The metrical dependency of tone placement
in Optimality Theory[*]

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Kim, Sun-Hoi. 2002. The metrical dependency of tone placement in Optimality Theory. *Studies in Phonetics, Phonology and Morphology* 8.1. 17-38. In this paper, I examine the metrical dependency of tone placement in OT. In Creek and Shingazidja, the determination of tone placement heavily draws on the special relationship between high tone and the metrically prominent position in the prosodic domain. In Shingazidja the metrically prominent position in the *metrical phrase* is tonally marked by high tone whereas the metrically prominent position in the *prosodic word* is tonally marked by high tone in Creek. In determining the metrically prominent position, the prosody of intonational phrase is metrically computed in Shingazidja whereas the prosody of prosodic word is metrically computed in Creek. In the metrical phrase in Shingazidja, the metrically prominent position is occupied by the rightmost vowel of the leftmost foot whereas the metrically prominent position is occupied by the rightmost vowel of the rightmost foot in the prosodic word in Creek. The ranking relationship of conflicting constraints formalizes the factors affecting the placement of high tone and the construction of metrical structure, and the parametric difference in the ranking relationship differentiates Shingazidja tonology from Creek tonology. **(Hyupsung University)**

1. Introduction

There are a significant number of tone languages where the determination of tone placement heavily draws on the special relationship between a marked tone and the metrically prominent position in the prosodic domain (Goldsmith 1987, Sietsema 1989, Bickmore 1995, Idsardi and Kim 1997 and many others). These languages are largely divided into two types: languages where no segments are specified with a tonal feature in the input and languages where specific segments called *sponsors* are specified with a tonal feature in the input.

In this paper, I attempt to analyze and compare the tone patterns of both types of languages in Optimality Theory (OT) (Prince and Smolensky 1993 and McCarthy and Prince 1993): Creek for the former type of languages and Shingazidja for the latter type of languages.

In OT, the ranking relationship between two conflicting constraints Head/H and Head/L, as defined below, captures the nature of special

relationship between a marked tone and the metrically prominent position: the ranking Head/H » Head/L produces a high-toned head vowel whereas Head/L » Head/H produces a low-toned head vowel.[1]

(1) a. Head/H: A head vowel is high-toned.
     b. Head/L: A head vowel is low-toned.

In addition to the special relationship between a marked tone and the metrically prominent position in the prosodic domain, the key to understanding the metrical dependency of tone placement is to capture the nature of metrical structure in the languages in question. For doing this, it is significant to examine the following factors that affect the construction of metrical structure.

- Effect of specific segments or syllables on footing
- Parsing of prosodic elements into their higher prosodic units
- Type of metrical grouping of syllables (moras) and feet
- Edge-preference of metrical grouping
- Location of head

In the following sections, I describe the tone patterns in Creek and Shingazidja and investigate how the metrical factors affect the construction of metrical structure in these two languages.

In Section 2, it is shown that in constructing metrical structure and assigning high tone to the metrically prominent position in Creek, the significant maximal unit is the prosodic word. It is also shown that in Shingazidja the significant maximal unit in constructing metrical structure is the intonational phrase but the significant maximal unit in assigning high tone to the metrically prominent position is the domain called "metrical phrase", which is located higher than the prosodic word and lower than the intonational phrase in the prosodic hierarchy.

In Section 3, it is shown that the following effects characterize the metrical dependency of tone placement in Creek and Shingazidja and these effects are formalized in terms of the ranking relationship of constraints within the OT framework.

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[1] As shown below, high tone is placed on the metrically prominent position of the prosodic word in Creek and on the metrically prominent position of the phonological phrase called *Metrical Phrase* in Shingazidja by the ranking Head/H » Head/L. The theoretical implication of this ranking is that there may also be languages where the opposite ranking Head/L » Head/H forces low tone to fall on the metrically prominent position of a particular prosodic domain. According to S. Kim (1999), Narada Japanese has the same metrical-tonal system as Tokyo Japanese, with exception that the ranking between Head/H and Head/L is opposite to that of Tokyo Japanese; Head/H » Head/L in Tokyo Japanese, but Head/L » Head/H in Narada Japanese. In other words, low tone in Narada Japanese is placed as a marked tone on the metrically prominent position where high tone is placed in Tokyo Japanese.

