
- b. Otherwise, the initial vowel of V-initial suffixes is [Λ].

Since the occurrence of a-initial forms is much more restricted than that of *Λ*-initial forms, the latter has been considered as the default choice (or underlying form) in most previous studies.

#### 4.1.1 The historical background

Vowel harmony in Contemporary Korean is limited to ideophones and certain verbal inflections. Nominal inflections show no alternations involving vowel harmony, and there exist disharmonic root morphemes in Korean lexicon.

In Middle Korean, vowel harmony was more widely attested. Not only verbal but also nominal inflections show harmonic alternations. Harmony also holds within roots, excluding Sino-Korean words. Although there is some disagreement on the vowel phoneme inventory and the harmonic feature of vowel harmony in Middle Korean, it is generally accepted that vowel harmony was pervasive and productive in Middle Korean.<sup>10</sup> A variety of historical changes such as vowel shift, vowel loss, monophthongization, and borrowing a number of loanwords from Chinese caused the disruption of vowel harmony system, resulting in the limited application of vowel harmony in Contemporary Korean (Kim 1973: 138; Kim-Renaud 1976/1986: 63, 69-70; Ahn 1985: 183; Cho 1994: 136; Cho 2001: 192, 196, 199; Kang 2012: 8-12).

Contrary to the general assumption that vowel harmony in Contemporary Korean is limited only to ideophones and certain verbal inflections, some previous studies (Lee 1985: 16; Hong 2010) argue that it is still active in the lexicon of native words in Contemporary Korean. Hong's study on a dictionary corpus shows that the vowel co-occurrence restrictions reflecting the vowel harmony patterns in ideophones hold gradiently in monomorphemic native Korean words.

But, notice that the results of Hong's corpus study do not necessarily mean that in Contemporary Korean, the same harmony system governs both dynamic alternations in verbal inflection and static vowel co-occurrence restrictions in the native word lexicon. This is because harmony patterns of verbal inflection are somewhat different from those in ideophones which Hong found to be consistent with root-internal co-occurrence restrictions. The main difference is in the harmonic groupings, as shown in (30).

(30) Harmonic groups of vowels in Korean vowel harmony

<u>Traditional classification</u>	<u>a. ideophones</u>	<u>b. verbal inflection</u>
light (or bright)	/a, o, ε, ø/	/a, o/
dark	/i, e, y, i̇, ʌ, u/	/i, e, ε, y, ø, i̇, ʌ, u/

In ideophones, given the two groups of vowels under (30a), vowels may co-occur only with vowels from the same group: e.g. /c<sup>h</sup>ollanɕ<sup>h</sup>ollan/ 'frivolously' vs. /c<sup>h</sup>ullanɕ<sup>h</sup>ullan/ 'sloshing'; /molakmolak/ 'steamy' vs. /mulakmulak/ 'growing rapidly'. The first group, /a, o, ε, ø/, is traditionally called 'light' (or 'bright') whereas the second group consisting of the remaining vowels 'dark'. In the vowel harmony system of verbal inflection, the 'light' set is reduced to /a, o/ whereas the 'dark' set is expanded to include all the remaining vowels. In addition, high vowels in non-initial syllables may be neutral in the harmony system of ideophones unlike in that of verbal inflection with no neutral vowels.

To summarize, in Middle Korean, vowel harmony was pervasive and absolute in that it applies uniformly and categorically in verbal and nominal inflections, and within roots. In contrast, vowel harmony is limited in Contemporary Korean. Alternations involving harmony

<sup>10</sup> Previous studies argue that vowel harmony in Middle Korean is based on the backness distinctions (Kim 1973: 137; K. Lee 1972; Ahn 1985: 183; Cheun 1975: 36, 56, 60; Kang 2012: 7) or the ATR/RTR values (Y. Kim 1984: 178-9; Lee 1985: 6; Kim 1988, 1993; Cho 1994: 140; and Ko 2012: 174-5).

occur only in verbal inflections. The static requirements for vowel harmony based on different harmonic vowel groupings are absolute only for ideophones. The same harmony requirements additionally hold gradiently in the monomorphemic lexicon of native Korean words.

#### 4.1.2 The nature of harmonic feature

The harmonic feature active in Korean vowel harmony is very difficult to define for the following reasons. First, as mentioned in the previous section, harmonic vowel groupings are different between the harmonic systems of ideophones and of verbal inflection. It is impossible that a single feature, or a single set of features, consistently separate two harmonic groups across the harmony systems of ideophones and of verbal inflection.

What is more important is that regardless of whether or not the same harmonic feature may be posited for the harmony systems of ideophones and verbal inflection, it is difficult to find a phonetically transparent distinctive feature which can separate the two harmonic groups of vowels either in ideophones or in verbal inflection. Note that ‘light’ vowels /a, o/ (along with /ε, ø/ in ideophones) can hardly form a natural class, excluding the rest of the phonemic vowels in Korean (Kim 1973: 137; Kim-Renaud 1976/1986: 65; Ahn 1985: 186; Sohn 1987: 168, 197; and many others). For this reason, most previous proposals on the harmonic feature of Korean vowel harmony, shown in (31), are somewhat different from the conventional phonological analysis of vowel harmony adopting phonetically transparent distinctive features as the harmonic feature.

- (31) Previous proposals on the harmonic feature of vowel harmony in Contemporary Korean
- a. semantic features: [bright] and [dark] (Kim-Renaud 1976/1986)
  - b. acoustic features: [dual] and [drop] (Y. Kim 1984: 65-6); [DVR] (deep voice resonance) (Y. Kim 1984: 178)
  - c. backness (Kim 1973: 138)
  - d. lowness (McCarthy 1983: 145-7; Ahn 1985: 188-9; Sohn 1987: 198; Kim 2007)
  - e. ATR and/or RTR (Y. Kim 1984; Lee 1985: 17-18; Lee 1992: ch. 4; Lee 1993; Cho 1994: 127; Chung 2000; Hong 2008: 406-7; Hong 2010: 280-1; Kang 2012: 1-2, 58)

Some previous approaches to Korean vowel harmony (31a, b) give up on the use of phonetically transparent distinctive features as the harmonic feature, adopting language-specific semantic features (Kim-Renaud 1976/1986) or rarely-used acoustic features (Y. Kim 1984: 65-6, 178). Other studies (31c-e) adopt [back], [low] or [ATR/RTR] as the harmonic feature, but these feature specifications are not justified independent of the vowel harmony process. In Kim’s (1973) derivational rule-based analysis of Korean vowel harmony, the underlying vowel system of Contemporary Korean is first changed, by adjustment rules, into one similar to that of Middle Korean which Kim assumes to have active backness harmony. After the backness harmony applies, the original vowel system is restored through the application of readjustment rules. This

analysis based on synchronic reconstruction of historical states has been criticized for being unrealistic and arbitrary (Kim-Renaud 1976/1986: 71-2; Ahn 1985: 185-6). McCarthy's (1983) analysis of Korean vowel harmony as lowness agreement may be subject to similar problems. He posits a rather abstract vowel system of Contemporary Korean in which all 'light' vowels are [+low] whereas 'dark' ones are [-low]. After the lowness harmony rule applies, a more realistic vowel system is restored through the application of adjustment rules.

