Foot Structure and Vowel Shortening*

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Kim, Jong-Kyoo. (2013). Foot Structure and Vowel Shortening. *The Linguistic Association of Korea Journal, 21*(2), 21-42. Korean vowel shortening, operating at the level of the foot, is a typical case of *trochaic shortening* motivated by the complete parsing of syllables into feet. As an anti-trapping effect, trochaic shortening saves a prosodically trapped light syllable in an uneven trochaic context like [H L]. The mechanism of extrasyllabification is closely related to and thus, plays a crucial role in Korean vowel shortening. Extrasyllabification of the final consonant is generally preferred over vowel shortening. When it would yield an unsyllabified consonant, extrasyllabification is replaced by vowel shortening. The major theoretical finding of this study is the active operation of trochaic shortening in an iambic system, Korean. This provides a new perspective in the typology of vowel shortening. Shortening processes, either trochaic or iambic, have been generally described as a typical characteristic of trochaic languages, mainly stemming from the so-called *Iambic/Trochaic Law*. Only lengthening processes such as *iambic lengthening* have been proposed as significant means of quantitative adjustment in iambic languages. As a foot-based process, however, trochaic shortening is metrically well-motivated in the iambic system of Korean.

Key Words: vowel shortening, foot, metrical structure, stress system, iamb, trochee, trochaic shortening, iambic shortening, anti-trapping effect, extrametricality, complete parsing

* I am grateful to three anonymous reviewers of *The Linguistic Association of Korea Journal* for their valuable comments and suggestions. All errors are my own. This work was supported by 2011 Hongik University Research Fund.

1. Introduction: Aim and Scope

The main purpose of this study is to investigate the phonological motivation of vowel shortening in Korean as a foot-based metrical process and to provide a new perspective in the typology of quantitative adjustment. Regarding the significant role of foot in phonology as a phonological constituent, it is a little surprising that there has been no comprehensive study on Korean metrical structure, especially focusing on its active role in a quantity-sensitive phonological process like vowel shortening.

Korean displays the process of stem-vowel shortening in the course of suffixation. It has been one of the most generally accepted facts of Korean phonology that such a shortening of the stem vowel crucially depends on the segmental difference of suffixes. Specifically, vowel shortening can be triggered only by vowel-initial suffixes, but not by consonant-initial suffixes, as the following data show.

(1) Korean Vowel Shortening in Suffixation[1)]

UR	*Declarative*	*Connective*	*Stative*	*Effective*	*Gloss*
ta:m	ta:m-ta	ta:m-ko	tam-a	tam-ɨni	'put in'
si:n	si:n-ta	si:n-ko	sin-ə	sin-ɨni	'put on shoes'
ku:lm	ku:m-ta	ku:m-ko	kulm-ə	kulm-ɨni	'starve'
tə:p	tə:p-ta	tə:p-ko	təp-ə	təp-ɨni	'be hot'

Related to the data in (1), one simple question can be easily raised; What is the phonological motivation of Korean vowel shortening? The traditional account that a vowel-initial suffix triggers vowel shortening cannot be a sufficient answer. It can only be a description of the phenomenon. As for this issue, however, this study is based on a totally different perspective, compared with previous traditional studies. Instead of referring to the segmental character of suffixes, reference to the nature of prosodic structure(syllable structure and foot structure) is presented as a crucial factor inducing vowel shortening in Korean.

1) The actual forms of stative and effective of a so-called p-irregular verb like *tə:p* are *təw* and *təuni*, respectively.

It has been generally accepted in recent phonological theories that foot structure, as a centering component of phonological constituent, plays a crucial role in a variety of phonological processes as well as in stress systems(Mester 1994). The shape of foot structure(trochee or iamb) in a language actively participates in prosodic morphological processes such as reduplication, truncation, the minimal word effect, and so forth (MaCarthy and Prince 1986, 1993, 1995). Moreover, the well-formedness of foot structure is often responsible for phonological processes like segmental changes(deletion, epenthesis, reduction) and quantitative adjustments(shortening, lengthening, gemination) (Baković 1996, Hayes 1995. Kager 1999, Mester 1994. Prince 1990 and others). Narrowing this down into the major issue of this study, our focus is centered on the role of foot structure in subtractive quantitative adjustment, that is, vowel shortening.