- In Creek, footing is sensitive to the weight of heavy syllables. / In Shingazidja, footing is sensitive to the *sponsoring* property of specific segments.
- In Creek, foot-binarity is preferred to the parsing of syllables or moras into feet if they conflict with each other. / In Shingazidja, the left-edge alignment of a foot and a sponsor is preferred to the parsing of syllables or moras into feet if they conflict with each other.
- In Creek, moras or syllables are grouped within a foot in the binary way. / In Shingazidja, moras or syllables are grouped within a foot in the unbounded way.
- In Creek, feet are grouped within a prosodic word in the unbounded way. / In Shingazidja, feet are grouped within a metrical phrase in the binary way.
- In Creek, the left-edge of a prosodic word in footing is preferred to its right-edge. / In Shingazidja, the right-edge of an intonational phrase in grouping feet is preferred to its left-edge.
- In Creek, the rightmost foot in the prosodic word is a head. / In Shingazidja, the leftmost foot in the metrical phrase is a head.
- In Creek, the rightmost vowel of the head foot in a prosodic word occupies the metrically prominent position of the prosodic word. / In Shingazidja, the rightmost vowel of the head foot in a metrical phrase occupies the metrically prominent position of the metrical phrase.
- In Creek, the metrically prominent position of the prosodic word is tonally marked by high tone. / In Shingazidja, the metrically prominent position of the metrical phrase is tonally marked by high tone.

Conclusions are presented in Section 4.

2. Tone Patterns in Creek and Shingazidja

The Creek data are taken from McCarthy (1979), Halle and Vergnaud (1987), Hayes (1995) and Purnell (1997) and the Shingazidja data are from Cassimjee and Kisseberth (1997), Idsardi and Purnell (1997) and Purnell (1997).

2.1. Tonal Prosody in Creek

In Creek only one high tone occurs within a prosodic word. In the words that have all light syllables (CV), high tone falls on the final syllable if the total number of syllables in a word is even, as in (2a). However, it falls on the penultimate syllable if the total number is odd, as in (2b). Here, accent marks stand for high tones.

(2) a. cokó   'house'
        ifá   'dog'
        pom-osaná   'our otter'
        apataká   'pancake'
        isimahicitá   'one to sight at one'
        am-anokicitá   'to love mine'
     b. am-ífa   'my dog'
        osána   'otter'
        am-apatáka   'my pancake'
        itiwanayipíta   'to tie each other'
        amanokic-ak-íta   'to love mine (pl. subj.)'

As pointed out in Halle and Vergnaud (1987), Hayes (1995) and Purnell (1997), this alternation shows that high tone is placed on the rightmost syllable in the final foot and low tone is placed on others under the assumption that binary feet are formed counting from the initial syllable, as illustrated in (3).[2]

(3) a. (cokó)   'house'
         (ifá)   'dog'
         (pom-o)(saná)   'our otter'
         (apa)(taká)   'pancake'
         (isi)(mahi)(citá)   'one to sight at one'
         (am-a)(noki)(citá)   'to love mine'
     b. (am-í)fa   'my dog'
         (osá)na   'otter'
         (am-a)(patá)ka   'my pancake'
         (iti)(wana)(yipí)ta 'to tie each other'
         (ama)(noki)(c-ak-í)ta 'to love mine (pl. subj.)'

The theoretical implication of these foot structures is that the rightmost foot in the prosodic word is a head and the rightmost vowel in the head foot occupies the metrically prominent position in the prosodic word.

While the *syllable-counting* binary feet successfully predict the tone placement in the words of all light syllables, they cannot predict the tone placement in the words that contain one or more heavy syllables (CVV, CVC), as shown in (4).

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[2] One might argue that instead of full metrical structure, only the partial grouping of high-toned syllable and its adjacent syllable is present in Creek. However, the following statement in Hayes (1995:67) strongly suggests that the full metrical structure is present in Creek: "Typically, high tone is placed on the metrically strongest syllable, and other tones may appear as well, as part of a verbal grade system. ... these additional tones sometimes dock onto the strongest syllables of feet other than the rightmost one in the word. This suggests that full metrical structure is indeed in Seminole/Creek surface representation, although its phonetic manifestation is often incomplete."

(4)   *Actual Forms*   *Predicted Forms*
   a. fó: *fo: 'bee'
      nihá: (nihá:)   'lard'
      hoktí: (hoktí:)   'woman'
      haɬi:ssí: *(haɬí:)ssi: 'moon'
      akhasí: *(akhá)si: 'lake'
      ti:ni:tkí: *(ti:ní:t)ki: 'thunder'
      ta:skitá   *(ta:skí)ta   'to jump (sg. subj.)'
      atilo:yitá   *(ati)(lo:yí)ta   'to gather (pl. obj.)'
      nafkitika:yitá   (nafki)(tika:)(yitá)   'to hit (pl. obj.)'
      iNkosapitá   *(iNko)(sapí)ta   'one to implore'
   b. ícki   *(ickí)   'mother'
      kofócka   (kofóc) ka   'mint'
      akcáwhka   (akcáwh)ka   'stork'
      ta:shokíta   *(ta:sho)(kitá)   'to jump (dual subj.)'
      tokoɬhokíta   (tokoɬ)(hokí)ta   'to run (dual subj.)'