Not a few previous studies on Middle and Contemporary Korean vowel harmony suggest that 'dark' vowels are [+ATR] (or [-RTR]) whereas 'light' vowels are [-ATR] (or [+RTR]) (Y. Kim 1984: 178-9; Kim 1988, 1993; and references in (31e)). The vowel system that they posit at least for the analysis of vowel harmony in Contemporary Korean verbal inflection is quite imbalanced since the 'light' vowels, i.e. two back vowels /a, o/, are [-ATR] (or [+RTR]), and thus the ATR/RTR contrast is active only among back vowels. In addition, the two members in each contrast pair, i.e. a-Λ and o-u, differ in height as well, which seems to be atypical of languages with ATR/RTR contrasts in which the vowels of the same height usually form a contrastive pair, alternating with each other, e.g. i-i, e-ε, o-ɔ and u-ʊ (Kim 2007: 441).

Finally, admitting that /a/ and /o/ cannot form a natural class in Korean, some previous studies provide separate accounts for /a/-triggering alternation and /o/-triggering one, considering only the former as a case of true vowel harmony. Sohn (1987: 197-201) considers /Λ/, i.e. her /ə/, as the underlying form of the alternating vowel. She explains the choice of the a-initial form after the last stem vowel /a/ by proposing the [+low] feature spreading rule, and thus [+low] should be considered the harmonic feature. In contrast, Sohn proposes vowel lowering rule, i.e. insertion of [+low] to the suffix-initial vowel occurring after the last stem vowel /o/ to explain the choice of the a-initial form in that context. In Sohn's analysis, vowel harmony occurs only when the last stem vowel is /a/, not /o/. Similarly, in her OT analysis of vowel harmony in Korean verbal inflection, Kim (2007: 444-5) attributes the choice of the a-initial form after the last stem vowel /a/ to a constraint for the general lowness harmony, but the same choice after the last stem vowel /o/ to a higher-ranked constraint for stem-final round vowels, which is thus relevant only for /o/, not /a/.

It seems that most previous proposals on Korean vowel harmony assume that the attested harmony patterns are quite idiosyncratic, thus resisting the conventional phonological analysis of vowel harmony normally adopting phonetically transparent distinctive features as the harmonic feature. For those adopting [ATR/RTR] as the harmonic feature, the posited vowel system with a [ATR/RTR] contrast needs to be justified independently of vowel harmony analysis unless the [ATR/RTR] feature is simply employed as a diacritic marker indicating harmonic classes.

#### ***4.2 Conditioning factors: vowel harmony***

As presented in (29) above, the basic harmony pattern in Korean verbal inflection is that V-initial suffixes are realized as a-initial allomorphic forms when they immediately follow stems with the last vowel /a/ or /o/; otherwise, Λ-initial allomorphs are chosen. This section discusses how this



basic pattern varies and what factors influence the variation. Let us begin with the following factors.

(32) Factors for the occurrence of exceptions and variations in Korean vowel harmony

- a. The quality of the last stem vowel
- b. The presence or absence of the stem-final consonant
- c. The stem class
- d. The suffix type

First, if the last stem vowel is /a/, and the stem ends in a consonant, not only the harmonic a-initial forms but also the disharmonic  $\Lambda$ -initial forms can be chosen for the following V-initial suffix, as shown in (33a) (Kim-Renaud 1976/1986; Cho 1994: 130; Hong 2008: 406-10, references therein; Han 2009: 343; Kang 2012: 2-3, 48; and Kang & Ryu 2015).

(33) The occurrence and non-occurrence of a~ $\Lambda$  variation: the quality of the last stem vowel

- |                           |                                      |             |
|---------------------------|--------------------------------------|-------------|
| a. /mak-A/                | [mak- <b>a</b> ] ~ [mak- $\Lambda$ ] | ‘block-IMP’ |
| b. /c’oc <sup>h</sup> -A/ | [c’oc <sup>h</sup> - <b>a</b> ]      | ‘chase-IMP’ |

Out of the two variants, the harmonic one is generally more frequent than the disharmonic one. This a~ $\Lambda$  variation does not occur for stems with the last vowel /o/ which can combine only with the harmonic a-initial forms, but not with the disharmonic  $\Lambda$ -initial ones (33b).

Second, not all stems with the last vowel /a/ show the a~ $\Lambda$  variation. If there is no intervening consonant between the trigger vowel /a/ and the target vowel of the following V-initial suffix, no variation arises (Cho 1994: 131; Kang 2012: 80-1). Specifically, when stems end in a vowel, i.e. /a/, only a single [a] can surface at the stem-suffix boundary (34a), which may be analyzed as either deletion of the suffix-initial vowel or vowel degemination (ordered after vowel harmony).

(34) No a~ $\Lambda$  variation when the stem-final consonant is absent.

- |            |                 |                     |
|------------|-----------------|---------------------|
| a. /ka-A/  | [ka]            | ‘go-IMP’            |
| b. /nah-A/ | [na- <b>a</b> ] | ‘give birth to-IMP’ |
| c. /nas-A/ | [na- <b>a</b> ] | ‘recover-IMP’       |

Disharmonic forms such as \*[ka- $\Lambda$ ] and \*[k $\Lambda$ ] are not possible. This is also true for stems which end in a consonant underlyingly, but lose it at the surface. In Korean verbal inflection, before V-initial suffixes, stem-final /h/ deletes with no exception, and stem-final /s/ deletes in a certain selected set of stems, traditionally called ‘s-irregular’. Stems with the last vowel /a/, which are subject to such final consonant deletions, can combine only with a-initial forms, as can be seen in (34b, c). Kang & Ryu’s (2015) recent analysis of a Korean dialect speech corpus (constructed by

NIKL in 2004-2010) shows that such predominant use of a-initial forms in the absence of intervening consonants is true across dialects of Korean.

An interesting case is that the stem-final segment deletes before V-initial suffixes, rendering /a/ the last stem vowel, and consonants intervene between the final /a/ and V-initial suffixes. Recall that stems with the last vowel /i/ are always combined with  $\Lambda$ -initial suffixal forms. This is true even when stem-final /i/ undergoes deletion before V-initial suffixes and no stem vowel remains (35a).

(35) verb stems with final /i/

- |              |  |             |
|--------------|--|-------------|
| a. /s'i-A/   | [s'- $\Lambda$ ]                         | 'write-IMP' |
| b. /camki-A/ | [camk- <b>a</b> ] (~ [camk- $\Lambda$ ]) | 'lock-IMP'  |

But, as in (35b), if /a/ precedes the final vowel /i/ in the stem, the penultimate vowel, i.e. /a/, determines the harmony pattern, mainly taking a-initial forms. Here, disharmonic  $\Lambda$ -initial forms are also possible. Notice that the stem in (35b) ends with consonants after /i/-deletion, and thus there are intervening consonants between the now stem-last vowel /a/ and the suffix vowel. This is in contrast with the stems in (34b,c) that show no variation and end in a vowel after stem-final consonant deletions. All this suggests that the harmony pattern involving stem-final segment deletions is basically determined based on the surface form, and variation occurs only under the condition that consonants intervene between the last stem vowel /a/ and V-initial suffixes.

