Mora Augmentation in Korean Noun SubCompounding

Junghyoe Yoon

Abstract: There are two types of epenthesis across the noun compound boundary in Korean: traditionally called [t]-epenthesis and [n]-epenthesis. The literature on this in derivational phonology has attempted to analyze the two types of epenthesis in a unified way (e.g. J.M Kim 1984, Ahn 1985, and Ahn 1998, among others). However, the analysis in derivational phonology cannot be viewed as a unified explanation since it does not present a complete explanation for the two types of epenthesis. In addition, the studies cannot provide any explanatory analysis as to what mechanism constrains the way epenthesis occurs.

This paper aims to provide a unified analysis to deal with the two types of epenthesis in the framework of Optimality Theory. In this paper, I will offer a new view that there is an underlying mora marking the noun compound in input (indicated by "μ_c"), which should be realized by the addition of a mora. By assuming that gemination and derived tense consonants (Tak & Davis 1994) involve mora addition, this new analysis of mora augmentation elaborates the way epenthesis is constrained. Furthermore, the constraint ranking in this study suggests answers to fundamental but critical questions, such as why [n]-epenthesis occurs rather than [t]-epenthesis or why no epenthesis happens at all, in certain environments.

1. Introduction

Korean exhibits a three-way distinction of obstruents in terms of laryngeal specification: plain /p, t, k, c, s/, tensed /p', t', k', c', s'/, and aspirated /p^h, t^h, k^h, c^h/. The underlying plain obstruents can surface as voiced or tense counterparts in certain contexts. Consider (1) for example:

(1)	input	output	gloss
a.	/otol/	[o.dol]	'hard and lumpy'
b.	/ontol/	[on.dol]	'Korean underfloor heating system'
c.	/oktol/	[ok.t'ol]	'a precious stone'

An underlyingly plain obstruent /t/ in (1) can voice intervocalically or between sonorants as in (1a) and (1b) or tensify after an obstruent as in (1c). The environments triggering voicing or tensification are summarized in (2) and (3).

(2) Intervocalic Voicing Rule (=VR)
[-sonorant, -continuant, -tense, -aspiration] → [+voice]/ [+sonorant] ___ [+syllabic] (Ahn 1998:44)

(3) Post-Obstruent Tensing (=POT)
[-sonorant, -aspiration] → [+tense] / [-sonorant] ___ (Ahn 1998:50)

The voicing rule in (2) states that all plain stops become voiced after a sonorant (including vowels) and before a vowel as in (1a) and (1b). Since voiced stops appear only in that context, they are considered as allophones of their voiceless counterparts in Korean. The other rule POT in (3) predicts that the second obstruent in an obstruent cluster is tensified. The phonological modifications that occur in (1a) and (1c) are accounted for by VR and POT, respectively.

However, we have exceptions where POT applies even though the conditioning environment

satisfies VR rather than POT. Compare (4a) and (4b) with (5a) and (5b), respectively.

(4)	input		output	gloss
a.	/næ+ka/	'river + side'	[næ.k'a]	'riverside'
b.	/cam+cali/	'sleep + place'	[cam.c'ari]	'sleeping place'

(5)	input		output	gloss	
a.	/næ -ka/	'I - NOM'	[næ.ga]	'I-Nominative marker'	
b.	/camcali/	'dragonfly'	[cam.ja.ri]	'dragonfly'	(Ahn 1998: 138)

Each pair (i.e. (4a) and (5a), and (4b) and (5b)) is phonologically uniform, so the rule VR would voice the intervocalic /k/ in *næka* or the post-nasal /c/ in *camcali* both in (4) and (5) regardless of its meaning. Nonetheless, the data in (4) undergo tensification rather than voicing, whereas the counterparts in (5) observe VR.

The contrast between (4) and (5) lies in the different morpheme structures of those homophonous words. The words in (4a) and (4b) are composed of two nouns, while those in (5) are not. For example, the word *camcali* 'dragonfly' in (5b) is composed of one morpheme, where the intervocalic consonant voices observing VR stated in (2). On the other hand, the compound noun *camcali* 'sleeping place' in (4b) results in tensification of the onset consonant in the second morpheme, even though the input condition satisfies VR rather than POT. Consequently, the difference between (4) and (5) is understood to reveal that Korean marks the second member of a nominal compound in a special way.

To account for tensification across the compound boundary as in (4), previous studies attempt to devise a specific mechanism which would block VR and hence accommodate POT in a specific type of noun compounding (i.e. subcompounding). The traditional approach is to posit that [t] or [n] is epenthetic across the compound boundary whereas Cook (1986) proposes that the compound is marked by gemination of the word-initial consonant of the second noun. This paper will adopt Cook's gemination analysis though the term [t]-epenthesis will be maintained to distinguish it from [n]-epenthesis.[1] The relevant data are illustrated in (6):

[1] If I follow the epenthetic analysis, the corresponding process to (6) would be as follows:

	input	[t]-epenthesis	output	gloss
a.	/mæ + tol/	mæ **t t**ol	[mæt.t'ol]	'mill stone'
b.	/mu+kuk/	mu **t k**uk	[mut.k'uk]	'radish soup'
c.	/mul+soli/	mul **t s**oli	[mul.s'oli]/ *[mult.s'oli]	'sound of water'
d.	/næ+mul/	næ **t m**ul	[næ**n**.mul]	'river water'

The trigger of POT is an epentheisized [t], which is omitted in (c) and nasalized in (d). The output by [t]-epenthesis is considered as careful pronunciation while the output in (6) above by gemination as casual one. However, one crucial deficit of this epenthesis analysis is that we further need phonological stipulation to account for failure of [t]-epenthesis. Noun sub-compounding does not involve epenthesis when the second member starts in a vowel as in (7) below. Therefore, I will take [t] or [n] in careful pronunciation as being misled by hypercorrection and spelling following Cook (1984).

(6) [t]-epenthesis

	input	gemination	output	gloss
a.	/mæ + tol/	mæ **t t**ol	[mæt.t'ol]	'mill stone'
b.	/mu+kuk/	mu **k k**uk	[muk.k'uk]	'radish soup'
c.	/mul+soli/	mul **s s**oli	[mul.s'oli]/ *[muls.s'oli]	'sound of water'
d.	/næ+mul/	næ **m m**ul	[næ**m**.mul]	'river water'

The compounds from (6a) through (6c) in the output show that tensification of the second noun onset is essential for compounding. In (6d), on the other hand, gemination is indicative of compounding. When the first morpheme ends in a consonant as in (6c), a geminate consonant--the trigger of POT-- must be omitted because Korean does not allow a complex onset/coda.

However, the phonological modification presented by the compounds in (6) is not observed when the second noun starts in a vowel. This is seen in (7):

(7) Failure of [t]-epenthesis

	input	output		gloss
		[t]-epenthesis	Gemination	
a.	/molæ + al/	*[moræ.dal]	[moræ.al]	'a grain of sand'
b.	/kət + ot/	*[kət.t'ot]	[kə.dot]	'outer garment'
c.	/nun + usɨm/	*[nun.du.sɨm]	[nu.nu.sɨm]	'smile in one's eye'

In (7a), (7b), and (7c), the output has no consonant inserted. As Cook (1987: 365) predicts, gemination would not occur since there is no consonant to geminate.

Before considering [n]-epenthesis, I first schematize in (8) the contexts to illustrate the way noun subcompounding is marked on the basis of the data from (6) to (7).

(8)

Input		Output
a. (C)V+ C_1V(C)	➔	(C)V**C_1.C_1'**V(C)
b. (C)VC_1+ C_2V (C)	➔	(C)VC_1.**C_2'**V(C)
c. (C)V + N_1 V(C)	➔	(C)V **N_1. N_1** V(C)
d. (C)VC_1 + V(C)	➔	(C)V.C_1V(C)
e. (C)V + V(C)	➔	(C)V.V(C)

When the second noun starts in an obstruent, it tensifies as in (8a) and (8b). If the second noun starts with a nasal as in (8c) only gemination occurs; tensification of a nasal is phonetically impossible. No change occurs when the second noun is vowel-initial as in (8d) and (8e).[2]

So far we have only considered environments traditionally referred to as [t]-epenthesis. But what is known as [n]-epenthesis has a different and a very restrictive conditioning environment from [t]-epenthesis. As shown in (9), the compound boundary is marked by [n] or [l] across the morpheme boundary when the first constituent ends in a consonant and the following constituent starts with the

[2] In (8d), the consonant coda C_1 in the input is resyllabified as an onset in the output. However, if C_1 is a velar nasal [ŋ] resyllabification does not occur simply because Korean does not have [ŋ] in onset. If C_1 is a plain obstruent, we have its voiced counterpart in output by the rule VR. Since these constraints are undominated in Korean, I will not consider as a candidate an [ŋ] in onset and an intervocalic voiceless plain obstruent in the analysis part of Section 3.

glide /y/.[3]

(9) [n]-epenthesis

input	output	gloss
a. cip + yəlswe	[cim.**n**yəl.swe]	'house key'
b. hæt + yəlmu	[hæn.**n**yəl.mu]	'new baby radish'
c. pul + yəu	[pul.**l**yə.u]	'a vixen'
d. hopak + yət	[hobaŋ.**n**yət]	'pumpkin'

The traditional [n]-epenthesis explains that the epenthetic [n] triggers nasalization or undergoes lateralization, which are attributed to the fact that Korean does not allow rising sonority across a syllable boundary. As Davis & Shin (1999) show, these are regular processes of Korean phonology. In the output, we end up with nasal gemination or lateral gemination: [mn], [nn], [ll], and [ŋn] as illustrated in (9a), (9b), (9c), and (9d), respectively.[4]

If the first constituent ends with an open syllable, [n]-epenthesis fails as in (10).