In the words of (4a), where the total number of syllables following the rightmost heavy syllable is even, high tone falls on the final syllable. However, it falls on the penultimate syllable when the total number is odd, as shown in the words of (4b). In the high tone placement in (4), therefore, it matters whether the number of light syllables following the rightmost heavy syllable is even or odd.

   On the view that high tone in Creek is placed on the rightmost syllable of the rightmost foot in the prosodic word, binary feet should be formed counting from the syllable immediately following the rightmost heavy syllable in the words containing one or more heavy syllables. In constructing these binary feet, therefore, it is important to end a foot with the rightmost heavy syllable, as illustrated in (5).

(5) a. fó: #(fó:)#   'bee'
      nihá: #…há:)#   'lard'
      hoktí: #…tí:)#   'woman'
      haɬi:ssí: #…sí:)#   'moon'
      akhasí: #…sí:)#   'lake'
      ti:ni:tkí: #…kí:)#   'thunder'
      ta:skitá   #…ta:s)(kitá)#   'to jump (sg. subj.)'
      atilo:yitá   #…lo:)(yitá)#   'to gather (pl. obj.)'
      nafkitika:yitá   #…ka:)(yitá)#   'to hit (pl. obj.)'
      iNkosapitá   #(iN)(kosa)(pitá)#   'one to implore'
   b. ícki   #(íc)ki#   'mother'
      kofócka   #…fóc)ka#   'mint'
      akcáwhka   #…cáwh)ka#   'stork'
      ta:shokíta   #(ta:)(shokí)ta#   'to jump (dual subj.)'
      tokoɬhokíta   #…koɬ)(hokí)ta#   'to run (dual subj.)'

To summarize the Creek tonal prosody, high tone is placed on the rightmost vowel of the rightmost foot among the feet built in the prosodic word in the following way: (a) in the words of light syllables, binary feet are formed counting from the initial syllable and (b) in the words containing one or more heavy syllables, binary feet are formed counting from the syllable immediately following the rightmost heavy syllable, the right edge of which is aligned with the right edge of a foot. In Section 3, we will discuss how this metrically guided tone placement is formalized within the OT framework.

2.2. Tonal Prosody in Shingazidja

Unlike in the Creek examples in 2.1, in a large class of Shingazidja words, one or more segments are specified with a tonal feature. As stated in Section 1, these segments are called *sponsors*.[3] In Shingazidja, high tone is not always placed on its sponsor but sometimes move rightward across a word within an intonational phrase. Further, in the intonational phrase, the number of sponsors does not always coincide with the number of high-toned moras. According to Cassimjee and Kisseberth (1997), Idsardi and Purnell (1997) and Purnell (1997), high tone in Shingazidja is placed on the mora in front of every *even-numbered* sponsor in the intonational phrase, as illustrated in (6), where I will underline the vowels that can be regarded as sponsors and give accent marks to the vowels that are assigned actual high tone.[4]

(6) a. tsihulu̱ mágari mai̱ndji̱   'I bought many cars'
        I bought cars   many
        bángi̱li zíndji̱   'many bracelets'
        bracelets many
     b. ri̱húlu̱ magari mái̱ndjí   'we bought many cars'
        we bought cars many
        tsihulú̱ bangilí zi̱ndjí   'I bought many bracelets'
        I bought bracelets many

   In Shingazidja tonology, it is also noted that high tone is placed on the last odd-numbered sponsor when the total number of sponsors in the intonational phrase is odd, as illustrated in (6b) and (7).

(7) gári   'car'
     ri̱húlu̱ gári   'we bought a car'
     we bought car
     le kuvéti̱ la háhe   'his basin'
     basin   his

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[3] Sponsors are not predictable from the segmental or syllabic composition of lexical item. Therefore, the location of sponsors must be memorized for each lexical item.
[4] In Shingazidja, the coda consonant is not counted as a mora.

Now let us examine the tone patterns occurring when a single word is uttered in isolation. There are some words where high tone is placed on the final mora in isolation. I regard this high tone as a direct surface indication that the final vowels of these words are sponsors of high tone, as illustrated in (8).

(8) mezá   'table'   masohá   'axes'
     udjongá   'horn'   mailí   'two'
     nyumbá   'house'   maí   'bad'
     mbilí   'two'   zitsawazí   'wooden plates'
     djuú   'on'   tsihulú   'I bought'

In many other words, high tone is placed on the penultimate mora in isolation, as shown in (9), where I also consider these words to have a penultimate sponsor.