Third, the vowel harmony pattern may differ depending on the alternation class of verb stem. As shown in (33), stems with the last vowels /a, o/ are normally combined with a-initial suffix allomorphs although disharmonic  $\Lambda$ -initial variants are additionally attested for those ending in a sequence of /a/ and consonants. As discussed by Hong (2008: 406, 409) and Kang (2012: 5), this general harmony pattern does not hold for a certain set of verb stems, traditionally called 'p-irregular', in which the stem-final consonant appears as [p] before C-initial suffixes but as [w] before V-initial suffixes. The p-irregular verb stems are combined with  $\Lambda$ -initial suffix forms, regardless of the quality of the last stem vowel, as can be seen in (36a-d).

(36) p-irregular verbs suffixed with -A 'DECL' or 'IMP'

- |                          |  |                |
|--------------------------|--|----------------|
| a. /nup-A/               | [nuw- $\Lambda$ ]  | 'lie-IMP'      |
| b. /t $\Lambda$ p-A/     | [t $\Lambda$ w- $\Lambda$ ]  | 'hot-DECL'     |
| c. /pankap-A/            | [pankaw- $\Lambda$ ] (~ [pankaw- <b>a</b> ])                       | 'glad-DECL'    |
| d. /k $\emptyset$ lop-A/ | [k $\emptyset$ low- $\Lambda$ ] (~ [k $\emptyset$ low- <b>a</b> ]) | 'painful-DECL' |
| e. /top-A/               | [tow- <b>a</b> ]   | 'help-IMP'     |
| f. /kop-A/               | [kow- <b>a</b> ]   | 'pretty-DECL'  |

In particular, p-irregular stems with the last vowels /a, o/ (36c, d) are generally combined with disharmonic  $\Lambda$ -initial suffix forms although harmonic a-initial ones may occur as minor variants. Monosyllabic p-irregular stems with the last vowel /o/ (36e, f) are exceptions to this exceptional

behavior of p-irregular stems in vowel harmony. They are no different from other classes of verb stems with the last vowel /o/ in that they are combined only with the harmonic a-initial forms.

As pointed out by Kang (2012: 5), the exceptional harmony pattern of p-irregular verbs cannot be attributed solely to the final vocoid [w] of p-irregular verb stems occurring before V-initial suffixes since other verb stems ending in [w] at the surface do not behave like p-irregular verbs in vowel harmony. Stems ending in /u, o/ undergo glide formation before V-initial suffixes, surfacing as [w]-final forms like p-irregular stems. Stems ending in /o/ (37a,b) can combine only with a-initial forms, and stems ending in /u/ (37c,d) can combine only with  $\Lambda$ -initial forms with no variation, regardless of the quality of the vowel preceding the stem-final [w].

(37) verb stems ending in /u/ and /o/<sup>11</sup>

- |               |                      |                     |
|---------------|----------------------|---------------------|
| a. /na-o-A/   | [naw- <b>a</b> ]     | ‘come out-IMP’      |
| b. /pi-k’o-A/ | [pik’w- <b>a</b> ]   | ‘be sarcastic-IMP’  |
| c. /s’au-A/   | [s’aw- $\Lambda$ ]   | ‘fight-IMP’         |
| d. /totku-A/  | [totk’w- $\Lambda$ ] | ‘make stronger-IMP’ |

It seems that the harmony pattern involving stems ending in /u, o/ is determined based only on the underlying form of the stem, and the final [w] of the surface stem form plays no role in the harmony of these stems.

Fourth, all V-initial suffixes in principle show a~ $\Lambda$  variation in the relevant vowel harmony contexts, but their disharmonic variants are not equally likely. The occurrence of disharmonic forms is most likely for the sentence ending suffix consisting of a single vowel as shown in (33a) (Kang 2012: 48-50). The other V-initial suffixes such as -Ala ‘IMP’ and -As ‘PST’ generally show the harmonic pattern although their disharmonic forms are also possible.

I presented the above descriptions on the basis of previous studies on Korean vowel harmony, but it is obvious that not all of them agree with the above. See Kang (2016: section 3) for discussion of such studies.

### ***4.3 Productivity: vowel harmony***

Most previous studies on Korean vowel harmony argue that the vowel harmony system has been disrupted in Contemporary Korean, mainly based on the fact that vowel harmony holds only in some limited morphological areas, i.e. ideophones and V-initial suffixes in verbal inflection, and disharmonic forms in verbal inflection may occur with stems with the last vowel /a/.

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<sup>11</sup> /na-o/ ‘come out’ and /pi-k’o/ ‘be sarcastic’ in (37a,b) are etymologically multimorphemic verbs. But, their synchronic morphological composition is not clear, since their meanings are somewhat non-compositional, and it is very difficult to define the meanings of /na-/ and /pi-/ unlike the main verb stems, /o/ ‘come’ and /k’o/ ‘twist’.

Productivity of vowel harmony in Korean verbal inflection can hardly be tested with loanwords. As illustrated in (38), when Korean borrows verbs and adjectives from foreign languages, they are always combined with the verbalizer –ha ‘do’ which shows a unique alternation before V-initial suffixes: /ha-A/ [hɛ] (~[ha-jʌ]) ‘do-DECL’.<sup>12</sup>

(38) Loanword verbs and adjectives from English

- |                                  |                             |                     |
|----------------------------------|-----------------------------|---------------------|
| a. /p <sup>h</sup> aiti-ha-A/    | [p <sup>h</sup> aiti-hɛ]    | ‘fight-do-IMP’      |
| b. /pjulip <sup>h</sup> ul-ha-A/ | [pjulip <sup>h</sup> ul-hɛ] | ‘beautiful-do-DECL’ |

Since the verbalizer –ha, not the preceding loanword stem, always determines the allomorph choice of the following V-initial suffix, there is no way to see whether harmony holds between the last vowel of a loanword stem and the initial vowel of the following V-initial suffix.

But, there are some nonce word experiments on Korean vowel harmony: e.g. Kang (2012, 2016) and Jang (2016). Kang (2012) conducted production experiments on speakers of several dialects of Korean, mostly Seoul Korean, employing nonce and real verb stems. Results show that there are no significant differences between nonce and real verbs with the ‘dark’ last vowel. The harmonic ʌ-initial forms were predominantly chosen with both nonce and real verbs. In contrast, nonce and real verbs with the ‘light’ last vowel, i.e. /a, o/, show significant difference in that the disharmonic ʌ-initial forms were more frequently chosen for nonce verbs whereas the relative frequency between harmonic and disharmonic forms was reversed for real Korean verbs. In addition, the difference in the frequency of disharmonic forms between the last stem vowels /a/ and /o/ disappears in the results of the nonce word experiment. Recall that the variation occurs only when the last stem vowel is /a/, not /o/, which is more or less confirmed in the results of Kang’s experiment with real verbs. But, the results of Kang’s nonce word experiment show that variation with more frequent disharmonic forms occurs for stems with /o/ and the relative frequency between harmonic and disharmonic forms is not significantly different between the last stem vowels /a/ and /o/. Thus, the effect of the last stem vowel quality is lost in nonce words. Similar results were found from Kang’s (2016) experiment on Jeolla Korean speakers and Jang’s (2016) experiment on Seoul Korean speakers. Based on the results of his own production experiment, Kang (2012: 50-1) suggests that the Korean harmony process is losing its productivity, and Korean speakers become more dependent on the lexicon, rather than on phonological rules/constraints.