The fundamental property of vowel shortening refers to the fact that an underlyingly long vowel shortens because of certain prosodic pressure and thus, syllable weight is reduced. As a typical example of vowel shortening, vowel shortening in CVVC syllable, that is, closed syllable shortening, has been accounted for in terms of syllable structure. The bimoraic size restriction on a syllable motivates closed syllable shortening, preventing the generation of a trimoraic superheavy syllable. There is, however, another pattern of vowel shortening crucially induced by the formation of foot structure, which is the main focus of this study. As a process of mora loss, vowel shortening inevitably causes the change of moraic structure and eventually foot structure. From a reverse point of view, the well-formedness of foot structure(foot type and stress position) and the exhaustivity of foot formation often trigger vowel shortening.

In the framework of derivational approaches, metrically-motivated vowel shortening has been generally accounted for in a step-by-step manner such as *footing* → *repair strategy/rule* → *refooting*. However, in the Optimality-Theoretic(OT, hereafter) approach in the present study, vowel shortening is the natural result of the interaction of related constraints, especially the interaction between moraic faithfulness constraints and foot-based constraints.

2. Vowel Shortening: Type and Motivation

Two types of vowel shortening have been discussed in relation to foot structure in many studies: *trochaic shortening* and *iambic shortening*. However, these terms are somewhat misleading, since both of them are generally used to indicate vowel shortening in trochaic languages. Such a problem mainly comes from the fact that the terms such as *trochaic shortening*(HL→LL) and *iambic shortening*(LH→LL) concern the syllable sequence in the input, while the terms such as *trochee* and *iamb* indicate the well-formed feet like '(**H**), (**L** L)'and '(**H**), (L **L**), (L **H**)', respectively in the output.[2)]

2.1. Trochaic Shortening

Trochaic shortening generally refers to the process that shortens a long vowel in a penultimate syllable when the final vowel is short(V: → V/__CV#)(Hayes 1995). A typical example from Fijian, a moraic trochaic language, is presented in (2), following Hayes(1995).

(2) ta:-y-a	→	táya	'chop', TRANS-3sg. OBJ
mbu:-ŋgu	→	mbúŋgu	'my grandmother'
nre:-ta	→	nréta	'pull', TRANS

For the phonological motivation of such stressed vowel shortening[3)] as in Fijian, Prince(1990) and Hayes(1995) similarly propose that vowel shortening in this situation permits a more complete parsing of the word into metrical feet. To be more specific, by the operation of vowel shortening, as a repair strategy in a derivational sense, the exhaustive parsing of foot structure is accomplished, as follows.[4)]

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2) Throughout the paper, 'H' denotes a heavy syllable, while 'L' denotes a light syllable. For the prominence relation, a 'strong' position is indicated by **boldface**.

3) Shortening occurs even in a diphthong like /ei/. As a result, a phonetically shorter version of the diphthong surfaces(Schütz 1985, cited in Hayes 1995).

3) The account here is somewhat derivational for clearer understanding.

(3)	(**H**) L	→	L L	→	(**L** L)[5]
	ta: . ya		ta . ya		ta . ya
	footing		*vowel shortening*	*refooting*	

Without vowel shortening, the second syllable of the word would be unparsed or trapped, since it cannot be incorporated into foot structure.[6]Such *prosodic trapping* can be resolved by the loss of the mora of the first heavy syllable through vowel shortening. Therefore, the motivation of trochaic shortening is the complete parsing of syllables into feet, saving a finally-trapped syllable in the formation of metrical structure. Through vowel shortening, the trapped final syllable is able to form a licit trochaic foot like (**L** L) with the preceding syllable. This is a basic property of vowel shortening as an *anti-trapping effect* in the formation of foot structure.

The role of foot structure in trochaic shortening is more evident when the following data from Fijian are considered(Hayes 1995).

(4)	a. nre:nré:	[(**H**) (**H**)]	(*nrenré:)	'difficult'
	b. nbe:léti	[(**H**) (**L** L)]	(*nbeléti)	'belt'

In (4a) the penultimate syllable with a long vowel is followed by a heavy syllable; in (4b) the syllable with a long vowel is followed by two light syllables. Therefore, there is no case of final trapping as in (2) and thus, nothing can motivate vowel shortening. There is no need for the operation of vowel shortening; the sequences can be footed into a well-formed trochaic structure such as [(**H**) (**H**)] and [(**H**) (**L** L)], respectively.

Summarizing, the phonological motivation of trochaic shortening is the complete parsing of syllables into feet, saving a prosodically trapped syllable in the formation of metrical structure.

4) Throughout the present analysis, relevant phonological constituents and morphological categories are denoted as follows.