(9) nawíli   'fare'   mabúku   'books'
     rahísi   'cheap'   sufuríya   'pan(s)'
     magóra   'hats'   maráru   'three'
     ndráru   'three'   mádji   'water'
     mfúpvi   'short'   mádu   'black'

The key point of tonal prosody in Shingazidja is that while high tone is placed on the sponsors in the words of (8) and (9) in isolation, it is placed on the mora in front of the second sponsor when two sponsors appear in the input, as illustrated in (10).

(10) a. **final + final**
        meza djúu 'on a table'   mezá 'table'   djuú 'on'
        masoha maíli 'two axes'   masohá 'axes'   mailí 'two'
        tsihulu nyúmba   tsihulú 'I bought'   nyumbá 'house'
        'I bought a house'
     b. **penult + final**
        magora maíli 'two hats'   magóra 'hats'   mailí 'two'
        mabuku mái 'bad books'   mabúku 'books'   maí 'bad'
        sufuriya mbíli 'two pans'   sufuríya 'pan(s)'   mbilí 'two'
     c. **penult + penult**
        magora máraru 'three hats'   magóra 'hats'   maráru 'three'
        madjí madu 'black water'   mádji 'water'   mádu 'black'
        nawili ráhisi 'cheap fare'   nawíli 'fare'   rahísi 'cheap'
     d. **final + penult**
        masera máraru 'three ghosts' maserá   'ghosts'   maráru 'three'
        udjongá mfupvi 'short horn'   udjongá 'horn'   mfúpvi 'short'
        mezá ndraru 'three tables'   mezá 'table'   ndráru 'three'

When another sponsor follows the first sponsor immediately, high tone is placed on the first sponsor (*udjongá mfu̱pvi* "short horn' and *mezá ndra̱ru* 'three tables'). If there are one or more moras between two sponsors, then high tone is not placed on either of the two sponsors but on the mora in front of the second sponsor. This high tone placement comes from the generalization that high tone in Shingazidja is placed on the mora in front of every *even-numbered* sponsor. The general theory of prosodic domination tells us that when the segmental string of a prosodic word is uttered in isolation, it independently forms larger units: Prosodic Word → Phonological Phrase → Intonational Phrase. In this view, we see that if the significant maximal unit, where the generalization under discussion applies, is the intonational phrase in Shingazidja, the generalization can be extended to the high tone placement in (8), (9) and (10).

This pattern of tonal prosody provides us with crucial evidence to support the fact that in Shingazidja there are also words where two sponsors appear. In Shingazidja, there are apparently strange words that have high tone on the penultimate mora in isolation but exhibit the unusual tonal behavior, as illustrated in (11).

(11) kuvéti dju̱ú 'on the basin'   kuvéti 'basin'   dju̱ú 'on'
    mhógo mtí̱ti 'small cassava' mhógo 'cassava' mtí̱ti 'small'
    zipúlu zizá̱ru   zipúlu 'nose rings'   zizá̱ru 'three'
    'three nose rings'

If *kuvéti* 'basin,' *mhógo* 'cassava' and *zipúlu* 'nose rings' in (11) have a sponsor only in the penultimate position, then we fail to explain the generalization that high tone is placed on the mora in front of the second sponsor when two sponsors appear in the input. The way to maintain this generalization is to assume that these words have two sponsors, as illustrated in (12).

(12) kuvé̱ti dju̱ú 'on the basin'   kuvé̱ti 'basin'   dju̱ú 'on'
    mhó̱go mtí̱ti 'small cassava'   mhó̱go 'cassava'   mtí̱ti 'small'
    zipú̱lu̱ zizá̱ru   zipú̱lu 'nose rings'   zizá̱ru 'three'
    'three nose rings'

It is also noted that the second high tone is placed on the third sponsor in the phrases in (12). This second high tone is a direct indication that high tone is placed on the last odd-numbered sponsor when the total number of sponsors in the intonational phrase is odd.

There is another evidence to support the fact that two sponsors occur in some words that have a penultimate high tone in isolation. Let us examine the following verbal examples.

(13) tsi-lindí 'I waited' ¦ ri-líndi 'we waited'
       tsi-hulú 'I bought' ¦ ri-húlu 'we bought'
       tsi-lipví 'I paid'   ¦ ri-lípvi

If the prefix *ri-* 'we' has a sponsor, then we easily explain why high tone is placed on the mora in front of the sponsor within the stem in the *ri*-prefixed words whereas it falls on the sponsor within the stem in the *tsi*-prefixed words.

When some words have an antepenultimate high tone in isolation, their tonal behavior illustrates that they have two sponsors, as shown in (14).