Given that only a small number of nonce word experiments with a limited number of test items were performed on Korean vowel harmony, its productivity still needs to be further explored through more extensive and rigorous studies.

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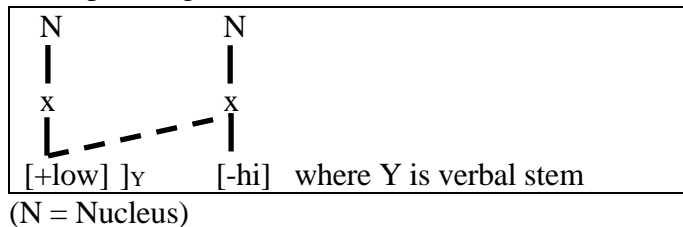
<sup>12</sup> The long form [ha-jʌ] may occur only in certain V-initial suffixes such as –As’ ‘PST’: e.g. /ha-As’-A/ [hɛs’-ʌ] ~ [ha-jʌs’-ʌ] ‘do-PST-DECL’.

#### 4.4 Analysis: vowel harmony

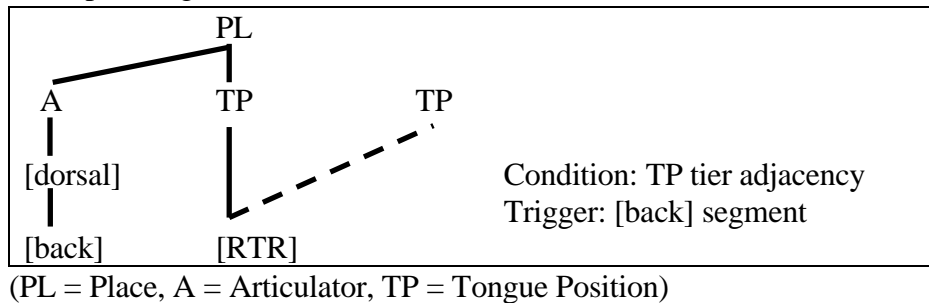
Most previous studies on the vowel alternations in Korean V-initial verbal suffixes attribute the basic alternations (i.e. [a] after stems with the last vowels /a, o/ and [ʌ] after those with the rest of the vowels) to the vowel-to-vowel assimilation for harmonic features, discussed in section 4.1.2. Among them, rule-based approaches propose rules for this vowel harmony, mostly represented in terms of autosegmental spreading, in which the suffix-initial vowel takes on the value of the harmonic feature of the last stem vowel, as shown in (39).

#### (39) Vowel harmony rules

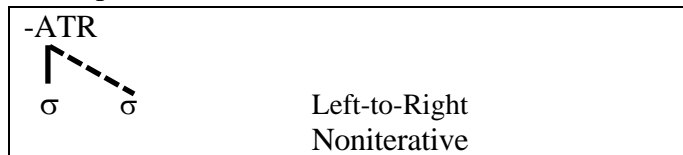
- a. [+low] spreading (Sohn 1987: 198, (3.180))



- b. [RTR] spreading (Lee 1993: 265, (52))



- c. [-ATR] spread (Cho 1994: 133, (46))



In OT approaches to Korean vowel harmony, such spreading rules are replaced by constraints such as alignment (Cho 2001), AGREE (Hong 2008; Kang 2012) and MATCH (Kim 2007; Han 2009).

As mentioned in section 4.1.2, some previous studies argue that not all the basic alternations involve vowel harmony. They analyze only the a-initial forms occurring after stems with the last vowel /a/ as being derived through spreading rules or their constraint counterparts, under the assumption that the two vowels /a, o/ cannot form a natural class in Korean. To explain the occurrence of a-initial forms after stems with the last vowel /o/, they propose separate non-harmony rules or constraints. For instance, Sohn (1987) explains the occurrence of [a] after stems with /a/ by proposing a rule in (39a) above. In contrast, she explains the occurrence of a-

initial forms after the last stem vowel /o/ by proposing the suffix-vowel lowering rule shown in (40).

(40) Vowel lowering (Sohn 1987: 201, (3.184))

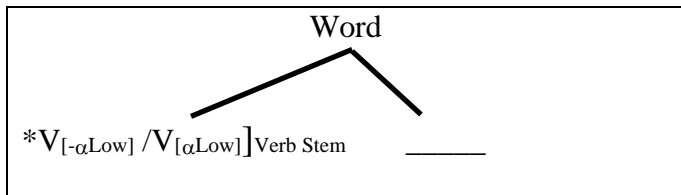
$$[ \quad ] \rightarrow [+low] / o ]_x \left[ \begin{array}{c} \text{---} \\ -high \end{array} \right]$$

where x is verbal stem.

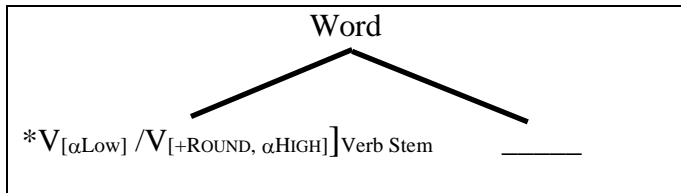
A similar line of approach is adopted in an OT analysis of Korean vowel harmony. Kim (2007: 444-5) proposes the general MATCH constraint (41a) which demands agreement in the [low] feature value between the last stem vowels and the suffix-initial vowels, and thus explains the occurrence of a-initial forms after the last stem vowel /a/.

(41) MATCH constraints (Kim 2007: 444-5, (14), (15))

a. MATCH-R(low)/V



b. MATCH-R(low)/[V, +round]



Since the last stem vowel /o/ is [-low], and the initial vowel /a/ in the following suffix is [+low], this general MATCH constraint cannot explain the choice of a-initial suffixal forms after the last stem vowel /o/. Thus, Kim proposes a separate higher-ranking MATCH constraint (41b) for the verb stems with round vowels, i.e. /o, u/. Its effect is that the last stem vowels /o/ and /u/ are required to precede the low vowel /a/ and nonlow vowel /ʌ/, respectively. Notice that this MATCH constraint is not a constraint for vowel harmony, since it concerns two different features, i.e. [low] and [high], crucially demanding disagreement, not agreement, in their values. (To clarify, see the definition of MATCH constraint in McCarthy (2003: 128).) Obviously, the question of whether stems with the last vowel /o/ trigger the same vowel harmony as stems with the last vowel /a/ depends on what the right harmonic feature in Korean vowel harmony is.