. syllable ( ) foot [ ] prosodic word { } stem

6) Related to this analysis, it should be noted again that an uneven trochee like (H L) is not a well-formed moraic trochee by the notion of bimoraic maximality(Mester 1994, Hayes 1995). According to Mester(1994), the moraic trochee should be strictly bimoraic, conforming to both bimoraic maximality and bimoraic minimality.

2.2. Iambic Shortening

The typical example of iambic shortening comes from Latin which is also a moraic trochee language with moraic coda consonants. Latin has a rule known as *Brevis Brevian* which shortens a vowel when the preceding syllable is light(Mester 1994). Even though the environment of iambic shortening is totally different from that of trochaic shortening, their motivation is essentially identical, which is the complete parsing of words into bimoraic metrical feet. In Latin where disyllabic words composed of a light syllable and a heavy syllable, the final heavy syllable is made light through shortening(data from Mester 1994).

(5)	[L H]	→	[**L** L]	
	pu.ta:	→	pu.ta	'believe', 2sg.imp.
	vo.lo:	→	vo.lo	'want', 1sg.
	ho.mo:	→	ho.mo	'human being', gen.sg., nom.sg.
	a.ma:	→	a.ma	'love', 2sg.imp.

Before shortening, disyllabic words provide the iambic environment like [L H]$_{PrWd}$ where word-final syllables are heavy. Given the fact that final syllables are extrametrical in Latin, these iambic-shaped words provide a typical trapping configuration in which the first light syllable is prosodically stranded like [L <H>].[7] Even if extrametricality is suspended[8] and thus, the final syllable is incorporated into the foot, the foot cannot form a legitimate moraic trochee. Leftward footing may produce initial trapping like [L (**H**)]. However, if the final vowel shortens, then a proper moraic trochee like [(**L** L)] is formed, saving a potentially trapped light syllable. As a conquence, the motivation of iambic shortening, like trochaic shortening, is the exhaustive parsing of metrical structure.

The assumption that an iambic environment like [L H] is the determining

6) The symbol '< >' indicates an extrametrical/extrasyllabic constituent.

7) Extrametricality must be suspended in this context, since extrametricality should not be applied in an exhaustive way(Hayes 1982). To be more specific, in either monosyllabic words or bisyllabic words such as [L <L>] and [L <H>], the formation of foot structure is impossible with the extrametrical final syllables.

factor for this kind of shortening process is more evident with the comparison of the data in (5) with the following data in (6) (Mester 1994).

(6)	a.	manda:	[(**H**) (**H**)]	(*manda)	'entrust', 2sg.imper.
		laudo:	[(**H**) (**H**)]	(*laudo)	'praise', 1sg.pres.
	b.	simula:	[(**L** L) (**H**)]	(*simula)	'simulate', 2sg.imper.
		habito:	[(**L** L) (**H**)]	(*habito)	'inhibit', 1sg.pres.

When the final CV: syllable is preceded by either a heavy syllable or two light syllables, no shortening is needed. In these sequences, final syllable extrametricality is at work and the preceding syllable(s) can form a bimoraic trochee such as (**H**) and (**L** L), respectively without the help of vowel shortening.

2.3. Cretic Shortening

As another example of metrically-conditioned shortening, Latin provides an intriguing case of vowel shortening, known as *cretic shortening*, which has an identical phonological effect as iambic shortening. Cretic shortening occurs when a light syllable is flanked by two heavy syllables as in [⋯H L H].[9] As in iambic shortening, the long vowel in the final syllable shortens, resulting in [⋯H L L].

(7) dí:cito:	→	dí:cito	'say', imp.fut.
ímpera:	→	ímpera	'rule', imp.
máksume:	→	máksume	'most', adv.

By cretic shortening, a medially-trapped light syllable can form a foot with the shortened final syllable as in '[⋯(**H**) L (**H**)] → [⋯(**H**) (**L** L)]'.[10]

9) In this case, the main stress is on the heavy syllable preceding the flanked light syllable, as in (7). Here again, extrametricality of the final syllable is suspended.

10) An interesting property of cretic shortening is that the quantity of the antepenultimate syllable which is not adjacent is a decisive condition on the shortening of the final syllable. As the following data show, only heavy anpepenultimate syllables can trigger vowel shortening of the final syllable.

[(L L) (H)]: facito: (*facito) 'do', imp.fut.