(14) a. tsi-lála 'I slept'   rí-lala 'we slept'
        tsi-sambúwa 'I cleaned'   ri-sámbuwa   'we cleaned'
        tsi-píha 'I cooked'   rí-piha 'we cooked'
     b. bángili 'bracelets'   bángili mbilí 'two bracelets'
                                    (*mbilí* 'two')
        mafúkare 'seven'   masoha máfukáre 'seven axes'
                                    (*masohá* 'axes')

The data so far presented show that in the intonational phrase of Shingazidja, (a) high tone is placed on the mora in front of every *even-numbered* sponsor and (b) high tone is placed on the last odd-numbered sponsor when the total number of sponsors is odd.

Now let us examine how this generalization is explained by the metrical-tonal interaction. As illustrated below, in the intonational phrase, each foot begins with a sponsor and, except for the final foot, ends with the mora in front of the next sponsor.

(15) a. tsihu(lu má)(gari ma)(ín)(dji)   'I bought many cars'
        b(án)(gili) (zín)(dji)   'many bracelets'
     b. (gá)ri   'car'
        (rihú)(lu) (gá)ri   'we bought a car'
        le ku(vé)(ti) la (há)he   'his basin'
     c. (rihú)(lu ma)(gari má)(in)(djí)   'we bought many cars'
        tsihu(lú) (ban)(gilí) (zin)(djí) 'I bought many bracelets'

The final foot always begins with the final sponsor. However, while it ends with the penultimate mora when the final sponsor is not final as in (15b), it ends with the final mora when the final sponsor is final as in (15c). In all the phrases in (15), high tone is placed on the rightmost vowel of every odd-numbered foot. More examples are presented in (16).

(16) a. single word in isolation
         me(zá)   'table'   maso(há)   'axes'
         naw(í)li   'fare'   ma(bú)ku   'books'
         ku(vé)(ti) 'basin'   (ri-sám)(bu)wa 'we cleaned'

b. two-word combination in isolation

me(z<u>a</u> djú)(<u>u</u>)	'on a table'
ma(g<u>o</u>ra maí)(l<u>i</u>)	'two hats'
(m<u>a</u>djí) (m<u>a</u>)du	'black water'
mase(r<u>a</u> má)(r<u>a</u>)ru	'three ghosts'
zi(p<u>ú</u>)(l<u>u</u> zi)(z<u>á</u>)ru	'three nose rings'
(b<u>á</u>n)(g<u>i</u>li mbi)(l<u>í</u>)	'two bracelets'

This relationship between high tone placement and foot structure shows that while the prosody of intonational phrase is metrically computed, the significant maximal unit in assigning a single high tone to the metrically prominent position is the prosodic domain containing one or two feet, which is located lower than the intonational phrase in the prosodic hierarchy.[5] We will call this prosodic domain *Metrical Phrase* (MPh).

To summarize the Shingazidja tonal prosody, high tone is placed on the rightmost mora of every odd-numbered foot among the feet built in the intonational phrase in the following way: (a) each foot begins with a sponsor and, except for the final foot, ends with the mora in front of the next sponsor and (b) while the final foot always begins with the final sponsor, it ends with the penultimate mora when the final sponsor is not final but it ends with the final mora when the final sponsor is final.

3. The Metrical Dependency of Tone Placement: An Optimality Account

In the following OT analysis, the ranking relationship of conflicting constraints formalizes the factors affecting the placement of high tone and the construction of metrical structure, and the parametric difference in the ranking relationship differentiates Shingazidja tonology from Creek tonology.

3.1. Weight Sensitivity and Sponsoring Effect in the Foot Formation

As mentioned in Section 1, the tonal markedness of the metrically prominent position in the prosodic domain is formalized in terms of the ranking relationship between Head/H and Head/L. The ranking Head (PWd)/H » Head(PWd)/L produces the high-toned head in the prosodic word in Creek and the ranking Head(MPh)/H » Head(MPh)/L produces the high-toned head in the metrical phrase in Shingazidja, as shown in (17), where it is assumed that the rightmost vowel of a foot is the head of the foot.[6]

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[5] This domain should be located higher than the prosodic word in the prosodic hierarchy since there are feet that are formed across a prosodic word in Shingazidja.

[6] As illustrated below, in the prosodic word in Creek and in the metrical phrase in Shingazidja, the metrically prominent position is occupied by the rightmost vowel of the head foot.

(17) cokó 'house'(Creek) gári 'car' (Shingazidja)
     Head(PWd)/H » Head(PWd)/L (Creek)
     Head(MPh)/H » Head(MPh)/L (Shingazidja)

Input: coko	Head(PWd)/H	Head(PWd)/L
a. (cokó)		*
b. (cóko)	*!	