Let us now consider how to extend the analyses of the basic alternations to explain variations and exceptions, discussed in section 4.2. Recall that a~ʌ variation occurs with stems ending in /aC/ and multi-syllabic p-irregular stems. Such variable patterns are usually explained by adopting rule optionality in rule-based phonology and probabilistic models in OT. Kim-

Renaud (1976/1986: 68) in fact proposes an optional vowel harmony rule to explain the a~ʌ variation after the stem-final /aC/. Stochastic Optimality Theory (Boersma 1998; Boersma & Hayes 2001) is adopted by Kang (2011, 2012: 35-6) to explain both variations after the stem-final /aC/ and p-irregular stems. In contrast, Hong (2008) provides an OT analysis of the variation couched within Coetzee's (2006) Rank Ordering model of Eval (ROE) in which the ranking of a certain set of constraints indicates the relative frequency of relevant candidates.

In order to explain the vowel quality dependent patterns and alternation class specific patterns, previous constraint-based approaches to Korean vowel harmony adopted constraints or rankings specific to relevant groups of verbs. Let us first consider previous analyses of the exceptional harmony patterns involving p-irregular stems. Kim (2007: 445, (16)), followed by Han (2009: 345), adopts MATCH constraint specific to multi-syllabic p-irregular stems. In contrast, Kang (2012: 35-6), following Kang (2011: 173), adopts cophonology approach in which different rankings may apply to different lexical classes, as shown below.

(42) Cophonology approach to the vowel harmony of p-irregularity in Korean (Kang 2012: 36, (20))

- a. Regular stem:           AGREE[RTR] ≥ IDENT-V
- b. p-irregular stem:       IDENT-V ≥ AGREE[RTR]

The analyses relying on such class-specific constraints and rankings are no more than descriptive in that they do not say much about why the observed exceptional patterns occur in a specific set of verb stems, i.e. p-irregular, as opposed to p-regular, stems. Hong's (2008) analyses of such 'exceptional' patterns may be subject to a similar criticism. He subdivided AGREE and IDENT constraints into their specific versions to deal with the effects of vowel quality and alternation class. He explains vowel quality dependent patterns by relying on parameterized AGREE constraints. In addition to the general harmony constraint, AGREE(RTR) ("an [αRTR] vowel is followed by an [αRTR] vowel."), Hong (2008: 416-8), followed by Kang (2012: 68), proposes AGREE(-RTR) for stems with the last vowels other than /a, o/, AGREE(+RTR, o) for stems with the last vowel /o/ and AGREE(+RTR, a) for stems with the last vowel /a/. The different vowel harmony patterns depending on the last stem vowel are derived by the interaction of these AGREE constraints and faithfulness constraints. In order to explain the special behavior of p-irregular stems, Hong adopts a lexically-specific version of Faithfulness constraint IDENT(RTR). By ranking this lexically-specific constraint, termed as IDENT(RTR)-L, over AGREE(+RTR, a), he explains why the disharmonic ʌ-initial suffix forms can be used after (multisyllabic) p-irregular stems under the argument that the underlying form of the initial vowel of V-initial suffixes is /ʌ/. Here, it would be a total coincidence that Korean verbs with certain commonalities, for instance "p-irregular" alternation, are more likely to resist vowel harmony than verbs lacking them. (See Kager (2009) for the criticism on the diacritic OT approaches employing morpheme-specific constraints or rankings.)

Let us now consider how to analyze harmony patterns involving /i/-deletion and vowel contraction of stems ending in /a/ or /ʌ/. As mentioned in section 4.2, for stems ending in /i/, since the penultimate vowel of the stem becomes the last stem vowel at the surface, and the vowel harmony pattern depends on it, it can be considered as a case of vowel harmony in which stems end in that penultimate vowel, and thus no special mechanism would be needed, as is done by Han (2009: 348-50). Recall, in (35a), that when the stem ending in /i/ is monosyllabic and thus no trigger vowel is available, ʌ-initial forms are always chosen. This can be understood if we assume, in line with most previous studies, that /ʌ/ is the underlying form of the initial vowel of V-initial suffixes. Finally, when stems end in either /a/ or /ʌ/, a single vowel identical to the stem-final vowel survives and no variation takes place. One might analyze this case as deletion of suffix-initial vowel (Han 2009: 355-7). But, recall in section 4.2 that lack of variation is not confined to such cases where an underlying vowel, whether stem-final or suffix-initial, disappears obviously. As shown in (34b,c) above, even when the suffix vowel clearly survives after deletion of stem-final consonant, the suffix vowel is always realized as its harmonic form: e.g. /nas-A/ [naa] ‘recover-IMP’, and /nah-A/ [naa] ‘give birth to-IMP’. As suggested by Kang & Ryu (2015), this “obligatory” application of vowel harmony in words with no intervening consonants may be due to strict adjacency between trigger and target vowels. Given that vowel harmony is always obligatory when no consonant intervenes between the last stem vowel and the suffix-initial vowel at the surface, cases of vowel contraction with no variation in vowel harmony can plausibly be derived through vowel degemination applying after the obligatory vowel harmony.

Finally, for the analysis of the suffix type effect, i.e. that disharmonic forms are most frequent with the sentence ending suffix consisting of a single vowel -A, Kang (2012: 50, 52) adopts a positional faithfulness constraint, IDENT<sub>S-final-V</sub>, which is motivated by phonological and semantic prominence at the end of the sentence.

Consequently, it seems that we cannot complete the analysis of Korean vowel harmony without employing language-specific and/or lexically-specific mechanisms. But, much work is still needed to figure out exactly what mechanism is responsible for each of exceptional patterns.

## ***5. Conclusion***

For the eventual purpose of exploring the mechanisms governing morpho-phonological processes in general, this article provides an in-depth review of previous studies on three much discussed phenomena in Korean, n-insertion, sai-siot and vowel harmony.

All three phenomena have many exceptions and variations, which make them look quite irregular. Nonetheless, it seems that the variable application of each process is still systematic in that various factors, phonological, morpho-syntactic, socio-linguistic, processing, etc., contribute to the overall probability of rule application. Crucially, grammatical rules and constraints, which have been proposed within generative linguistics to analyze categorical and exceptionless



phenomena, may also be responsible for the variable, though still systematic, application of the three processes in question. Despite many previous studies on the morpho-phonological processes in Korean, only recently has this line of approach been pursued. For the successful investigation and analysis of the processes, a lot more experimental and corpus research on both existing and novel Korean words is required.