(10) Failure of [n]-epenthesis

input	output	gloss
a. c^ho + yəlim	[c^ho.yə.lim]	'early summer'
b. k'æ + yət	[k' æ.yət]	'sesame starch'

The [n]-epenthesis is schematized as in (11). The epenthesis requires a coda and the glide /y/ at the noun subcompound boundary as in (11a); otherwise, no change occurs as shown in (11b). Further phonological modifications are subject to general rules of Korean phonology.

(11) Input → Output

a. (C)VC+yV(C) → (C)VC.**n**yV(C)
b. (C)V +yV(C) → (C)V . yV(C)

If we compare (8) with (11), it seems to be difficult to unite the two different epenthetic phenomena. [T]-epenthesis requires the second member of a nominal compound to have a word-initial consonant, whereas [n]-epenthesis needs across the compound boundary a word-final consonant of the first member and a word-initial /y/-glide of the second member. While [t]-epenthesis results in tensification or gemination of the initial consonant of the second noun, [n]-epenthesis yields an epenthetic [n] before /y/, which in turn triggers regressive nasalization or is subject to progressive lateralization.

Even with the disparity of two epentheses in triggering environments and the phonological modification, however, this paper aims to provide a unified analysis. The crucial motivation of the unified analysis is that the two epentheses are subject to a specific morphological structure: noun subcompounidng. Simply put, the first member in noun subcompounds functions to modify the

[3] I will just account for [n]-epenthesis before /y/ in this paper, though other studies (Hong 2002; Park 2004 among others) argue that [n] is inserted before a high front vowel /i/ or glide /y/. However, [n]-epenthesis before /i/ applies only to several native Korean words. Because the /i/ environment has considerable counterexamples, this paper assumes that [n]-epenthesis only before /y/ is rule-governed and that the /n/ before /i/ belongs to the lexical properties. See Section 4.2 for more details.

[4] The nasal clusters such as [mn] in (9a) and [ŋn] in (9d) cannot be gemination under the strict meaning of *gemination*. However, since the clusters undergo assimilation (i.e. nasalization) I will posit that the clusters are geminates of the feature [+nasal]. What is essential, though, for the analysis is that the first member of these clusters constitutes a moraic coda.

following member (refer to Section 3.1 for details). Also, studies (Ahn 1998, Lee 2004:, among others) provide the identical function of the two epentheses that the consonant epenthesis phonetically strengthens the connection of the two elements in noun compounds through avoiding the weakening of the initial consonant of the second member.

For the sake of a unified analysis, I will offer a new view that there is an underlying mora (indicated by "μ_c") marking the noun subcompound in the input, which should be realized by the addition of a mora. What the two types of epenthesis ([t]-epenthesis and [n]-epenthesis) have in common is gemination (i.e., obstruent gemination, nasal gemination, and lateral gemination) of the initial onset of the second noun of the compound. Therefore, I will argue that compounding is marked by mora augmentation viz. gemination/tensification. This will further explain that a non-geminate consonant cannot be inserted since it would not affect moracity. Compare (12a) and (12b) below:

Input	(12a)=(6a) μ μ_c μ | | /m æ + t o l/ 'mill stone'	(12b)=(7 b) μ μ_c μ | | /kət + ot/ 'outer garment'
Output	σ σ μ μ_c μ [m æ t. t' o l]	σ σ μ μ_c μ * [k ə. d o t]

In (12a), the underlying mora "μ_c" is realized in the output by adding a mora through tensification. But a consonant epenthesis fails in (12b) where it does not add a mora. When there is no onset available across a compound boundary, epenthesis is meaningless in terms of mora augmentation.

To capture the mechanism governing mora augmentation of noun subcompounding, the analysis is based on two assumptions. First, the mora augmentation analysis is applicable to Pure Korean words. To minimize exceptions and mismatches between [t]- and [n]- epentheses, this paper will limit data to Native Korean subcompounds.[5] Second, gemination and derived tense consonants involve mora addition (Tak & Davis 1994).

This paper is organized as follows. Section 2 reviews previous studies and suggests assumptions for the present analysis. This section compares the proposal of this study with previous studies and provides the assumption that the gemination of an onset and a derived tense consonant results in an

[5] Professor Yongsung Lee points out that we have exceptions and mismatches between [t]-epenthesis and [n]-epenthesis in Sino Korean subcompounds. The following example represents a mismatch:

i.	input	output			gloss
		Epenthesis		No epenthesis	
a.	p^husan+ pal	*[p^husan.**p'**al]	/	[p^husan.bal]	'departure from Pusan'
b.	onc^hən + yok	[onc^hən.**n**yok]	/	*[onc^hə.nyok]	'hot-spring bath'

The phonological environment of (ia) and (ib), respectively, satisfies [t]-epenthesis and [n]-epenthesis. But [t]-epenthesis fails to occur as in (ia). Also, both [t]- and [n]-epentheses fail to occur with Sino Korean subcompounds such as /sam+pæk/ 'three+hundred', /kɨm+yən/ 'ban on smoking', etc. Therefore, this study will focus on Native Korean subcompounds. Note that Native Korean subcompounds include Sino Korean-Native Korean subcompounds as well as Native Korean-Native Korean subcompounds.

additional mora. Section 3 attempts an OT analysis to account for [t]-epenthesis and [n]-epenthesis in a unified way. Section 4 introduces further issues of epenthesis. Subsection 4.1 deals with the difference between the /w/-glide and the /y/-glide in terms of epenthesis. 4.2 discusses some issues of epenthesis from a diachronic point of view and 4.3 will revisit difference in moracity between derived and underived tense consonants. Finally, Section 5 is the conclusion.

2. Previous Studies on Epenthesis in Korean Noun Compounds

Epenthesis in compounds has its base in historical change, so various approaches have been suggested to deal with exceptions and to understand the phenomenon properly. In this section, I will briefly compare Ahn (1998) and Shin (2002) in developing the analysis in this paper. Ahn (1998) attempts a unified analysis to explain both [t]-epenthesis and [n]-epenthesis within derivational phonology. Shin (2002), on the other hand, provides a constraint-based analysis excluding [n]-epenthesis.

Ahn (1998) presents one rule as in (13) which is formulated by J.-M Kim (1984) and Ahn (1985). Since the epenthetic sounds are coronal stops, the rule is called C(oronal)-Epenthesis.

(13) C-epenthesis

$$\text{ø} \rightarrow [+\text{cor}, -\text{cont}] \;/\; \left\{ \begin{array}{l} \text{C}]_{\text{N}} \_\_ \,{}_{\text{N}}[\,\text{y} \\ ]_{\text{N}} \_\_ \,{}_{\text{N}}[\,\text{C} \end{array} \right\}$$

(Ahn 1998:146)

This rule states that a coronal stop is inserted at the noun compound boundary where the preceding noun ends in a consonant and the following noun starts with a glide /y/; or where the second member of a compound has an onset consonant.

With the key rule in (13), Ahn proposes the derivation of epenthesis as follows:

(14) Derivation

a. /pusan + yək/ 'Pusan station'	b. / næ + ka / 'riverside'	Input
Pusan C yək	næ C ka	C-epenthesis
Pusan n yək	-----	n-specification
------	næ t ka	Default t-specification
------	næt k'a	POT
------	næ k k'a	Place Assimilation
[pu.san.nyək]	[næ (k).k'a]	Phonetic Representation

(Ahn 1998:147)

The rule C-epenthesis requires a coronal stop to be inserted at the first stage when noun compounding occurs. The next stage decides on the nasality of the inserted coronal. If the second noun starts with /y/, the specified /n/ appears; otherwise, default /t/ specification follows. Then, POT and Place Assimilation rules apply as shown in (14).

Ahn's analysis is valuable in his attempt to treat together the two different epenthesis phenomena. However, his analysis contains some pitfalls. First, the analysis in Ahn (1998) cannot be viewed as a unified explanation. Even though Ahn devises one single rule for both epentheses, the derivation process may not yield a proper output. In (14b), we have two possible outputs, the geminate output [næk.k'a] and the degeminate one [næ_.k'a]. To predict the degeminate output, Ahn suggests that as an optional rule a degemination rule is put after Place Assimilation. However, if the optional rule applies to (14a), we would get [pu.sa_.nyək], a wrong output. Even if he wants the rule to be applicable only to [t]-epenthesis, there is no reason why [n]-epenthesis skips just this rule, especially as far as the analysis

is aimed to give a unified explanation to the two types of epenthesis.