Input: gari	Head(MPh)/H	Head(MPh)/L
a. (gári)		*
b. (ga)rí	*!	

Since the determination of the metrically prominent position in the prosodic word in Creek is influenced by the presence of heavy syllables, we should formalize the weight effect of heavy syllables on the foot formation. In doing this, it should be noted that high tone is not always placed on heavy syllables in Creek. Its theoretical implication is that heavy syllables in Creek do not directly attract high tone but just affect the foot formation. In accounting for the weight effect of heavy syllables in Creek in OT, therefore, it is not proper to employ Weight-to-Tone Principle (WTP) that forces heavy syllables directly to attract high tone.[7] Instead, when FT-BIN and *tri-μ-FT are ranked above PARSE-σ, the actual forms in Creek are correctly produced, as illustrated in (18), where FT-BIN forces a foot to have two syllables or moras and *tri-μ-FT bans a trimoraic foot.

(18) ícki 'mother' cokó 'house' osána 'otter'
     FT-BIN, *tri-μ-FT » PARSE-σ

Input: icki, coko, osana	FT-BIN	*tri-μ-FT	PARSE-σ
a. (íc)ki			*
b. (ickí)		*!	
a. (cokó)			
b. (có)ko	*!		*
a. (osá)na			*
b. (osaná)	*!	*	
c. (osá)(ná)	*!		

The second example (cokó) 'house' in (18) shows that NONFINALITY is ranked below FT-BIN.

While FT-BIN does not conflict with PARSE-σ in the words of light syllables where the total number of syllables is even, they conflict with

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[7] In S. Kim (2001), it is shown that in English it is not proper to employ Weight-to-Stress Principle (WSP) in explaining stressed heavy syllables (see S. Kim (2001) for more details).

each other in the words of light syllables where the total number is odd. The *penultimate* high tone is due to the *unparsed* effect of final syllable, as shown in (19), where square brackets indicate the boundaries of the head foot.

(19) [am-í]fa   'my dog'
    [osá]na   'otter'
    (am-a)[patá]ka   'my pancake'
    (iti)(wana)[yipí]ta   'to tie each other'
    (ama)(noki)[c-ak-í]ta   'to love mine (pl. subj.)'

In Creek, the driving force of unparsed final syllable is FT-BIN and *tri-σ-FT. In other words, in order to satisfy FT-BIN and *tri-σ-FT a syllable is not parsed in the words of light syllables where the total number of syllables is odd. The rightmost unparsed syllable in Creek is due to the fact that the left-edge of a prosodic word in footing is preferred to its right-edge in Creek. This edge-preference is formalized in terms of the ranking relationship between the following two constraints (ALL-FT-LEFT » ALL-FT-RIGHT).[8]

(20) a. ALL-FT-LEFT
      Every foot stands at the left edge of the prosodic word.
    b. ALL-FT-RIGHT
      Every foot stands at the right edge of the prosodic word.

Further, since all the syllables should be parsed into feet unless FT-BIN and *tri-σ-FT are violated, PARSE-σ is ranked above ALL-FT-LEFT, as illustrated in (21).

(21) osána 'otter'   apataká 'pancake'   am-apatáka 'my pancake'
    PARSE-σ » ALL-FT-LEFT » ALL-FT-RIGHT

Input: osana, apataka, am-apataka	PARSE-σ	ALL-FT-LEFT	ALL-FT-RIGHT
a. [osá]na	*		*
b. o[saná]	*	*!	
a. (apa)[taká]		**	**
b. [apá]taka	*!*		**
a. (ama)[patá]ka	*	**	*, ***
b. [amá]pataka	**!*		***
c. (ama)pa[taká]	*	***!	***

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[8]   In Shingazidja, as shown below, the right-edge of an intonational phrase is preferred to its left-edge in determining the location of every metrical phrase where feet are parsed.

The application of this constraint-ranking is extended to the words containing one or more heavy syllables in Creek, as shown in (22).

(22) akcáwhka 'to jump (dual subj.)' tokołhokíta 'to run (dual subj.)'

Input: akcawhka Tokołhokita	PARSE-σ	ALL-FT-LEFT	ALL-FT-RIGHT
a. (ak)[cáwh]ka	*	*	*, **
b. (ák)cawhká	**!		**
a. to(koł)[hokí]ta	**	*, **	*, ***
b. to[kół]hokita	***!*	*	***
c. to(koł)ho[kitá]	**	*, ***!	***

We have so far examined the OT formalism of several factors affecting the placement of high tone and the construction of metrical structure in Creek, except for the following two issues: (a) the production of head foot in the prosodic word and (b) the choice of head syllable in the head foot.