## References

- Ahn, Mee-Jin (2008) The Korean /n/-insertion before [j] as [nasal] insertion. *Studies in Phonetics, Phonology and Morphology* 14.3, 371-388.
- Ahn, Mee-Jin (2009) /n/-insertion and onset simplification in Kyungsang Korean. *Studies in Phonetics, Phonology and Morphology* 15.2, 263-282.
- Ahn, Sang-Cheol (1985) *The interplay of Phonology and Morphology in Korean*. Ph.D. dissertation, University of Illinois at Urbana-Champaign.
- Albright, Adam. (2002a). *The identification of Bases in Morphological Paradigms*. Ph.D dissertation, UCLA.
- Albright, Adam. (2002b). Islands of reliability for regular morphology: Evidence from Italian. *Language* 78.4, 684–709.
- Albright, Adam, Argelia Andrade, & Bruce Hayes. (2001). Segmental environments of Spanish diphthongization. In Adam Albright & Taehong Cho (eds.), *UCLA Working Papers in Linguistics 7: Papers in phonology* 5, 117–151.
- Albright, Adam & Bruce Hayes. (2003). Rules vs. Analogy in English Past Tenses: A Computational/Experimental Study. *Cognition* 90, 119–161.
- An, Pyeonghui. (1968). On the genitive suffix ‘-s’ in Middle Korean. [Cwungsey kwukeuy sokkyekemi ‘-s’ ey tayhaye.] *Festschrift for Professor Sungnyeong Lee*, 337-345. Seoul: Ulyu Munhwasa.
- Bae, Ju-Chae (2003). *The pronunciation of Korean*. [Hankwukeyu palum] Seoul: Samkyong Munhwasa.
- Becker, Michael. (2009). Phonological trends in the lexicon: The role of constraints. Ph.D. dissertation, University of Massachusetts.
- Boersma, Paul. (1998) *Functional Phonology: Formalizing the Interaction between Articulatory and Perceptual Drives*. The Hague: Holland Academic Graphics. [Doctoral dissertation, University of Amsterdam.]
- Boersma, Paul & Bruce Hayes. (2001) Empirical tests of the Gradual Learning Algorithm. *Linguistic Inquiry* 32, 45-86.
- Bybee, Joan. (2001). *Phonology and language use*. Cambridge: Cambridge University Press.
- Cheun, Sang-buom (1975) *Phonological aspects of late middle Korean*. Ph.D dissertation, Indiana University.
- Cho, Mi-Hui. (1994) *Vowel harmony in Korean: A grounded phonology approach*. PhD dissertation. Indiana University.
- Cho, Seung-Bog. (1967). *A phonological study of Korean*. (Acta Universitatis Upsalensis. Studia Uralica et Altaica Upsalensia 2.) Uppsala: Almqvist and Wiksells.

- Cho, Sung-Moon. (2001) An optimality-theoretic analysis on the change of the vowel harmony in Korean. [Choejeokseongirone uihan moeumjohwau pyeonghwap punseok.] *Studies in Phonetics, Phonology and Morphology* 7, 191-213.
- Cho, Young-mee Yu (1995). In defense of juncture rules/constraints. *Language Research*, 31.4: 589–614.
- Cho, Young-mee Yu (2011). Laryngeal contrast in Korean. In M. v. Oostendorp, C. J. Ewen, E. Hume, & K. Rice (eds.), *The Blackwell companion to phonology*, 2662–2684. Malden, MA: Wiley-Blackwell.
- Cho, Young-mee Yu (2016). Korean phonetics and phonology. In Mark Aronoff (ed.), *Oxford research encyclopedia of linguistics*. Oxford: Oxford University Press. (published online)
- Cho, Young-mee Yu & Gregory K. Iverson. (1997) Korean phonology in the late twentieth century. *Language Research* 33.4, 687-735.
- Cho, Young-mee Yu & Peter Sells. (1995) A lexical account of inflectional suffixes in Korean. *Journal of East Asian Linguistics* 4, 119-174.
- Choi, Hyewon (2002). *A survey of standard pronunciation* [Phyocunpalum silthaycosa] Seoul: The National Institute of the Korean Language.
- Choi, Myungok. (1985) Phonological phenomena of irregular verbs with focus on p-, s-, t-irregulars. [pyenchik tongsaury umwunhyensangey tayhaye – p-, s-, t-pyenchiktongsalul cwungsimulo] *kwukehak* 14, 149–188.
- Choi, Myungok. (2003) The acceptance of western phonological theories and Korean phonology. [Kumiumwunlonuy swuyongkwa kukeumwunlon] *Kwanakemwunyenku* 25, 91-159.
- Choi, Seongwon & Jongho Jun (1998) Are Korean fortis and aspirated consonants geminates? [Hankuke kyengum kiumun cwungpokcauminka?] *Language Research* 34.3, 521-546.
- Choy, Hyen Pay (1971) *Wulimalpon* [Our grammar]. 4th ed. (posthumous), Seoul: Cengumsa.
- Chung, Chin-Wan (2000) An Optimality-Theoretic account of vowel harmony in Korean ideophones. *Studies in Phonetics, Phonology and Morphology* 6, 431-450.
- Chung, Chin Wan (2001). The behavior of velar nasal and syllabification. *Studies in Phonetics, Phonology and Morphology* 7.1, 177-189.
- Chung, Kook (1980). *Neutralization in Korean: a functional view*. PhD dissertation, University of Texas at Austin. Seoul: Hanshin.
- Coetzee, Andries (2006) Variation as accessing ‘non-optimal’ candidates. *Phonology* 23, 337-385.
- Coetzee, Andries & Joe Pater (2011) The place of variation in phonological theory. In J. Goldsmith, J. Riggle & A. Yu (eds.) *The Handbook of Phonological Theory*, 2nd edition, 401-434. Malden, MA and Oxford, UK: Blackwell.
- Cook, Eung-Do (1987) Sai-sios: A mistaken identity of gemination. *Language Research* 23, 595-605.
- Cook, Eung-Do (1991) Rendaku (Japanese) and sai-sios (Korean): Are the similarities fortuitous and spurious? In Susumu Kuno, Ik-Hwan Lee, John Whitman, Joan Marling, Young-Se Kang & Young-joo Kim. (eds.), *Harvard studies in Korean linguistics* 4, 3-12. Harvard University.
- Goldwater, Sharon & Mark Johnson (2003). Learning OT constraint rankings using a Maximum Entropy model. In Jennifer Spenador, Andres Eriksson & Östen Dahl (eds.) *Proceedings of the Workshop on Variation within Optimality Theory*, 111-120. Stockholm: Stockholm University.