2.4. Summary and Issues

The necessity of vowel shortening in a trochaic system stems from the prohibition on the occurrence of illegal moraic trochees: either an uneven trochee (**H** L) or an uneven iamb (L **H**). To avoid such ill-formed moraic trochee, another undesirable foot structure, one with a prosodically trapped syllable, would have to be tolerated. Vowel shortening can save such a trapped syllable, providing a legitimate trochee (**L** L).

The discussion so far, however, raises one simple question: Is there any identical shotening process in an iambic system, compared with the typologically common shortening processes in a trochaic system? It is a natural result that iambic shortening is not needed in an iambic system, since the uneven-iambic environment already provides the canonical iamb like (L **H**). But it can be expected that iambic languages may also require a trochaic shortening process motivated by the exhaustivity of foot structure, since the exact same type of prosodic trapping such as [(**H**) L] can occur in an iambic system.

However, it is a surprisingly unexpected aspect that there has never been a serious attempt at exaplaining such a possibility. In the analysis of the iambic system, only iambic lengthening like [(L **L**) → (L **H**)] has been paid much attention to. The phonological effect of iambic lengthening is attributed to make a maximal(that is, canonical) iamb, mainly based on the notion of the *Iambic/Trochaic Law*(Hayes 1995). Since the iambic system is duration-based, iambic lengthening provides optimal iambic foot structure which is more distinctive with unequal duration. Related to this, however, it should be noted that iambic lengthening only concerns the inherent prominence relation in a single foot. What trochaic shortening in the iambic system would concern is the whole sequence of foot structure in a prosodic word. Therefore, the possibility of phonologically active trochaic shortening in the iambic system should be a

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studeo:	(*studeo)	'strive', 1sg.
simula:	(*simula)	'simulate', imp.

When the antepenultimate syllable is light, there exists no prosodically-trapped syllable and thus, vowel shortening is not required as in '[(L L) <H>]'. Such a character of action at a distance in cretic shortening has been problematic in previous segment/syllable-based approaches. In a foot-based approach(Mester 1994) adopted here, however, it is a natural result of the anti-trapping effect.

good issue to aim at. This study contends that vowel shortening in Korean discussed in the following section is actually the occurrence of trochaic shortening in an iambic language for the avoidance of prosodic trapping in complete foot formation.

3. Vowel Shortening in English

Korean is not the only language which displays vowel shortening with the affixation of vowel-initial suffixes. English also provides interesting patterns of vowel shortening conditioned by the segmental property of vowel-initial suffixes. As a moraic trochee system, English displays typical types of both trochaic shortening and iambic shortening which can be accounted for in the relation with foot formation.

3.1. Trochaic Shortening in English

A famous vowel alternation in English phonology is provided by the data in (8). Such vowel alternation is conditioned by so-called root-level suffixes such *-able, -ity, -ative, -ify, -ual, -acy* etc., which are always vowel-initial.

(8) Trisyllabic Shortening in English (Myers 1987)

sincere	sincerity	sane	sanity
derive	derivative	compete	competitive
flame	flammable	divide	divisible
mode	modify	sole	solitude
grade	gradual	supreme	supremacy

The data here reflect the notorious *Trisyllabic Shortening* in SPE(Chomsky and Halle 1968); such vowel alternations have often been analyzed by the notion of resyllabification(V.CV→VC.V) in many derivational approaches(Selkirk 1982, Borowsky 1986, Myers 1987 among others) which will not be discussed in detail in the present study.

Related to the current issue, what is significant in English vowel alternation is that all the triggering vowel-initial suffixes consist of two syllables, the first of which is light(Myers 1987). The weight of the second syllable is not important here, since it ends up extrametrical after suffixation.[11] Preceded by a heavy syllable in the stem-final position, the light suffix-initial syllable is a vulnerable target of prosodic trapping. The uneven trochaic environment [H L] is provided here.

(9)	sane-ity:	ˈsej . nə . <ti>	→	ˈsæ . nə . <ti>
		(**H**) L		(**L** L)

This is the exact identical situation where trochaic shortening occurs. Here again, by shortening the long vowel(here, monophthongization of off-glide diphthong), the trapped syllable can be a part of a moraic trochee like (**L** L).[12]

The activity of metrically-governed vowel shortening in English become clearer in the consideration of the data (10) where the addition of the vowel-initial suffix seemingly triggers shortening in a non-adjacent syllable of the stem.

(10)	nature	natural	patron	patronize
	omen	ominous	table	tabular

In this case, vowel-initial suffixes such as *-al, ize, -ous, -ar* are monosyllabic and thus, eventually end up extramettical. In the course of suffixation, the final consonant of the stem is invited to the onset position and thus, a trapping situation is provided. Again, shortening saves a trapped syllable for the persistent parsing of foot structure.