Leaving these issues for the discussion in 3.2, let us examine the factors affecting the placement of high tone and the construction of metrical structure in Shingazidja.

While the foot formation is influenced by the weight effect of heavy syllables in Creek, it is not in Shingazidja. Instead, the key to understanding the foot formation in Shingazidja comes from formalizing the *sponsoring* effect of specific segments in terms of the ranking relationship between the following two constraints.

(23) a. Align-L(Ft, Sponsor)
   The left edge of a foot and the left edge of a sponsor mora are aligned with each other.
   b. Align-R(Ft, Sponsor)
   The right edge of a foot and the right edge of a sponsor mora are aligned with each other.

In Shingazidja, Align-L(Ft, Sponsor) is undominated. Syllables are parsed into feet unless the parsing of syllables causes the violation of Align-L(Ft, Sponsor). Without any discussion, for the time being, let us just assume that the head foot in the intonational phrase in Shingazidja is every odd-numbered one and the head vowel in the head foot is its rightmost one.

The relationship between syllable parsing and foot formation is formalized by the ranking Align-L(Ft, Sponsor) » PARSE-σ » Align-R(Ft, Sponsor), as shown in (24).

(24) **final + final**: tsihul<u>u</u> nyúmb<u>a</u> 'I bought a house'
   Align-L(Ft, Sponsor) » PARSE-σ » Align-R(Ft, Sponsor)

Input: tsihulu̱ nyumba̱	Align-L (Ft, Spon.)	PARSE-σ	Align-R (Ft, Spon.)
a. tsihu[lu̱ nyúm](ba̱)		**	*
b. tsihu[lú] nyum(ba̱)		***!	
c. [tsihulú] nyum(ba̱)	*!	*	

Now let us examine the ranking relationship between FT-BIN and PARSE-σ in Shingazidja. While FT-BIN is ranked above PARSE-σ in Creek, the following examples show that the opposite ranking PARSE-σ » FT-BIN produces the well-formed foot structure in Shingazidja.

(25) **penult + final**: sufuṟiya mbíli̱ 'two pans'
     penult + penult: naw̱ili ráhi̱si 'cheap fare'
     PARSE-σ » FT-BIN

Input: sufuṟiya mbili̱ naw̱ili rahi̱si	PARSE-σ	FT-BIN
a. sufu[ṟiya mbí](li̱)	**	**
b. sufu[ṟiyá] mbi(li̱)	***!	*
a. na[w̱ili rá](hi̱)si	**	**
b. na[w̱ilí] ra(hi̱)si	***!	*

The tableau in (25) illustrates that the violation of FT-BIN is allowed to maximally satisfy PARSE-σ.

One can argue that the foot structure in *naw̱ili ráhi̱si* 'cheap fare' in (25) should be *na(w̱ili rá)(hi̱si)*, one that violates PARSE-σ less significantly than *na(w̱ili rá)(hi̱)si*, one that is chosen as an optimal form. However, the following discussion tells us that this is not the case.

In the high tone placement of the phrases where the total number of feet is even, such as in the examples in (25), it does not matter whether the last foot ends with the penultimate mora or ends with the final mora since only the odd-numbered feet have high tone in Shingazidja. As shown in the following examples, however, in the phrases where the total number of feet is odd, the shape of the last foot crucially affects the high tone placement.[9]

(26) me(zá)   'table'
     na(wí)li   'fare'   *na(w̱ilí)
     b(án)(gi̱li mbi)(lí)   'two bracelets'
     zi(pú)(lu̱ zi)(zá)ru   'three nose rings' *zi(pú)(lu̱ zi)(za̱rú)
     (ri̱hú)(lu̱ ma)(ga̱ri má)(i̱n)(dji̱)   'we bought many cars'

In the phrases in (26), if the final mora is a sponsor, then the last foot ends

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9   In the examples in (25) and (26), the inviolability of Align-L(Ft, Sponsor) forces the total number of sponsors to coincide with the total number of feet.

with the final mora. Otherwise, it ends with the penultimate mora. The theoretical implication of the examples in (26) is that there is another crucial constraint that is ranked below Align-L(Ft, Sponsor) but above PARSE-σ and FT-BIN. That is NONFINALITY. The ranking NONFINALITY » PARSE-σ » FT-BIN produces the foot structure where the last foot ends with the penultimate mora in *nawíli* 'fare' and *zipúlu zizáru* 'three nose rings,' as illustrated in (27).