- Ernestus, Mirjam & R. Harald Baayen. (2003). Predicting the unpredictable: Interpreting neutralized segments in Dutch. *Language* 79, 5–38.
- Ha, Se-Kyeong (2006). *The morphology and phonology of 'sai-sori' phenomena in modern Korean*. [Hyentaykuke saissoli hyensanguy hyengtaylonkwa umwunlon.] PhD dissertation, Seoul National University.
- Han, Eunjoo (1993) The phonological word in Korean. In Patricia M. Clancy (ed.), *Japanese/Korean Linguistics* 2, 117-129. Stanford University: CSLI.
- Han, Eunjoo (1994) *Prosodic structure in compounds*. PhD dissertation, Stanford University.
- Han, Eunjoo (2009) Vowel harmony in hiatus contexts in Korean verbal morphology. *Studies in Phonetics, Phonology and Morphology* 15.2, 341-360.
- Han, Jeong-Im (1996) *The phonetics and phonology of tense and plain consonants in Korean*. PhD dissertation, Cornell University.
- Han, Jeong-Im (1997) Interface between phonological timing and phonetic duration in Korean. *Language Research* 33.2, 265-292.
- Hayes, Bruce and Zsuzsa Cziráky Londe. (2006) Stochastic phonological knowledge: the case of Hungarian vowel harmony. *Phonology* 23, 59-104.
- Hayes, Bruce & Colin Wilson (2008). A maximum entropy model of phonotactics and phonotactic learning. *LI* 39, 379-440.
- Hong, Soonhyun (1997) *Prosodic domains and ambisyllabicity in Optimality Theory*. Doctoral dissertation. University of Pennsylvania.
- Hong, Soonhyun (2006) /n/-insertion in native Korean and Sino-Korean revisited. *Studies in Phonetics, Phonology and Morphology* 12.2, 391-413.
- Hong, Sung-Hoon (2008) Variation and exceptions in the vowel harmony of Korean suffixes. *The Journal of Studies in Language* 24, 405-428.
- Hong, Sung-Hoon (2010) Gradient vowel cooccurrence restrictions in monomorphemic native Korean words. *Studies in Phonetics, Phonology and Morphology* 16, 279-295.
- Huh, Woong (1984) *Korean phonology*. [Kukeumwunhak] Seoul: Cengumsa.
- Huh, Woong (1985) *Korean phonology*. [Kukeumwunhak] Seoul: Saymmwunhwas.
- Hwang, Sangjin (2008) *Korean speakers' knowledge of /n/-insertion: P-map approach*. MA thesis, Seoul National University.
- Im, Hong-Pin (1981). For the solution of sai-sios problem. [Sai-sios mwunceyuy haekyelul wihaye] *Kukehak* 10, 1-35.
- Ito, Chiyuki (2014). Compound tensification and laryngeal co-occurrence restrictions in Yanbian Korean. *Phonology* 31.3, 349-398.
- Jang, Hayeun (2016) /o/-stems as faster late-starters in decay of Korean vowel harmony. A paper presented at Japanese-Korean Linguistics Conference 2016.
- Jun, Cheolwoong (1979). A study on phonemic change [Umsopyentongey kwanhan ilkochal] *Sancheongeomun* 10, 65-95.
- Jun, Jaeho (1967). A study of inserted s in vol. I of Tusionhae. [Sai siot yenkwu] *The Korean Language and Literature [Kukekwukmwunhak]* 37, 38, 17-36.
- Jun, Jongho (1994) Metrical weight consistency in Korean Partial Reduplication. *Phonology* 11.1, 69-88.
- Jun, Jongho. (2010) Stem-final obstruent variation in Korean. *Journal of East Asian Linguistics* 19(2), 137–179.
- Jun, Jongho. (2015) Korean n-insertion: A mismatch between data and learning. *Phonology* 32(3), 417–458.

- Jun, Jongho & Adam Albright. (2017) Speakers' knowledge of alternations is asymmetrical: Evidence from Seoul Korean verb paradigms. *Journal of Linguistics* 53.3, 567-611.
- Jun, Jongho & Jeehyun Lee. (2007). Multiple stem-final variants in Korean native nouns and loanwords. *Eoneohak* 47, 159-187.
- Jun, Sun-Ah (1993). *The phonetics and phonology of Korean prosody*. PhD dissertation, Ohio State University.
- Kager, René (2009) Lexical irregularity and the typology of contrast. In Kristin Hanson & Sharon Inkelas (eds.), *The nature of the word: studies in honor of Paul Kiparsky*, 397-432. Cambridge, MA: MIT Press.
- Kang, Hijo (2011) What role does morphology play in historical change? In William McClure & Marcel den Dikken (eds.), *Japanese/Korean Linguistics* 18, 165-76. Stanford: CSLI.
- Kang, Hijo (2012) *Diachrony in synchrony: Korean vowel harmony in verbal conjugation*. Ph.D. dissertation, Stony Brook University.
- Kang, Hijo (2016) Variation and change of Korean vowel harmony in verbal conjugation: an apparent time and real time study. [Hankuke yongenhwalyongeyse pounun moumcohwaury pyeniwa pyenhwa: hyencangsiwa silceysi yenku] *Eoneohak* 76, 27-56.
- Kang, Ongmi (1989). Conditions on T-epenthesis in Korean noun compounds. MA thesis, University of Washington.
- Kang, Ongmi (2003) *Korean Phonology*. [hankwuke umwunlon] Taehaksa: Seoul.
- Kang, Yoonjung. (2006). Neutralizations and variations in Korean verbal paradigms. In Susumu Kuno, Ik-Hwan Lee, John Whitman, Joan Maling, Young-Se Kang, Peter Sells & Hyang-Sook Sohn (eds.), *Harvard Studies in Korean Linguistics* XI, 183-196. Korea: Hanshin.
- Kang, Yoonjung & Na-Young Ryu. (2015) Variation in Korean vowel harmony and the emergent locality effect. The joint meeting the ICKL (International Circle of Korean Linguistics) and the Harvard-ISOKL (International Symposium on Korean Linguistics). July 24-26, 2015, University of Chicago.
- Ki, Se-kwan (1990) *A phonological study of /l/-deletion and /n/-addition in Korean word-formation*. Ph.D dissertation, Wonkwang University, Iksan, Korea.
- Kim, Cha-Gyun (1981). Syllable theory and Korean phonological rules. [Umcelilonkwa kukeuy umwunkyuchik] *Inmwunkwahakyenkwuso Nonmwuncip* 8.1, 35-81.
- Kim, Cha-Gyun (1984) Modern Korean saisiot. [hyentaykwukeuy sai 's'] *Eoneohak* 7, 67-82.
- Kim, Chin-Wu (1970) Boundary phenomena in Korean. *Papers in Linguistics* 2, 1-26.
- Kim, Chin-Wu. (1973) Adjustment rules in phonology. In Michael Kenstowicz & Charles Kisseberth (eds.), *Issues in phonological theory*, 130-144. The Hague: Mouton.
- Kim, Choong-Bae. (1974). Tensification revisited. *Language Research* 10, 129-142.
- Kim, Gyung-Ran. (2001) Obstruent alternations in sub-compounds. *Studies in Phonetics, Phonology and Morphology* 7.2, 315-331.
- Kim, Jin-hyung (1992) *A study on word formation in English and Korean*. [Yengewa hankukeuy ehyengsengey kwanhan yenku] Ph.D. dissertation, Seoul National University.
- Kim, Jong-mi (1986) *Phonology and syntax of Korean morphology*. PhD dissertation, University of Southern California, Los Angeles.
- Kim, Jong Shil. (2007) Vowel harmony in Korean verbs. *Studies in Phonetics, Phonology and Morphology* 14.3, 433-451.
- Kim, Juwon (1988) Vowel harmony and the feature [tongue retracted]. [moumcohwawa seolchuk] *Eoneohak* 9, 28-43.