11) The stress pattern in English poses two kinds of extrametricaltiy(Hayes 1982); (i) A root-final consonant is extrametical. (ii) A final-syllable is extrametrical in nouns and suffixed forms.

12) A foot-based analysis of English trisyllabic shortening is provided in Prince(1990). Since the bimoraic maximality was not assumed in his analysis, the motivation of trisyllabic shortening was accounted for in a slightly different way. Instead of the avoidance of prosodic trapping, *Grouping Harmony* was proposed as the metrical motivation of vowel shortening, where (L L) is assumed as a typologically more harmonic foot than (H L).

(11) omen-ous: ˈa: . mə . <nəs> → ˈa . mə . <nəs>
(**H**) L (**L** L)

3.2. Iambic Shortenig in English

The analysis of English vowel shortening under the notion of anti-trapping effect allows us to provide a consistent account for the data (12) which displays a peculiar stress shift.

(12)	a.	proˈvide	ˈprovident	reˈfer	ˈreference
		reˈlate	ˈrelative	reˈvere	ˈreverend
	b.	reˈfute	refuˈtation	deˈrive	deriˈvation

The segmental shape of suffixes in (12a) is the same as those in (10) in the sense that they are vowel-initial and monosyllabic. However, the structure of the stem-final syllable provides a totally different environment for foot formation. Since it is still a CVV heavy syllable after suffixation, with the preceding light syllable, a [L H] iambic environment is formed here.

(13) provide-ent : pro . ˈvaj . <dənt> → ˈpra . vi . <dənt>
L (**H**) (L **L**)

In order to parse an initially-trapped syllable into a foot, vowel shortening is needed. This is a typical example of iambic shortening. The only difference between English and Latin is that in English iambic shortening occurs in the penultimate syllable with consistent final extrametricality. Stress shift in this case is inevitable, since the second syllable is no longer in the prosodically strong position after shortening. The left-headedness of the trochaic relation of prominence induces stress shift onto the first syllable.

The suffix *-ation* in (12b) has a unique structure composed of two syllables, the first of which is heavy. This implies that the suffix-initial syllable can form an independent foot by itself. This provides another environment of iambic shortening as seen by the stress/vowel shortening alternation in *derive/derivation* shown in (14).

(14) derive-ation : di . raj . ˈvej . <ʃən> → de . ri . ˈvej . <ʃən>
L (**H**) (**H**) (**L** L) (**H**)

An initially-trapped syllable in the iambic construction is parsed into a foot by shortening the long vowel of the second syllable. Since the penultimate syllable can form the non-final rightmost foot, it induces the main stress, causing stress shift.

3.3. Summary and Issues

To summarize, the analysis of the complex patterns of English vowel shortening can be accounted for in a systematic way in terms of anti-trapping effect. As a moraic trochee system, English provides typical examples of trochaic shortening and iambic shortening in the affixation of vowel-initial suffixes. Stress shift in some cases is a natural by-product of such metrically-conditioned shortening processes. Based on the discussion so far, it is argued in the present study that the process of vowel shortening in Korean has the exact same characteristics as that of trochaic shortening which is typologically very common in moraic trochee languages. That is, the removal of a mora for exhaustive parsing is the phonological motivation of vowel shortening in Korean verbal morphology. One important finding of the Korean shortening data is that from the typological perspective, so-called trochaic shortening occurs in an iambic languages including Korean as well as trochaic languages.

4. Foot Structure and Vowel Shortening in Korean

As indicated previously, there has been no comprehensive study on the metrical structure of Korean, focusing on its active role in Korean phonology. Korean metrical structure has only been sporadically mentioned in a few studies in the attempt of bolstering arguments as minor evidence(H-B Jung 1990, J-H Jun 1994, Y-S Lee 1992, M-S Shim 1997 among others). The main reason why foot structure has not been paid much attention to may be due to the assumption that the role of stress in Korean is almost invisible, in light of the view that stress is the most crucial evidence for the establishment of metrical structure in a language.

In many previous studies, Korean has been implicitly regarded as a non-stress language, ignoring its activity in phonology. However, even if Korean is not a stress language, the need for the justification of Korean metrical structure still remains. As succinctly proposed in Poser(1988, 1990), the active role of foot structure in phonology is evident and extensive even in a typical non-stress language like Japanese. If this is the case, the shape and role of metrical structure deserve an in-depth investigation for the comprehensive analysis of Korean phonology, as an independent issue.