Second, Ahn does not consider mismatches between [t]-epenthesis and [n]-epenthesis in Sino Korean subcompounds. His unification fails with Sino Korean subcompounds such as /pusan+kyəŋce/ 'Pusan economy' or /kyəŋcu+pal/ 'departure from Kyungju,' which are not subject to [t]-epenthesis even with the same morpheme structure as (14). For the purpose of a unified explanation, therefore, this paper limits the target of the analysis to Native Korean subcompounds, such as Sino Korean-Native Korean subcompounds and Native Korean-Native Korean subcompounds (refer to footnote 5 on page 5).

Third, his analysis does not really achieve explanatory adequacy though it satisfies descriptive adequacy. The rule Coronal-epenthesis perfectly describes the morphological and the phonological environments triggering both of the sound insertions. Epenthesis occurs morphologically in noun subcompounding, and phonologically with an onset consonant across the noun compound boundary or with a coda and a /y/ glide at the compound boundary. However, the analysis is not clear about the reason those extraneous conditions get united under the single rule. It does not answer why a certain type of noun compounds (i.e. subcompounds) undergoes epenthesis. Even if Ahn can answer that epenthesis is characteristic of noun subcompounding, it still contains no discussion as to why the inserted coronal stop ends up with various realizations depending on the environments.

Regarding the first question, however, the OT analysis in this paper proposes that epenthesis occurs to realize the mora to mark a noun compound boundary. This mora augmentation analysis leads to the answer to the second question. To realize the mora, epenthesis or sound modification must be constrained in such a way that it adds one mora. That is why we can observe a derived tense obstruent or sonorant gemination at the noun compound boundary. Mora augmentation is observed crosslinguistically (Davis & Ueda 2006), which shows that Korean is not unique.

In addition, Ahn's analysis does not examine what mechanism changes an underspecified coronal stop to *n*-specification or default *t*-specification. He just maintains that *n*-specification happens before the /y/-glide while the default *t* is given elsewhere. With respect to this problem, this study can provide a clue. The analysis proposes that the epenthetic sound in [t]-epenthesis is not [t]: instead, if the onset of the second noun is an obstruent its tense counterpart indicates the compounding while gemination is evidence for the compounding if the onset at the compound boundary starts with a sonorant. Both these strategies reflect the mora augmentation that marks subcompounding.

Shin (2002) basically adopts Cook's (1984) proposal that the epenthetic sound is not [t] and assumes that [n]-epenthesis is the realization of underlying [n]. His proposal successfully accounts for (15), where no epenthesis occurs.

(15) Failure of [t]-epenthesis application

Input	Output		Gloss
a. pata+oli	pa.da.o.li	*pa.da.do.li	'sea crow'
b. k^ho+usim	k^ho.u.sim	*k^ho.du.sim	'sneering'
c. c^ha+an	c^ha.an	* c^ha.dan	'inside of a car'
d. k'æ+al	k'æ.al	*k'æ.dal	'a grain of sesame'

However, Shin argues against Cook's proposal of gemination and optional degemination. Instead, he proposes the Mark Compound analysis in (16) and (17).

(16) MarkCompound: A compound must be marked.

(17) A set of MarkCompound
a. MarkCompound-[c.g]: A compound must be marked by [constricted glottis].
b. MarkCompound-geminate: A compound must be marked by a geminate. (Shin 2002: 79)

Shin's observation as to how a compound boundary is marked reflects the empirical data successfully. As his proposal in (16) and (17) predicts, compound marking occurs through tensification or gemination of the onset of the second member.

While I consider that the notion of "compound marking" brings in a new insight, Shin (2002)'s approach is insufficient at least in two respects. First, although it was not pursued, his proposal in (16) and (17) could be further extended to analyze [n]-epenthesis as Ahn (1998) attempts. As shown in (18) through (20), the [n]-epenthesis eventually surfaces at the compound boundary as [mn, nn, ŋn, ll]:

(18) obstruent + yV: / p, t, k + yV / → p, t, k + nyV → [mn, nn, ŋn]

	input	output	gloss
a.	cip+yəlswe	[cim.**n**yəl.swe]	'house key'
b.	hæt+yəlmu	[hæn.nyəl.mu]	'new baby radish'
c.	hopak+yət	[ho.paŋ.nyət]	'pumpkin starch'

(19) nasal + yV: /m, n, ŋ + yV/ → m, n + n → [mn, nn, ŋn]

	input	output	gloss
a.	am+yəmso	[am.nyəm.so]	'she-goat'
b.	han+yəlim	[han.nyə.lim]	'mid-summer'
c.	koŋ+yət	[koŋ.nyət]	'bean starch'

(20) lateral + yV: / l + yV / → l + n → [ll]

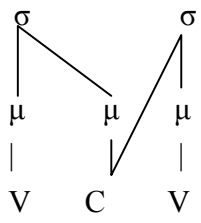
	input	output	gloss
a.	pul-+yəu	[pul.**l**yə.u]	'a vixen'
b.	mul+yət	[mul.**l**yət]	'starch syrup'

The nasal feature or lateral gemination in noun compounding would be predicted by Shin's proposal in (16) and (17).

Second, perhaps more importantly, Shin's proposal in (16) and (17) fails to offer any insight as to why compounding must be marked by means of gemination or tensification of the onset over morpheme boundaries.

In this paper, I will maintain that compounding is marked through mora augmentation. This will account for both [t]-epenthesis and [n]-epenthesis. The proposal of mora augmentation is similar to Shin's proposal in (17) in requiring that the output should surface with gemination or tensification of the initial onset of the second word. However, mora augmentation accounts for how gemination or tensification can fulfill its role of marking noun compounding. If I assume that both the gemination and the tensing of a consonant involve an additional mora then no epenthesis other than gemination or tensification can achieve mora augmentation.

The moracity of geminates is represented in the structure of (21). (See Davis 2007 for an overview regarding the issue of the moracity of geminates.)

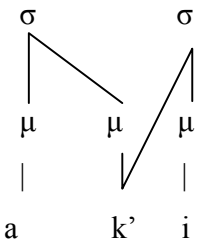
(21) 

Tranel (1991: 292)

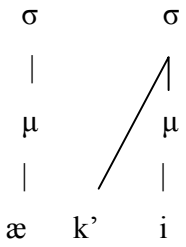
This paper will assume this representation in (21) which is originally proposed by Hayes (1989: 257-258).

Moreover, Tak & Davis (1994) argue specifically that derived tense consonants are moraic in Korean, contra Jun (1994) who proposed that even underived tense consonants are moraic. In this paper I follow Tak & Davis in making the distinction shown in (22) between a derived tense consonant which is moraic (22a) and an underived tense consonant which is not moraic (22b). One difference between the two types of tense consonants according to them is that umlaut is blocked by the former but not the latter.

(22) a. /ak + ki/ → [ak'i] 'instrument' b. /ak'i/ → [æk'i] 'to hold dear'



(Umlaut does not apply)



(Umlaut applies)

(Tak & Davis 1994: example (25))

To summarize, this paper will argue that noun compounding is marked through mora augmentation, and that mora augmentation can be achieved by gemination or tensification of the initial onset of the second member of the compound. This argument is based on the assumption that geminates and derived tense consonants are moraic.

3. Optimality-Theoretic Analysis

3.1 DATA and CONSTRAINTS

This subsection introduces the data and constraints in brief. I will use the constraints in (22) to analyze [t]-epenthesis and [n]-epenthesis phenomena.

(23) Constraints

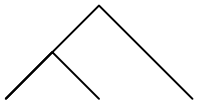
a. Syllable contact - Avoid rising sonority over a syllable boundary.
b. *Complex - No complex syllable margins are permitted.
c. Align-HN-Left - The left edge of a head noun coincides with the left edge of a syllable.
d. Dep[place] - The [place] feature in the output has a correspondent in the input.
e. *Spread-Vowel-[F] - Do not spread vowel features.
f. Post-Obstruent Tensing (POT)
- Obstruents surface as tense after other obstruents.
g. Max- μ_c - The mora marking noun compounds "μ_c" in an input is realized in the output.
h. Dep[c.g] - The [constricted glottis] feature in the output has a correspondent in the input.
i. Max-[lateral] - The [lateral] feature in an input is realized in the output
j. *Spread-[F] - Do not spread features (specifically all features but places).
k. *Spread-[place]-progressive
- Place assimilation cannot be progressive.
l. Dep-[lateral] - The [lateral] feature in the output has a correspondent in the input.
m.Dep-[nasal] - The [nasal] feature in the output has a correspondent in the input.

Before continuing, I briefly go over the constraints in (23). Syllable Contact in (23a) is used by Davis and Shin (1999) for their analysis of Korean manner alternations. The constraint *Complex in (23b) is a standard syllable structure constraint (Kager 1999). Constraints on the insertion and deletion of features, such as that in (23d), (23h), (23i), (23l), and (23m) are expressed by the use of Dep and Max constraints by Lombardi (1995) and Davis and Shin (1999) among others. The various *Spread constraints in (23j) and (23k) are one way of accounting for assimilation in Optimality Theory and are used by Kager (1999) among others. The *Spread constraint in (23k) ensures the cross-linguistic preference for place assimilation to be regressive. The POT constraint in (23f) has been adapted by others working on Korean such as Shin (2002).[6] The constraint in (23g) Max- μ_c has been discussed earlier; it requires that the mora introduced as part of the compounding process be realized. Finally, with respect to the constraint in (23c) Align-HeadNoun-Left, we briefly turn to a discussion of the notion *headnoun*.