- Kim, Juwon (1993) *A review of the study on vowel shift in Korean*. [moumcohwaury yenku] Kyongsan, Korea: Yeungnam University Press.
- Kim, Seoncheol (2003). *A survey of standard pronunciation II*. [Phyocwunpalum silthaycosa II] Seoul: The National Institute of the Korean Language.
- Kim, Seoyoung (2016) *Phonological trends in Seoul Korean compound tensification*. MA thesis, Seoul National University, Korea.
- Kim, Soo-Jung (2000). *Accentual effects on phonological rules in Korean*. PhD dissertation, University of North Carolina. Chapel Hill.
- Kim, Young-Seok. (1984) *Aspects of Korean morphology*. PhD dissertation. University of Texas, Austin.
- Kim, Yu-Pum; Sunwoo Park; Byoung-Sup Ahn & Bongwon Lee (2002). An overview on the studies of Korean /n/-insertion. [Niun sapiphyensanguy yenkwusacek kemtho] *Emwunnoncip* 46, 43-71.
- Kim-Renaud, Young-Key. (1974/1991) *Korean consonantal phonology*. Ph.D dissertation, University of Hawaii, Honolulu. Seoul: Hanshin.
- Kim-Renaud, Young-Key (1976/1986) Semantic features in phonology: evidence from vowel harmony in Korean. In Young-Key Kim-Renaud (ed.), *Studies in Korean Linguistics*, 63-76. Seoul: Hanshin. [Originally published in *CLS* 12: 397-412]
- Ko, Kwang-mo (1992). The n-epenthesis and sai-sios in Korean. [Niun chemkawa saisioseytayhan yenkwu] *Eoneohak* 14, 31-51.
- Ko, Seongyeon (2012). *Tongue root harmony and vowel contrast in Northeast Asian languages*. PhD dissertation, Cornell University.
- Kwack, Dong-Kee (1992). *A phonological study on the Korean prosodic structures*. [Wunyultanwiew uyhan kwuke umwunhyensanguy pwunsek] PhD dissertation, Seoul National University.
- Kwuklip kwuke yenkwuwen [National Institute of the Korean Language] (ed.) (1999). *Standard Korean dictionary*. [Pyocwun kwuke taysacen.] Seoul: Doosan Dong-A. Available at <http://stdweb2.korean.go.kr>.
- Labrune, Laurence (2016) Rendaku in cross-linguistic perspective. In Timothy J. Vance & Mark Irwin (eds.), *Sequential Voicing in Japanese: Papers from the NINJAL Rendaku Project*, 195-234. Amsterdam and Philadelphia: John Benjamins.
- Lee, Byung-Gun (1985) Some tangible properties of vowel harmony. [moumcohwaury thukseng] *Inmunnonchong* 15: 3-36.
- Lee, Chungmin. (1972). Boundary phenomena in Korean revisited. *Papers in Linguistics* 5.3, 454-474.
- Lee, Hoyoung (1996). *Korean phonetics* [Kukeumsenghak] Seoul: Thaehaksa.
- Lee, Jin-Seong (1992) *Phonology and sound symbolism of Korean ideophones*. PhD dissertation, Indiana University.
- Lee, Ki-Moon. (1972) *A study of Korean historical phonology*. [Kwuke Umwunsa Yenuk.] Seoul: Tower press.
- Lee, Minkyung (2006). Gyeongsang Korean /n/-insertion revisited. *Studies in Phonetics, Phonology and Morphology* 12.3, 623-641.
- Lee, Ponghyung (2004). Korean sonorant modifications as domain initial strengthening. *Korean Journal of Linguistics*, 29.4, 607-633.
- Lee, Sechang (2016) Revisiting the /n/-insertion in Korean. [kukeuy /n/-sapip hyensanguey kwanhan cayko] *Korean Journal of Linguistics* 41.4, 637-659.

- Lee, Swung Nyeong. (1954/1955) *Studies in phonology*. [Umwunlon yenkwu] Seoul: Mincwungsekwan.
- Lee, Yong-Sung. (1993) *Topics in the vowel phonology of Korean*. PhD dissertation: Bloomington.
- Lee, Yongsung & Minkyung Lee (2006). n-insertion as y-devocalization in Korean. *Korean Journal of Linguistics* 31.3, 413-440.
- Lee, Yundong (1983). Fortition of voiceless consonants between voiced segments in Modern Korean. [Hyentaykwuke yusengumkan mwusengumuy kanghwaey tayhaye]. *Eomunhak* 43, 127-153.
- Martin, Samuel E. (1954) *Korean morphophonemics*. (William Dwight Whitney Linguistic Series) Baltimore: The Linguistic Society of America.
- McCarthy, John (1983) Phonological features and morphological structure. In John F. Richardson, Marks Mitchell, and Amy Chukerman (eds.), *Papers from the Parasessions on the Interplay of Phonology, Morphology, and Syntax*, 135-161. Chicago: CLS.
- McCarthy, John (2003) OT constraints are categorical. *Phonology* 20, 75-138.
- Moon, Soo-Mee (1989) *A phonetic study of 'Sais-Sori' Current Korean – An experimental phonetic approach*. [hyentay kwukeuy saissoriey kwanhan umsenghakcek kochal – silhemumsenghakcek cepkun] MA thesis, Seoul National University.
- Moon, Yang-soo (1997) The 'Sais-sori' phenomena of Korean. [kwukeuy saissori hyensang] *Inmunnonchong* 37, 63-80.
- O, Won-gyo (2000) Les valeurs phoniques de 's parasite'. [Sai siosuy solikaps] *The Korean Language and Literature* [Emwunhak] 71, 91-106.
- Oh, Jungran (1988) *A diachronic study of Korean fortis*. [Gyengumuy kukesacek yenku] Seoul: Hanshin.
- Oh, Mira (2006). Reexamination of environments for /n/-insertion. [Niun-sapip hwankenguy caykemtho] *The Linguistic Association of Korea Journal* 14.3, 117-135.
- Park, Sunwoo (2005). Positional markednes and /n/-insertion in Korean. [Wichicek yuphosengkwa hankwukeyu niunsapip] *Studies in Phonetics, Phonology and Morphology* 11.2, 323-335.
- Pierrehumbert, Janet B. (2006) The statistical basis of an unnatural alternation. In Louis Goldstein, Douglas H. Whalen and Catherine T. Best (eds.), *Laboratory Phonology VIII, Varieties of phonological competence*, 81–107. Berlin: Mouton de Gruyter.
- Ryu, Chang-Don. (1963). On the additional /t/ phenomenon. [[t] chemkahyensanguy yenku—saissori hyensangko] *The Journal of Korean Studies* [Tong Bang Hak Chi] 7: 19-39.
- Shin, Seung-Hoon (1997). *Constraints within and between syllables: syllable licensing and contact in Optimality Theory*. PhD dissertation, Indiana University.
- Sohn, Ho-Min. (1999). *The Korean language*. Cambridge: Cambridge University Press.
- Sohn, Hyang-Sook (1987) *Underspecification in Korean Phonology*. PhD dissertation, University of Illinois at Urbana-Champaign.
- You, Jaewon. (1989). A study on tense and aspirated consonants in modern Korean. [Hyentaykukeuy toynsoliwa keseynsoliey tayhan yenku.] *Hanguel* 203. 25-43.
- Zuraw, Kie. (2000) *Patterned exceptions in phonology*. PhD dissertation, UCLA.
- Zuraw, Kie. (2002) Aggressive reduplication. *Phonology* 19.3, 395-539.
- Zuraw, Kie. (2007) The role of phonetic knowledge in phonological patterning: Corpus and survey evidence from Tagalog infixation. *Language* 83, 277–316.
- Zuraw, Kie (2010) A model of lexical variation and the grammar with application to Tagalog

nasal substitution. *Natural Language and Linguistic Theory* 28.2, 417-472.

Zuraw, Kie. (2011) Predicting sai-siot in Korean compound nouns: Phonological and non-phonological factors. Handout presented at the 21st Japanese/Korean Linguistic Conference, Seoul National University.