4.1. Korean Stress System

In the establishment of foot structure of a language, the stress system provides the most fundamental ground. To put it differently, all the parametric metrical theories of stress have been mainly based on foot structure. In this sense, it is reasonable to start from the stress system in the analysis of Korean foot structure. It is argued in this study that Korean has a legitimate stress system which is based on the iambic relation among quantitative syllables.

In a series of works by H-B Lee(1974, 1985, 1989) and H-Y Lee(1990), Korean is convincingly described as a legitimate stress language, emphasizing the fact that even though stress in Korean does not have such a lexically distinctive function as in English, it has all the other functions carried by typical stress languages. According to these works, Korean has a duration-based stress system in which the duration of syllables plays a key role, whereas the role of the pitch patterns is only marginal in the decision of the position of main stress. Based on these works and my own intuitions as a native speaker, the stress system of phonological words in Korean can be described as follows.

(15) (a) In Korean, stress falls on[13)]

(i) the first syllable, if it is heavy(CVV or CVC)

(ii) the second syllable, if the first syllable is light(CV)

13) Only the primary stress is considered in this study, since secondary stresses are neither regularly prominent nor significant in Korean.

(b)	'twe:ci	'pig'	i.'ya.ki	'story'
	'cam.ca.li	'dragongly'	kə.'ul	'mirror'
	'mak.næ	'lastborn'	ə.'mə.ni	'mother'

This stress system clearly implies two main points of Korean metrical structure. First, coda consonants in Korean are treated as moraic. CVC syllables group with CVV syllables as heavy against CV light syllables in the assignment of stress. Secondly, Korean has a rightward right-headed iambic foot structure. The stress system of Korean is exactly like those of typical iambic languages such as Hopi, Ossetic, and Sierra Miwok etc.(Hayes 1995). The fact that Korean has a duration-based stress system and iambic foot structure also conforms to the so-called *Iambic/Trochaic Law* in Hayes(1985, 1989, 1995)[14] which is based on the traditional psychological experiments on rhythmic grouping. The requirement of Iambic/Trochaic Law for the foot structure in languages is witnessed by the preference for the canonical foot to be a durationally uneven iamb (L **H**) in an iambic system and an even trochee (**L** L) in a trochaic system.[15]

4.2 Trochaic Shortening in Korean

As we discussed above, the phonological motivation of trochaic shortening is the complete parsing of the word into foot structure. Based on such an assumption, this study contends that the exhaustivity of foot structure also motivates trochaic shortening in an iambic system and Korean provides a typical example. That is, Korean vowel shortening is actually an occurrence of trochaic shortening in an iambic language for the avoidance of prosodic trapping. The relevant data of Korean vowel shortening are repeated here in (16).

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14) Iambic/Trochaic Law
  a. Elements contrasting in intensity naturally form groupings with initial prominence.
  b. Elements contrasting in duration naturally form groupings with final prominence.

15) Such a preference for the canonical foot type often induces quantitative segmental changes such as iambic(rhythmic) lengthening in iambic systems(Hayes 1995). Iambic lengthening converts an even iamb (L L) into an optimal uneven iamb (L H)

(16) Korean Vowel Shortening in Suffixation

UR	Declarative	Connective	Stative	Effective	Gloss
ta:m	ta:m-ta	ta:m-ko	tam-a	tam-ɨni	'put in'
si:n	si:n-ta	si:n-ko	sin-ə	sin-ɨni	'put on shoes'
ku:lm	ku:m-ta	ku:m-ko	kulm-ə	kulm-ɨni	'starve'
tə:p	tə:p-ta	tə:p-ko	təp-ə	təp-ɨni	'be hot'

Note that underlying fomrs of both stative and effect suffixations in (16) are composed of 'heave syllable + light syllable [H L]'. Such an uneven trochaic environment cannot make a well-formed iamb. Thus, the first heavy syllable should form an iambic foot by itself, leaving the second light syllable prosodically trapped. This is an exactly identical situation where trochaic shortening occurs as discussed above with the Fijian data in (2) and (4). The designated repair strategy for the prosodic trapping is also identical. By removing a mora of the preceding long vowel, exhaustive parsing is accomplished, as in (17).