To understand the notion *headnoun* in the constraint Align-HeadNoun-Left as shown in (23c), consider the structure of the noun compounds involving a sound insertion by Ahn (1998: 148). In (24), X is the first member, Y is the second member, and C is the inserted consonant. If Y is head as illustrated in (24), its features indicated by the subscript *y* are percolated to the upper node:

[6] Shin (2002) suggests a constraint $*[obs]^2_{syllable}$ saying "two plain obstruents cannot be adjacent over a syllable boundary (p.79)." The content of the constraint $*[obs]^2_{syllable}$ from Shin (2002) is equivalent to the constraint POT in this paper.

(24) $Compound_y$



X_x C Y_y (Ahn 1998:147)

Ahn maintains that this type of noun compounding is subcompounding, which means that one member of the compound functions as head and the other as modifier. Since Korean is consistently right-headed, the head of a subcompound is the rightmost element. Hence, we can interpret the constraint Align-HeadNoun-Left as aligning the left edge of the rightmost noun with the left edge of a syllable. The main role of Align-HeadNoun-left in the analysis is to rule out consonant insertion when the first member of a compound ends in a vowel and the second member begins with a vowel. For example, /k'æ + al/ 'a grain of sesame' is realized as [k'æ.al] and not as * [k'æ.t'al] since the latter violates Align-HeadNoun-Left. This is because the head noun of the compound [al] does not coincide with the left edge of the syllable in *[k'æ.t'al].

Key data of [t]-epenthesis relevant to the present analysis are illustrated in (25). If the second member of the noun compound starts with an obstruent as in (25a), (25b) and (25c), tensification of the obstruent is observed at the morpheme boundary. However, if the second member begins with a sonorant consonant as in (25d) then the gemination of that sonorant is observed at the morpheme boundary.

(25) [t]-epenthesis

input	output		gloss
	gemination	optional degemination	
a. mæ+ tol	mæ**t**.t'ol	mæ.t'ol	'mill stone'
b. mu+kuk	mu**k**.k'uk	mu.k'uk	'radish soup'
c. san+kil	*san**k**.k'il	san.k**'**il	'mountain pass'
d. næ+mul	næ**m**.mul		'river water'

In (25a) and (25b), the onset geminate [t] or [k] is optionally omitted which is marked in the bold face. In (25c), on the contrary, dropping the geminate obstruent [k] (i.e. degemination) is obligatory; onset gemination would yield a complex coda/onset, otherwise. This means the constraint *Complex in (23b) is highly ranked in Korean. In (25d), on the other hand, only gemination of the initial onset of the second noun is observed because a nasal does not have a tense counterpart.

As demonstrated above, the initial onset tensification of the second noun is essential for the compounds when the second noun starts with an obstruent while gemination indicates noun compounding if the onset of the second noun is a sonorant (e.g. a nasal or a lateral). Therefore, I will assume that onset tensification/gemination at the morpheme boundary is indicative of noun compounding. In addition, I will also posit that the phonetic representation of (25a) or (25b) is the geminate one for the convenience of the analysis.[7]

[7] The existence of a geminate consonant in the coda leads to further discussion on the moracity of a coda in Korean. However, since this paper focuses on mora augmentation which is achieved through gemination/tensification at the compound boudary, I will assume that a single coda is not usually moraic. Following this postulate, I will take the phonetic representation of input

This study will argue that epenthesis is the realization of the mora marking a noun compound, given that tensification/gemination can be understood as adding a specific mora to the input form. The analysis can take advantage of the constraint Max-μ_c and POT described in (23d) and (23f), which will constrain the way that epenthesis occurs. To satisfy Max-μ_c, epenthesis must involve gemination or tensification; epenthesis of any other consonant cannot affect moracity. Tensification occurs when an obstruent is geminated by POT, a regular process of Korean phonology.

The data in (25) show that the presence of an onset over a morpheme boundary (i.e. the second noun must start with a consonant) accommodates [t]-epenthesis. This observation further predicts that without an onset at the beginning of the second noun, epenthesis would not be triggerred; any epenthesis without gemination or tensification could not increase a mora. This is shown in (26).

(26) Failure of [t]-epenthesis

input		output	gloss
a. k'æ+al	k'æ.al	*k'æ.dal/*k'æ.t'al	'a grain of sesame'
b. c^ha+an	c^ha.an	*c^ha.dan/*c^ha.t'an	'inside of a car'

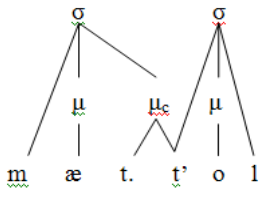
Failure of [t]-epenthesis can be accounted for by the fact that there is no single way to augment a mora for noun compounding. For example, the output [k'æ.dal] or [c^ha.dan] does not have an additional mora since the epenthetic consonant is not moraic in the onset. If, on the other hand, a tense moraic consonant is epenthesized as in the case of hypothetical *[c^ha.t'an] in (26b), then Dep-[place] in (23d) will eliminate the candidate, since there is no place licensor available intervocalically. That is, the place features of an epenthetic element must be dependent on place features that already exist in the input.

Now, consider key data for [n]-epenthesis. In (27a) through (27f), one can observe [n]-epenthesis at the compound boundary, which in turn triggers regressive nasalization. However, the epenthetic sound is lateralized in (27f).

(27) [n]-epenthesis

input	output	gloss
a. cip + yəlswe	[cim.**n**yəl.swe]	'house key'
b. hæt + yəlmu	[hæn.**n**yəl.mu]	'new baby radish'
c. am +yəmso	[am.**n**yəm.so]	'she-goat'
d. hopak + yət	[ho.baŋ.**n**yət]	'pumpkin starch'
e. han + yəlim	[han.**n**yə.lim]	'mid-summer'
f. pul + yəu	[pul.**l**yə.u]	'a vixen'

/mæ+tol/ as follows:

Input	/mæ + tol/ 'mill stone'
Output	

Practically speaking, there really isn't a difference between the two outputs in (25a) because they both can be understood as the phonetic realization of the representation.

Korean does not allow rising sonority over a syllable boundary, i.e. Syllable Contact in (23a). When the second noun starts in /y/, resyllabification or epenthesis can avoid the violation of Syllable Contact. However, Max-μ_c will eliminate resyllabified candidates. For example, a possible candidate [ci.byəl.swe] for (27a) does not add a mora and so fails to realize μ_c; epenthesis then can be seen as a means of realizing μ_c given the active constraints.

The choice of /n/ being epenthetic will be decided by Dep[place] in (23d), POT in (23f), and Dep[constricted glottis] in (23h). Most of all, the onset /y/ at the morpheme boundary accommodates [n]-epenthesis since it can license the place of articulation [coronal], so satisfying Dep[place]. That is, since /y/ is coronal, it can share its place features with the epenthetic [n] which is also [coronal]. However, the question why /n/ not /t/ is inserted can be solved by the interaction of POT and Dep[constricted glottis].

After epenthesis, nasalization and lateralization are observed in (27). The regressive nasalization will be explained by *Spread-[F] in (23j), *Spread[place]-progressive in (23k), and low ranked Dep[lateral] in (23l) and Dep[nasal] in (23m). The constraint Max[lateral] in (23i) will account for lateralization.

The outputs in (27) bear nasal feature gemination (e.g. [mn], [nn], [ŋn]) or lateral gemination [ll] at the compound boundary. Given that the nasal feature gemination is a type of gemination, the mora for noun compounding is realized through gemination satisfying Max-μ_c like in [t]-epenthesis. (While [mn] and [ŋn] are technically not geminates, one can still view such outputs as having a moraic nasal.)

However, [n]-epenthesis fails even with the /y/-glide at the boundary if the preceding syllable ends in a vowel as in (28).

(28) Failure of [n]-epenthesis

	input	output		gloss
a.	c^{h}o + yəlim	[c^{h}o.yə.rɨm]	*[c^{h}o.nyə.rɨm]/*[c^{h}on.nyə.rɨm]	‘early summer’
b.	k’æ + yət	[k’æ.yət]	*[k’æ.nyət]/ *[k’æn.nyət]	‘sesame starch’

The data in (28) involve no coda at the compound boundary, so epenthesis alone cannot satisfy Max- μ_c. Whatever consonant is inserted will violate high ranked Align-HeadNoun-Left in (23c). However, the data in (27) all violate Align-HeadNoun-Left. Also, a candidate with a nasal in the coda, such as *[k’æn.yət] or *[c^{h}o.nyə.lɨm] as resyllabified from (28), violates Syllable Contact in (23a). But a candidate such as *[c^{h}on.nyə.rɨm] or *[k’æn.nyət] with an inserted geminate nasal would seem to win but it does not. The difference between these hypothetical but non-occurring candidates for (28) and the similar but surfacing candidates for (27) will be explained by constraint interaction.

3.2 TABLEAUX

In this section, I will present tableaux for the different compounds. Constraint rankings will be discussed as they come up. I will first examine the input of /mu + kuk/ in (25b). The ranking of constraints is illustrated in the tableau in (29):

(29) = (25b) /mu+kuk/ → [mu**k**.k'uk] 'radish soup'

μ μc μ mu + kuk	SyllCon/ *Cmplx	Dep[place] / Align-HN -L/ *Spread-V-F	POT/ Max-μ_c	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[place]-progressive	Dep[lat]	Dep[nas]
μ μc μ a. mu.guk			*! (Max-μ_c)				
μ μc μ →b. muk.k'uk				*	* (*Spr-F)		
μ μc μ c. muk.kuk			*! (POT)		* (*Spr-F)		

The winning candidate for the input /mu + kuk/ is (29b) where the underlying compound mora, i.e. "μ_c," is successfully realized.[8] The faithful candidate (29a) violates Max-μ_c. Candidate (29c) satisfying Max-μ_c, however, violates POT.

Let's examine the ranking relationship closely. Consider (30) first. The winning candidate (30a) violates Dep[c.g] but satisfies Max- μ_c while (30b) has the reverse. The candidate in (30c) satisfies Max- μ_c, but violates POT which the proper output (30a) observes. Therefore, the ranking is POT, Max-μ_c >>Dep[c.g].

(30) /mu+kuk/ → [mu**k**.k'uk] 'radish soup'

μ μc μ mu + kuk	POT	Max- μ_c	Dep[c.g]
μ μc μ →a. muk.k'uk			*
μ μc μ b. mu.guk		*	
μ μc μ c. muk.kuk	*		

In (31), the input has hiatus over the morpheme boundary. The proper output (31a) does not satisfy Max- μ_c, while (31b) violates *Spread-Vowel-[F] and (31c) violates Dep[place]; so, *Spread-Vowel-[F] and Dep[place] outrank Max-μ_c. The ranking so far is shown in (32).

(31) /k'æ+al/ → [k'æ.al] 'a grain of sesame'

μ μc μ k' æ + al	*Spread-Vowel-Feature	Dep[place]	Max-μ_c
μ μc μ →a. k'æ.al			*
μ μc μ b. k'æ.aal [F]	*!		
μ μc μ c. k æ .t'al [cor]		*!	

[8] Jun (1994: 71-72) says "Following the principles of moraic phonology (Hyman 1985; Hayes 1989), I assume that Korean aspirated and fortis obstruents both bear an underlying mora… If the output maintains the fortition or aspiration on its second syllable, the extrametrical mora of a fortis/aspirated onset would be associated to the first syllable,…" This paper will adopt Jun's association of a mora with a derived tense (=fortis) onset as shown in (29b). The fuller representation of a proper output of (29b) would be similar to (21a); also, refer to footnote 7 on page 17.

(32) *Spread-Vowel-Feature, Dep[place]>>POT, Max- μ_c >>Dep[c.g]

Let's look at the no epenthesis example repeated from (28b). Because the winning candidate (33a) violates Max-μ_c but satisfies Align-HN-L, Align-HN-L is ranked higher than Max-μ_c. The ranking is in (34).

(33)=(28b) /k'æ + yət/ → [k' æ.yət] 'sesame starch'

	Align-HN-Left	Max-μ_c
μ μc μ k' æ + yət		
μ μc μ →a. k' æ.yət		*
μ μc μ b. k'æn.nyət	*	

(34) Align-HN-Left, *Spread-Vowel-Feature, Dep[place]>>POT, Max- μ_c >>Dep[c.g]

The input /cip + yəlswe/ provides the ranking between SyllCon and Align-HN-L. The winning candidate (35a) observes SyllCon, which (35b) violates, so the ranking is like (36).

(35) = (27a) /cip + yəlswe/ → [cim.**n**yəl.swe] 'house key'

cip + yəlswe	SyllCon	Align-HN -L
→ a. cim.nyəl.swe		*
b. cip.yəl.swe	*	

(36) SyllCon>> Align-HN -Left, Dep[plc], *Spread-Vowel-F >> Max-μ_c, POT >>Dep[c.g.]

In comparing (35) with (33), we observe that the winning candidate (35a) violates Align-HN-L which is a relatively high-ranked constraint as shown in (33). The violation of Align-HN-L in (35a) is compelled by SyllCon, since as shown by (35b) respecting Align-HN-L results in a SyllCon violation. SyllCon is not at issue in (33) so Align-HN-L can be respected without violating SyllCon.

The input /am + yəmso/ surfaces as [am.nyəm.so] rather than [am.t'yəm.so] as in (27c). The tableau in (37) shows why /t/ cannot be epenthesized when the head noun starts in /y/: it may violate high ranked Dep[c.g]. As a result, Dep[c.g] outranks *Spread-F.

(37) = (27c) /am +yəmso/ → [am.**n**yəm.so] 'she-goat'

am + yəmso	Dep[c.g]	*Spread-F
a. am.t'yəm.so	*	
→b. am.nyəm.so		*

The whole ranking so far is illustrated in (38). Let's examine input /næ+mul/ with this ranking. The faithful candidate (39a) violates Max-μ_c while (39c) with a coronal epenthesized violates Dep[place] since there is no [coronal] licensor. The candidate (39b) violates the lowly ranked *Spread-F, so it wins.

(38) SyllCon>> Align-HN-Left, Dep[plc], *Spread-Vowel-F >> Max-μ_c, POT >>Dep[c.g.]>> *Spread-Feature

(39) /næ+mul/ → [næ**m**.mul] ‘river water’

μ μc μ n æ + mul [lab]	Syll. Con	Dep[place]/ Align-HN-L/ *Spread-Vowel-F	POT	Max-μ_c	Dep[c.g]	*Spread-F
μ μc μ a. n æ.mul				*!		
μ μc μ →b. n æ m.mul [lab]						*
μ μc μ c. n æ n.mul [cor] [lab]		*! (Dep[place])				

We need to consider more constraints and their ranking discussion since further phonological modification is observed in [n]-epenthesis because of Syllable Contact. For example, look at (40). The faithful candidate (40a) violates SyllCon, while the remaining candidates observe it by violating the constraint Align-HN-L. The epenthesis of a plain obstruent as in (40e) cannot satisfy both POT and Max-μ_c. If a tense obstruent is epenthesized as in (40f) and (40g), Dep[c.g] is violated.

With the constraints in (38), however, (40c) and (40d) are tied. To eliminate (40c), progressive spreading of a place feature must be less allowable than regressive spreading. When *Spread-[place]-progressive is introduced as in (41), then we can get the proper output (40d). Now the ranking is: SyllCon>>Align-HN-Left, Dep[place], *Spread-Vowel-F>>Max-μ_c, POT >>Dep[c.g.]>>*Spread-Feature, *Spread-[place]-progressive.

(40) =(27a) /cip + yəlswe/ → [ci**n**.**n**yəl.swe] ‘house key’

μ μc μ μ cip + yəlswe	SyllCon	Dep[place] / Align-HN-L/ *Spread-Vowel-F	POT	Max-μ_c	Dep[c.g]	*Spread-F
μ μc μ μ a. cip.yəl.swe	*!			*		
μ μc μ μ b. ci.byəl.swe		*(Align-HN-L)		*!		
μ μc μ μ ☹c. cim.myəl.swe [lab]		* (Align-HN-L)				*
μ μc μ μ →d. cim.nyəl.swe [cor]		* (Align-HN-L)				*
μ μc μ μ e. cip.tyəl.swe [cor]		* (Align-HN-L)	*!	*		*
μ μc μ μ f. cip.t’yəl.swe [cor]		* (Align-HN-L)			*!	*
μ μc μ μ g. cip.p’yəl.swe [lab]		* (Align-HN-L)			*!	*

(41) /cip + yəlswe/ → [cim.**n**yəl.swe] ‘house key’

cip + yəlswe [lab]	SyllCon	Dep[place] / Align-HN -L/ *Spr-Vowel-F	POT	Max-μ_c	Dep[c.g]	*Spr-F /*Spr-[place]-progressive
c. cim.myəl.swe [lab]		* (Align-HN –L)				*(Spr-F)/ *!(*Spr[P]-prg)
→d. cim.nyəl.swe [cor]		* (Align-HN –L)				* (Spr-F)

Now consider a case of lateralization after [n]-epenthesis. With the ranking discussed until now the proper output is (42c) rather than (42a) as illustrated below. To get the proper output (42a), we need for the manner feature [lateral] in the input to be realized in the output. Since the proper output violates *Spread[place]-progressive, it must be lower ranked as shown in (43). The ranking so far is illustrated in (44).