(17) $[(\mathbf{H})_F\ L]_{PrWd}$ → $[(L\ \ \mathbf{L})_F]_{PrWd}$
ta: . ma → ta . ma

The reason why a consonant-initial suffix cannot trigger vowel shortening is also based on the motivation of exhaustive parsing. One obvious difference between a vowel-initial suffix and a consonant-initial suffix is whether it can provide a landing site(that is, the onset position) to a stem-final consonant. Vowel-initial suffixes incorporate the stem-final consonant as the onset of their second syllable, while consonant-initial suffixes cannot affect the original syllable structure of the stem. This difference is crucial in a language like Korean with moraic coda consonants. When a consonant-initial suffix is attached to the stem, even if a mora from the long stem vowel is removed by vowel shortening, the exhaustivity of parsing cannot be enhanced. As (18) shows, the repaired structure still includes a prosodically trapped mora, since the first syllable is still heavy with a moraic coda.

(18)[16] [(**H** <C>)$_F$ L]$_{PrWd}$ → *[(**H**)$_F$ L]$_{PrWd}$
ta: <m> . ko → tam . ko

The seemingly no effect of the repair strategy of shortening in (18) is due to the role of *Weight-by-Position*[17] licensing a mora onto a coda consonant which is underlyingly moraless(Hayes 1989). In other words, in the affixation of consonant-initial suffixes the result of vowel shortening is still a CVC heavy syllable and the second light syllable is still prosodically trapped. Vowel shortening would yield the incomplete parsing of underlying moraic structure without any enhancement of foot structure. Consequently, in this case prosodic trapping should be tolerated. As Mester(1994) points out, the fact that the trapping configuration is disfavored and thus repaired does not mean that it is absolutely impossible. This is the exact reflection of the main spirit of OT.

4.3. OT Analysis of Korean Vowel Shortening

Our optimality-theoretic analysis crucially depends on the interaction of constraints which differentiate the suffxation of vowel-initial suffixes and consonant-initial suffixes with other related constraints such as basic faithfulness constraints, alignment constraints, and foot/syllable-based metrical constraints. Relevant constraints for the analysis of Korean vowel shortening are presented in (19).

(19) Relevant Constraints in the Analysis of Korean Vowel Shortening

a. MAX-μ

Input moras must have output correspondents (no mora deletion)

b. ONSET

Syllable must have onsets.

c. IAMB

Feet must be right-headed at the syllable level.

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16) Remember that in the stem-final CV:C syllable, the final consonant is extrasyllabic.

17) In the analysis based on constraint interaction, it can be replaced by a constraint such as *CODA-μ* (i.e. Codas must be moraic).

d. BIMORA

Syllables must have no more than two moras.

e. PARSE-σ

Syllables must be parsed into feet.

f. ALIGN-R(stem, foot)

Align the right edge of a stem with the right edge of foot

g. CODA-μ

Mora must be licensed onto coda consonants.

For a quantity-sensitive process such as vowel shortening, the related correspondence constraints refer to the corresponding relation between input and output moraic structure. The proposed moraic correspondence constraint *MAX-μ* can be compared with the constraint *WEIGHT-IDENTITY*(Urbanczyk 1996, Rosenthall and van der Hulst 1999) which basically refers to the quantitative identity relation at the segmental level, which is similar to the featural identity in McCarthy and Prince(1995). For the clear differentiation between vowel shortening(mora loss) and vowel lengthening(mora addition), it is decomposed into two independent constraints in this study, following Baković(1996). It is entirely possible that both types of moraic correspondence constraints are necessary. *ONSET* is a well-known markedness constraint and *IAMB* requires a right-headed foot formation. *BIMORA* displays a universal tendency preventing trimoraic syllables and *CODA-μ* requires moraic coda consonants through mora licensing. By the dominance of *BIMORA* over *CODA-μ*, coda consonants in CVVC syllables which are limited to the stem-final position in Korean do not get weight. *PARSE-σ* is a major constraint in this analysis which forces the complete parsing of syllables into feet and *ALIGN-R* is a constraint of the general alignment constraint family which requires aligned edges between a morphological category and a prosodic constraint.

As previously illustrated, vowel shortening in Korean can be triggered on by vowel-initial suffixes but not by consonant-initial suffixes. Such a general characteristic of Korean vowel shortening, especially trochaic shortening can be accounted for by the ranking relation among *ONSET*, *PARSE-σ*, and *MAX-μ*. As the following tableaux (20) and (21) show, the different activity between vowel-initial suffixes and consonant-initial suffixes in vowel shortening is the natural result of the dominance of the constraint *ONSET*.