(42)=(26f) /pul + yəu/ → [pul.**l**yə.u] ‘a vixen’

μ μc μ μ pul + yəu	SyllCon	Dep[place] / Align-HN -L/ *Spread-Vowel-F	POT	Max-μ_c	Dep[c.g]	*Spread-F /*Spr[plc]-prg
μ μc μ μ →a. pul.lyə.u [lat]		* (Align-HN –L)				* (*Spr-F) * (*Spr[P]-prg)
μ μc μ b. pul.nyə.u [cor]		* (Align-HN –L)		*!		* (*Spr-F)
μ μc μ μ ☹c. pun.nyə.u [cor]		* (Align-HN –L)				* (*Spr-F)
μ μc μ μ d. pul.t’yə.u [cor]		* (Align-HN –L)			*!	* (*Spr-F)
μ μc μ μ e. pum.myə.u [lab]		* (Dep[place])/ *! (*Align-HN –L)				* (*Spr-F)
μ μc μ μ f. pul.myə.u [lab]		* (Dep[place])/ *! (*Align-HN –L)		*		* (*Spread-F)

(43) /pul + yəu/ → [pul.**l**yə.u] ‘a vixen’

pul + yəu	Max[lat]	*Spread -[plc]-progressive
→a. pul.lyə.u		*
c. pun.nyə.u	*	

(44) SyllCon>> Align-PrWd-Left, Dep[plc], *Spread-Vowel-F >> Max-μ_c, POT >>Dep[c.g.], Max[lat], >>*Spread-Feature, *Spread[place]-progressive

The tableau in (45) shows nasalization. Since both /n/ and /l/ have the place of articulation [coronal] which the following glide /y/ can spread, both lateralization and nasalization are possible with the ranking in (44). However, the adequate output is (45b), so Dep[lat] must be higher than Dep[nas] in

ranking. The overall ranking is in (46).

(45) = (26b) /hæt + yəlmu/ → [hæ̲n.**n**yəl.mu] 'new baby radish'

hæt + yəlmu	Dep-[lat]	Dep-[nas]
a. hæl.lyəl.mu	*	
➔b. hæn.nyəl.mu		*

(46) SyllCon>> Align-PrWd-Left, Dep[plc], *Spread-Vowel-F >> Max-μ_c, POT >>Dep[c.g.], Max[lat]>> *Spread-Feature, *Spread[place]-progressive>> Dep -[lat]>>Dep-[nas]

With the ranking in (46), we can examine lateralization as in (47) and nasal gemination as in (48) and (49). As illustrated below, the ranking in (46) verifies the proper outputs in (47), (48), and (49).

(47)=(27f) /pul + yəu/ → [pul.**l**yə.u] 'a vixen'

μ μc μ μ pul + yəu	SyllCon	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
a. pul.nyə.u		*(Align-HN-L)	*!(Max-μ_c)		* (*Spr-F)		*
b. pul.t'yə.u		*(Align-HN-L)		*!(Dep[c.g]/)	* (*Spr-F)		
➔c. pul.lyə.u		*(Align-HN-L)			* (*Spr-F)	*	
d. pun.nyə.u		*(Align-HN-L)		*!(Max[lat])	* (*Spr-F)		*
e. pul.myə.u [lab]		*(Align-HN-L)/ *! (Dep[plc])	*!(Max-μ_c)				*
f. pum.myə.u [lab]		*(Align-HN-L)/ *! (Dep[plc])		*!(Max[lat])	* (*Spr-F)		*

(48) = (27c) /am +yəmso/ → [am.**n**yəm.so] ‘she-goat’

/am + yəmso/	SyllCon	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
a. am.yəm.so	*!		*(Max-μ_c)				
b. a.myəm.so		* (Align-HN –L)	*!(Max-μ_c)				
→c. am.nyəm.so [cor]		* (Align-HN –L)			*(*Spr-F)		*
d. am.myəm.so [lab]		* (Align-HN –L)			*(*Spr-F)/ *!(*Spr[P]-prg)		*
e. an.nyəm.so [cor][cor]		* (Align-HN –L)			**!(*Spr-F)		*
f. am.t’yəm.so [cor]		* (Align-HN –L)		*!	*(*Spr-F)		
g. am.p’yəm.so [lab]		* (Align-HN –L)		*!	*(*Spr-F)/ *(*Spr[P]-prg)		

(49)=(27d) /hopak + yət/ → [ho.baŋ.**n**yət] ‘pumpkin starch’

hopak + yət	SyllCon	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c/ POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
a. hobak.kyət [dor]		* (Align-HN –L)	*!(POT)		*(*Spr-F)/ *(*Spr[P]-prg)		
b. hobak.t’yət [cor]		* (Align-HN –L)		*!(Dep[c.g])	* (*Spr-F)		
c. hobak.k’yət [dor]		* (Align-HN –L)		*!(Dep[c.g])	* (*Spr-F)/ *(*Spr[P]-prg)		
d. hobak.nyət	*!	* (Align-HN –L)	*(Max-μ_c)		* (*Spr-F)		*
→ e. hobaŋ.nyət		* (Align-HN –L)			* (*Spr-F)		*
f. hoban.nyət [cor][cor]		* (Align-HN –L)			**!(*Spr-F)		*
g. hobam.myət [lab]		* (Align-HN –L) *! (Dep[plc])			* (*Spr-F)		*
h. hobaŋ.myət [lab]		* (Align-HN –L)/ *! (Dep[plc])			* (*Spr-F)		*

With this final ranking in (46), let's examine why /n/ is epenthesized rather than /t/ when the head noun starts with /y/ in noun compounding. The examples /hæt + yəlmu/ and /han + yəl⌊m/ are examined in (50) and (51), respectively. If /t/ is inserted as in (50b) and (50f), there would be a violation of either POT or Dep[c.g], neither of which the proper output (50d) violates.

(50)=(27b) /hæt + yəlmu/ → [hæ<u>n</u>.**n**yəl.mu] 'new baby radish'

μ μc μ μ hæt + yəlmu	SyllCon	Align-HN -L/ Dep[plc]/ *Spr-V-F/	Max-μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
a. hæt.yəl.mu	*!		*(Max-μ_c)				
b. hæt.t'yəl.mu		*(Align-HN –L)		*!(Dep[c.g])	* (*Spr-F)		
c. hæt.nyəl.mu	*!	*(Align-HN –L)	*(Max-μ_c)		* (*Spr-F)		*
→d.hæn.nyəl.mu		*(Align-HN –L)			* (*Spr-F)		*
e. hæl.lyəl.mu		*(Align-HN –L)			* (*Spr-F)/	*!	
f. hæt.tyəl.mu		*(Align-HN –L)	*! (POT)		* (*Spr-F)		

However, if we consider (51), the first morpheme ends in a sonorant which does not trigger POT. The plain /t/ epenthesis in (51h) violates Max- μ_c, which the winning candidate (51c) satisfies. The epenthesis of a tense coronal /t'/ in (51b) violates Dep[c.g] though satisfying Max- μ_c.

(51) = (27e) /han + yəlim/ →[han.**n**yə.lim] 'mid-summer'

μ μc μ μ han + yəlim	SyllCon	Align-HN-L/ Dep[plc]/ *Spr-V-F	Max- μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
a. han.yə.rim	*!		*!(Max- μ_c)				
b. han.t'yə.rim		* (Align-HN-L)		*!(Dep[c.g])	*(*Spr-F)		
→c. han.nyə.rim		* (Align-HN-L)			*(*Spr-F)		*
d. han.myə.rim [lab]		* (Align-HN-L)/ *! (Dep[plc])					*
e. ham.myə. rim [lab]		* (Align-HN-L)/ *! (Dep[plc])			*(*Spr-F)/		*
f. han.lyə.rim	*!	* (Align-HN-L)	*(Max- μ_c)		*(*Spr-F)	*	
g. hal.lyə.rim		* (Align-HN-L)			*(*Spr-F)	*!	
h. han.dyə.rim		* (Align-HN-L)	*!(Max- μ_c)		*(*Spr-F)		

Now, let's revisit all the different cases of epenthesis with the final ranking. First, the tableaux in (52), (53), and (54) show that the compound mora is realized by tensification of the word-initial

consonant of the second noun when a second noun starts in an obstruent.

(52)=(25a) /mæ+ tol/ → [mæ**t**.t'ol] 'mill stone'

μ μc μ mæ + tol	SyllCon	Align-HN-L/ Dep[plc]/ *Spr-V-F	Max-μc/ POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ a. mæ.dol			*! (Max-μc)				
μ μc μ b. mæt.tol			*! (POT)		* (*Spr-F)		
μ μc μ →c. mæt.t'ol				*(Dep[c.g])	* (*Spr-F)		
μ μc μ d. mæn.dol			*!(Max-μc)		* (*Spr-F)		*
μ μc μ e. mæn.t'ol				*(Dep[c.g])	*(*Spr-F)		*!

(53)=(24b) /mu+kuk/ → [mu**k**.k'uk] 'radish soup'

μ μc μ mu + kuk [dor]	SyllCon	Align-HN-L/ Dep[plc]/ *Spr-V-F	Max-μc / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ a. mu.guk			*! (Max-μc)				
μ μc μ b. muk.kuk			*! (POT)		* (*Spr-F)		
μ μc μ →c. muk.k'uk				*(Dep[c.g])	* (*Spr-F)		
μ μc μ d. mut.k'uk [cor]		*! (Dep[plc])		*(Dep[c.g])			
μ μc μ e. mut.t'uk [cor]		*! (Dep[plc])		*(Dep[c.g])	* (*Spr-F)/ *(*Spr[P]-prg)		

(54)=(25c) /san+kil/ → [san.k**'**il] 'mountain pass'

μ μc μ san + kil [dor]	SyllCon/ *Cmplx	Align-HN-L/ Dep[plc]/ *Spr-V-F	Max-μc / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ a. san.kil			* (Max-μc)				
μ μc μ → b. san.k'il				*			
μ μc μ c. sank.k'il	*! (*Cmplx)			*	*(*Spr-F)		
μ μc μ d. san.t'il [cor]				*	*!(*Spr-F)/ *(*Spr[plc]-prg)		

Second, when the second noun starts in a sonorant the subcompounding is marked by a sonorant geminate as shown in (55).

(55)=(25d) /næ+mul/ → [næ**m**.mul] ‘river water’

μ μc μ næ+ mul [lab]	SyllCon	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ a. næ.mul			*! (Max-μ_c)				
μ μc μ b. næt.mul [cor]	*!	* (Dep[plc])	* (Max-μ_c)				
μ μc μ c. næn.mul [cor]		*! (Dep[plc])			* (*Spr-F)		*
μ μc μ →d. næm.mul [lab]					* (*Spr-F)		*
μ μc μ e. næn.nul [cor]		*! (Dep[plc])			* (*Spr-F)/ * (*Spr[P]-prg)		*

The following are the tableaux to explain the cases in which there is no epenthesis at the noun compound boundary.

(56) =(26b) /c^ha+an/ →[c^ha.an] ‘inside of a car’

μ μc μ c^ha + an	SyllCon/ *cmplx	Align-HN-L/ Dep[plc]/ *Spr-V-F	Max-μ_c / POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ →a. c^ha.an			*(Max-μ_c)				
μ μc μ b. c^hat.an [cor]	*! (SyllCon)	*(Dep[plc])	*(Max-μ_c)				
μ μc μ c. c^ha.dan [cor]		*!(Align-HN-L)/ * (Dep[plc])	*(Max-μ_c)				
μ μc μ d. c^ha.t’an [cor]		*!(Align-HN-L)/ * (Dep[plc])		*(Dep[c.g])			

(57)=(28b) /k'æ + yət/ → [k' æ.yət] 'sesame starch'

μ μc μ k'æ + yət	SyllCon/ *cmplx	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c/ POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μc μ →a. k'æ.yət			*(Max-μ_c)				
μ μc μ b. k'æn.yət	*! (SyllCon)		*(Max-μ_c)		* (*Spr-F)		
μ μc μ c. k'æt.yət	*! (SyllCon)		*(Max-μ_c)		* (*Spr-F)		
μ μc μ d. k'æ.nyət		*! (Align-HN–L)	*(Max-μ_c)		* (*Spr-F)		
μ μc μ e. k'æ.dyət		*! (Align-HN–L)	*(Max-μ_c)		* (*Spr-F)		
μ μc μ f. k'æn.nyət [cor][cor]		*! (Align-HN–L)			* *(*Spr-F)		*
μ μc μ g. k'æ.t'yət		*! (Align-HN–L)		*(Dep[c.g])	* (*Spr-F)		

In brief, this section has shown that the two types of epenthesis can be accounted for under a unified analysis. It is the same constraint ranking that is applicable in all the different situations illustrated by the tableaux in (50)-(57). Given that tensification or gemination is observed at the compound boundary, we assume that a derived tense consonant and a geminate consonant are moraic. The three constraints of Max-μ_c, POT, and Dep[place] successfully predicts proper outputs involving tensification or gemination at the noun subcompounding boundary. The constraint Align-HeadNoun-Left, however, plays a crucial role for the failure of epenthesis.

4. FURTHER ISSUES ON EPENTHESIS

4.1 THE ASYMMETRY BETWEEN /W/-GLIDE AND /Y/-GLIDE

This subsection will consider the difference between the /w/-glide and the /y/-glide with respect to epenthesis over the compound morpheme boundary. The constraint SyllCon in section 3 works on the basis of the SSP (Sonority Sequencing Principle) and /w/ and /y/ are usually grouped together as glides under the SSP. This means that /w/ should exhibit the same behavior as /y/ within the present analysis. However, there is no epenthesis when /w/ is at the compound morpheme boundary as opposed to /y/.[9] This subsection will attempt to explain why /w/ does not trigger epenthesis in noun compounds.

Given the constraint ranking in (46), [n]-epenthesis is mainly driven by the constraints SyllCon, Max-μ_c, and Dep[place]. When the first morpheme ends in a consonant and the following head noun starts with the glide /y/, this would seem to violate the highly-ranked constraint SyllCon. Even with resyllabification of the coda into the onset, satisfying SyllCon, Max-μ_c would still be violated. Nonetheless, sound epenthesis can yield an appropriate output. The constraint Dep[place] allows for the epenthetic sound to be coronal since the glide /y/ can spread its coronal place of articulation. This is shown by the winning candidates in tableaux (50) and (51), for example.

[9] One might understand that lack of epenthesis before /w/ is contributed to no source available diachronically. This makes sense in that /n/-epenthesis was motivated by a historical change, which is discussed in section 4.2. However, the discrepancy between the two glides /w/ and /y/ still requires explanation from the synchronic perspective, because the key constraint SyllCon fails to discriminate these two segments under the SSP present.

In a similar manner, we might expect epenthesis when the head noun starts with a /w/-glide as the SSP generally assumes that both glides take the same place in terms of their sonority patterning. Consider (58);

(58)	input	output	gloss
a.	am + wənsuŋi	[a.mwən.suŋ.i]/*[am.nwən.suŋ.i]	'female monkey'
b.	son + wi	[so.nwi]/* [son.nwi]	'seniority'
c.	pəsət + wanca	[pə.sə.dwan.ja]/* [pə.sən.nwan.ja]	'mushroom meatball'

The examples in (58) are subcompounds and the first morpheme ends in consonant and the following head noun starts in /w/. According to the analysis in Section 3, epenthesis is expected; however, the outputs undergo resyllabification and the Voicing Rule applies.

To explain this discrepancy between /y/ and /w/, I posit that the glide /w/ cannot spread its place of articulation because of its dual place of articulation. The glide /w/ has two places when it is articulated: labial and velar. Let us reconsider the analysis of this study again; the onset across the compound morpheme boundary must be geminated or tensified to augment the compound mora. In the case of the /y/-glide, SyllCon triggers [n]-epenthesis and the ensuing nasalization over the morpheme boundary achieves mora augmentation. The epenthetic sound [n] can be specified in such a way that the place is spread from the onset glide /y/ and the nasality wins over tensification by means of Dep[c.g].

In this light, SyllCon may be predicted to trigger epenthesis in the case of the /w/-glide as well. For example, consider (58a). There is a nasal in the coda and /w/ in the onset across the compound morpheme boundary. Since the compounding process forms rising sonority (i.e. violates SyllCon), epenthesis may work best by satisfying SyllCon and Max-μ_c. But, what sound could be epenthesized? Nothing since there is no consonant in Korean with labio-velar articulation.[10] Therefore, I argue /w/ cannot spread its place of articulation; this in turn would yield a violation of Dep[place] if epenthesis were to occur. From this point of view, /w/ must be distinguished from /y/ with respect to epenthesis.

The discussion so far is illustrated in (59). Given that mora augmentation is to mark the specific morphological structure, i.e., noun subcompounding, the candidate in (59c) satisfies the constraint *Max-μ_c,* which the proper output (59b) violates. Since the segment [m͡ŋ] does not exist, the undominated constraint *[m͡ŋ] will eliminate (59c); which yields the final ranking as in (60).

(59)=(58c) /pəsət + wanca/ → [pə.sə.dwan.ja] 'mushroom meatball'

μ μ μ_c μ μ pəsət + wanca	SyllCon/ *cmplx	Align-HN -L/ Dep[plc]/ *Spr-V-F	Max-μ_c/ POT	Dep[c.g]/ Max[lat]	*Spr-F/ *Spr[plc]-prg	Dep [lat]	Dep [nas]
μ μ μ_c μ μ a. pə.sət.wan.ja	*!		*(Max-μ_c)				
μ μ μ_c μ μ →b. pə.sə.dwan.ja		*(Align-HN-L)	*(Max-μ_c)				
μ μ μ_c μ μ ☹c. pə.sən.m͡ŋwan.ja [labio-velar]		*(Align-HN-L)			*(*Spr-F)		*

[10] The question why the epenthetic sound must be a consonant not a vowel might depend on the triggering environment of mora augmentation. According to Davis & Ueda (2006), morphologically-driven mora augmentation tends to be done by means of a consonant.

(60) SyllCon, *Complex, *[m͡ŋ]>> Align-PrWd-Left, Dep[plc], *Spread-Vowel-F >> Max-μ_c, POT >>Dep[c.g.], Max[lat]>> *Spread-Feature, *Spread[place]-progressive>> Dep-[lat]>>Dep-[nas]

4.2 EPENTHESIS THROUGH HISTORY

This study assumes that the sound 'n' before the glide /y/ is epenthetic, not underlying contra Shin (2002). Some studies including Shin (2002), however, argue that the sound 'n' in noun compounds exists in underlying representation (UR) and that the underlying /n/ undergoes deletion word-initially. Their argument is based on word-initial /n, l/ deletion throughout history. For example, the word-initial /n, l/ deletion dates back to Middle Korean as shown in (61). Sohn (1999) provides the examples in (61) which were observed in the 15~16th centuries. The change of 'l > n' or the deletion of 'n' before [i/j] started and was in progress at that time. Word-initial 'l' started to alternate with 'n' as in (61a). Word-initial 'n' before [i/j] was still retained and words with an [n] being retained or deleted were contrastive like in (61b). This change was prevalent in the 17th century and was common in the Modern Korean of the 18th century.