(20) /ta:m-a/ → [tama]   'put in'

/ta:m-a/	ONSET	IAMB	ALIGN-R[18]	PARSE-σ	MAX-μ
a. (ta:)ma			*	*!	
b. (ta:ma)		*!	*		
☞ c. (tama)			*		*
d. (tam)a	*!			*	*

In the case of suffixation of vowel-initial suffixes in (20), the winning candidate (c) provides no prosodically trapped syllables by shortening, satisfying *PARSE-σ*, while candidate (a) which retains underlying vowel length violates *PARSE-σ* with a prosodically trapped syllable. This shows *PARSE-σ* must dominate moraic faithfulness constraint *MAX-μ*. Candidate (d) which only satisfies alignment between the stem edge and the foot edge is eliminated by violating the dominant constraint *ONSET*. Another faithful candidate (b) with an uneven trochaic foot fatally violates *IAMB*.

As discussed above, the situation for the suffixation of consonant-initial suffixes is quite different, as in (21). Since the suffix-initial consonant already has occupied the onset position, the stem-final consonant is forced to be parsed into the coda position.

(21) /ta:m-ko/ → [ta:mko]   'put in'[19]

/ta:m-ko/	IAMB	ALIGN	PARSE-σ	BIMORA	MAX-μ	CODA-μ
☞a. (ta:<m>)ko			*			*
b. (ta:m)ko			*	*!		
c. (tam)ko			*		*!	
d. (tamko)	*!	*				

18) The Alignment constraint which has been proposed as a basic prosody-sensitive constraint in many languages does not play a visible role in Korean vowel shortening with its relatively lower ranking in the constraint ranking system.

19) Logically, a candidate like *(ta:)<m>ko* may also be possible. In the present analysis, however, the precise metrical difference between *(ta:<m>)ko* and *(ta:)<m>ko* will not be provided.

With the affixation of consonant-initial suffixes, *ONSET* plays no visible role here. Candidate (b) violates *BIMORA* with an overweighed syllable. Candidate (d) with neither a prosodically trapped syllable nor an extrasyllabified loose syllable violates *IAMB* and thus, is eliminated, having the ill-fomred iamb (H L). The evaluation between candidates (a) and (c), both with a prosodically trapped syllable violating *PARSE-σ*, depends on the satisfaction fo the faithfulness constraint *MAX-μ*. This explains why there is no shortening in the suffixation of consonant-initial suffixes. Candidate (a) with an extrasyllabified stem-final consonant is a winning one here.

The evaluation of the winning candidate (a) with the constraint *ALIGN-R* is a little subtle and needs some clarification. What causes complexity here is the fact that candidate (a) has an extrasyllabified stem-final consonant. As previously discussed, an extrasyllabified consonant is outside the domain of a syllable, which is not dominated by the syllable node. In the light of alignment, what is important is that the extrasyllabified consonant is weakly-layered to a higher constituent(Itô and Mester 1992, McCarthy and Prince 1993 etc.), that is, directly adjoined to the foot node. With the structure of (22), it does not violate *ALIGN-R*, regarding the alignment of the right edge of the stem with the right edge of the foot.

(22) $[\{(\text{ta: . <m>})_{F}\}_{Stem}\ \text{ko}]_{PrWd}$

5. Conclusion

The phonological motivation of Korean vowel shortening is elucidated in this study. The analysis not only provides a systematic account of vowel shortening in Korean but it also sheds new light on the typology of quantitative adjustments.

Korean vowel shortening, operating at the level of the foot, is a typical case of trochaic shortening motivated by the complete parsing of syllables into feet. As an anti-trapping effect, trochaic shortening saves a prosodically trapped light syllable in an uneven trochaic context like [H L]. The mechanism of extrasyllabification is closely related to and thus, plays a crucial role in Korean vowel shortening. Extrasyllabification of the final consonant is generally preferred over vowel shortening. When it would yield an unsyllabified consonant, extrasyllabification is replaced by vowel shortening.

The major theoretical finding of this study is the active operation of trochaic shortening in an iambic system, Korean. This provides a new perspective in the typology of vowel shortening processes, either trochaic or iambic, have been generally described as a typical characteristic of trochaic languages, mainly stemming from the Iambic/Trochaic Law in Hayes(1985). Only lengthening processes such as iambic lengthening have been proposed as significant means of quantitative adjustment in iambic languages. As a foot-based process, however, trochaic shortening is metrically well-motivated in the iambic system of Korean.

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Received on March 31, 2013
Revised version received on May 9, 2013
Accepted on May 31, 2013