(61) a. word-initial l ~ n alternation
lakuj ~ nakuj 'donkey'; lɔsai ~ nɔsai 'mule'; ləjzil ~ nəjzil 'tomorrow'
b. word-initial n~ø
njəlɨm 'summer' : jəlɨm 'fruit'
nilta 'rise': ilta 'achieve'

As a result of the word-initial sound deletion, Korean came to have alternations *ip~nip* (word-initially~word-medially) like the following:

(62) a. nip > ip > ip 'leaf'
b. k'ot+nip > k'on**n**ip > k'on-**n**-ip 'flower leaf'

A word *nip* in (62a) underwent word-initial [n] deletion before the vowel [i] in the 18th century. However, the compound in (62b) retained the sound because it is positioned word-medially. This can be the diachronic grounds for arguing that /n/ before /i, y/ is underlying not epenthesized. Thus, on this view, all the examples in (27) where the second member of the compound starts with [y] would really start with underlying /n/ before the [y].

However, this argument for the underlying /n/ analysis has two problems as follows. First, there are still words bearing /n/ over the compound morpheme boundaries even though they did not undergo /n/-deletion as in (63).

(63) a. ilhɨm > ilɨm 'name' 15th Century
b. k'ot + ilɨm > k'on-**n**- ilɨm 'flower leaf'[11]

The word *ilhɨm* 'name' in (63a) did not have a word-initial [n] in the 15th century, but has [n] in the compound. The 'underlying /n/' analysis cannot explain this. Further examples are illustrated in (64) below. Park (2005) shows that the head nouns in (64) have nothing to do with historical deletion of /n/: they did not have any /n/ originally.

[11] The alternative output [k'o.di.ɾim] without epenthesis is not accepted as Standard Korean. (http://user.chollian.net/~k1784/korea/sub05_202.htm)

(64)	Input	Output	Gloss	
a.	tok.cəm + yok	[tok.c'əm.nyok]	'desire for monopolization'	
b.	tu.t^{h}oŋ + yak	[tu.t^{h}oŋ.nyak]	'headache remedy'	
c.	ma.c^{h}al + yəl	[ma.c^{h}al.lyəl]	'heat by friction'	Park (2005: p150)

Second, the 'underlying /n/' analysis cannot account for the discrepancy in environments between diachronic /n, l/ deletion and compensating /n, l/ insertion. To put it in detail, the compensating word-medial insertion is limited to when the preceding morpheme ends in a consonant, while the word-initial deletion occurred without that restriction. The word [yər⌊m] 'summer' can be assumed to have an underlying /n/ deleted word-initially. However, the deleted /n/ restrictively appears in word-medial position as in (65):

(65)	UR	PR word-initially	(C)VC+UR	(C)V+UR
	/nyəlim/	[yərim]	[han-nyərim]	[c^{h}o-yərim]/*[c^{h}o-nyərim]
			'mid-summer'	'early summer'

The underling /n/ analysis predicts that the sound will be deleted word-initially but must stay undeleted word-medially; however, the data in (65) illustrate that the presence or absence of /n/ in the word is subject to whether the preceding syllable is open or closed. That is, there would be no motivation for /n/-deletion in the hypothetical *[c^{h}o-nyərim] in (65).

In sum, the two pieces of evidence support the position that /n/ before /y/ can be epenthetic, whether or not it was underlying diachronically.

Another argument for this position concerns Sino Korean compounds where the second member begins with /y/ or /i/. The [n]-epenthesis before a high vowel /i/ does not obtain for Sino-Korean words while the epenthesis is consistent before /y/. As shown in (66), these behave exactly like Native Korean compounds though these words did not historically start with /n/.

(66)	input		output	gloss
a.	sip + yuk	'ten+six'	[sim.nyuk]	'sixteen'
b.	sip + i	'ten+two'	[si.bi]/ *[sim.ni]	'twelve'

As shown in (66), [n]-epenthesis only occurs when /y/ is involved at the compound boundary as in (66a).

It should be mentioned, furthermore, that [n]-epenthesis before /i/ involves more irregularities whereas [n]-epenthesis before /y/ is consistent. Consider the example in (67). To account for this example, I assume that the [n] sound before the high vowel /i/ is underlying, not epenthetic as in (67b). This is unlike (66b) where /i/ 'two' is underlyingly /i/ and not /ni/.

(67)	input	output	gloss
a.	/dæ+ ip/	[dæn.nip]	'bamboo leaf'
b.	/dæ+nip/	[dæn.nip]	'bamboo leaf'

At first glance, it seems that this word may undergo [n]-insertion, even though the preceding morpheme does not have a coda. If (67a) is true, we should postulate [n] gemination even intervocalically, which creates wrong predictions regarding the no-epenthesis data with hiatus across the compound morpheme boundary. However, since I assume that /n/ before /i/ is underlying, onset gemination as in (67b) is

predicted and consistent with the analysis in Section 3. Further examples are found in the following, with an underlying /n/ in the onset:

(68)	input	output	gloss
a.	/wi + ni/	[win.ni]	'upper teeth'
b.	/alæ+ ni/	[a.ræn.ni]	'lower teeth'

Traditional Korean phonology explains that the second geminate /n/ is underlying (or epenthetic before /i/) and that the first geminate nasal in the output is an inserted [t] which is nasalized by the following nasal sound. Within my analysis, however, the second [n] in the output is underlying and the onset is geminated to augment one mora in order to mark the noun compounding boundary.

4.3 MORACITY OF DERIVED TENSE CONSONANT REVISITED

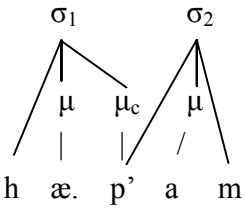
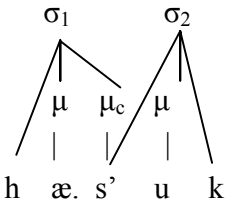
This paper has assumed that the derived tense consonant is moraic unlike the underived counterpart. Given this assumption, an interesting question arises as to how the compound mora "μ_c" is realized when the onset consonant at the compound boundary is underlyingly tense. The morpheme meaning 'new; the first product of the year' has two orthographic forms of [hæt-] and [hæ-] as shown in (69) and (70). In (69), it has been assumed that the [t] in orthography indicates noun compounding. However, as in (70), if the second word begins with a tense or aspirated consonant, the orthographic form [hæ-] is selected.

(69) Orthographic form	Input	Output	Gloss
a. [hæt.pam]	hæ+pam	[hæp'am]	'new chestnut'
b. [hæt.tolaci]	hæ+tolaci	[hæt'oraji]	'new balloonflower'
c. [hæt.kamca]	hæ+kamca	[hæk'amja]	'new potato'
d. [hæt.namul]	hæ+namul	[hænnamul]	'new vegetable'
e. [hæt.yaŋp^{h}a]	hæ+yaŋp^{h}a	[hæn.nyaŋ.p^{h}a]	'new onion'

(70) Orthographic form	Input	Output	Gloss
a. [hæ.s'uk]	hæ+s'uk	[hæs'uk]	'new mugwort'
b. [hæ.c^{h}a]	hæ+c^{h}a	[hæc^{h}a]	'new tea'
c. [hæ.k^{h}oŋ]	hæ+k^{h}oŋ	[hæk^{h}hoŋ]	'new bean'
d. [hæ.p^{h}at]	hæ+p^{h}at	[hæp^{h}at]	'new red-bean'

Assuming that the underlying form of the morpheme is /hæ-/, I can analyze tensification in (69a) through (69c), and gemination in (69d) and (69e) as indicative of the realization of the compound mora as in (71a). On the other hand, the examples in (70) have no difference between input and output. But the distinction in moracity between a derived and an underived consonants can demonstrate the realization of the compound mora as shown in (71b). That is, those in (70) undergo mora augmentation, but there is no phonetic realization of the consequence of having an extra mora.

(71) a. [hæp'am] 'new chestnut' b. [hæs'uk] 'new mugwort'

Input	μ μc μ hæ + pam	μ μc μ hæ + s'uk
Output		

The tense consonant [p'] or [s'] in output is doubly-linked. This ambisyllabic representation illustrates that the compound mora can be realized as a coda of the first syllable while the consonant as an onset respects the morpheme structure.

5. CONCLUSION

This study argues that [t]-epenthesis and [n]-epenthesis in noun compounds should be analyzed in a unified way. Despite apparent considerable differences between the two types of epenthesis, they are similar in that epenthesis ends up with gemination or tensification over the compound morpheme boundary. The basic idea is similar to Constrain MarkCompound by Shin (2002). However, the present paper proposes mora augmentation as the marker of the compound which constrains the way that epenthesis actually occurs.

The mora augmentation in Korean noun compounding also supports the argument of Davis & Ueda (2006). They maintain that morphologically-driven mora augmentation tends to be done by means of a consonant, such as gemination or consonant insertion to coda position, whereas prosodically-driven mora augmentation prefers vocalic augmentation by means of a vowel. As shown in this study, mora augmentation in Korean noun compounding is morphologically-driven, and a mora is augmented by means of moraic consonants (e.g. gemination of an onset or tensing of a consonant in Korean).

6. REFERENCES

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