(27) nawíli 'fare' zipúlu zizáru 'three nose rings'
    NONFINALITY » PARSE-σ » FT-BIN

Input: nawili zipulu zizaru		NONFIN	PARSE-σ	FT-BIN
a.	na[wí]li		**	*
b.	na[wilí]	*!	*	
a.	zi[pú](lu zi)[zá]ru		**	**
b.	zi[pú](lu zi)[zarú]	*!	*	*

The ranking Align-L(Ft, Sponsor) » NONFINALITY forces the last foot to end with the final mora when the final mora is a sponsor, as illustrated in (28).
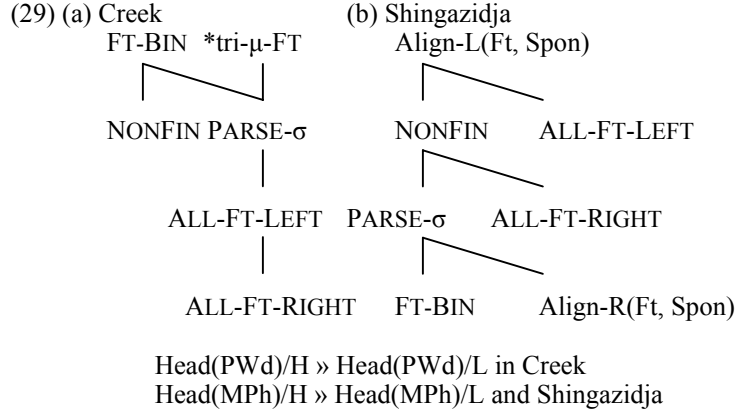
(28) bángili mbilí 'two bracelets'
    Align-L(Ft, Sponsor) » NONFINALITY

Input: bangili mbili	Align-L(Ft, Sponsor)	NONFIN
a.	[bán](gili mbi)[lí]		*
b.	[bán](gili mbi)li	*!	

Since the ranking Align-L(Ft, Sponsor) » NONFINALITY » PARSE-σ » FT-BIN also applies to the phrases where the total number of feet is even, the foot structures *sufu(riya mbí)(li)* and *na(wili rá)(hi)si* in (25) are preferred to the foot structures *sufu(riya mbí)li* and *na(wili rá)(hisi)*, respectively.

What is finally pointed out in this section is that the foot formation in Shingazidja is not influenced by the edge-preference formalized in terms of ranking relationship between ALL-FT-LEFT and ALL-FT-RIGHT. The inviolability of Align-L(Ft, Sponsor) incapacitates ALL-FT-LEFT and the ranking NONFINALITY » ALL-FT-RIGHT forces ALL-FT-RIGHT to take no effect on the foot formation in Shingazidja.

The following diagrams illustrate the partial rankings of constraints in Creek and Shingazidja presented in this section. In Section 3, we will discuss the issue of the determination of *head foot* and *head syllable* (*mora*).

(29) (a) Creek   (b) Shingazidja
         FT-BIN *tri-μ-FT   Align-L(Ft, Spon)

         NONFIN PARSE-σ   NONFIN   ALL-FT-LEFT

              ALL-FT-LEFT PARSE-σ   ALL-FT-RIGHT

                   ALL-FT-RIGHT FT-BIN   Align-R(Ft, Spon)

                   Head(PWd)/H » Head(PWd)/L in Creek
                   Head(MPh)/H » Head(MPh)/L and Shingazidja

3.2. Constraints on Prosodic Domination and Head Determination

While all the feet are parsed into prosodic words in Creek, they should be parsed into metrical phrases in Shingazidja. In Creek, all the actual forms satisfy the inviolable constraint PARSE-FT(PWd), which forces every foot to be parsed into prosodic words. Among the parsed feet in the prosodic word, the rightmost foot is chosen as a head by the ranking Rightmost(Hd-Ft) » Leftmost(Hd-Ft). These constraints are defined as follows.

(30) a. Rightmost(Hd-Ft)
        The rightmost foot in the prosodic word is a head.
     b. Leftmost(Hd-Ft)
        The leftmost foot in the prosodic word is a head.

The following example shows that this ranking correctly chooses an actual head foot as optimal in Creek.

(31) apataká 'pancake'
      Rightmost(Hd-Ft) » Leftmost(Hd-Ft)

Input: apataka	Rightmost(Hd-Ft)	Leftmost(Hd-Ft)
a. (apa)[taká]		*
b. [apá](taka)	*!	

In the word *apataká* 'pancake' in (31), where the high-toned final vowel is produced by the ranking Head(PWd)/H » Head(PWd)/L, the final vowel is assigned the *headedness* property in the prosodic word by the ranking Rightmost(Hd-σ) » Leftmost(Hd-σ). These constraints are defined as follows.

(32) a. Rightmost(Hd-σ)
     The rightmost syllable in the head foot is a head.
   b. Leftmost(Hd-σ)
     The leftmost syllable in the head foot is a head.

In the following tableau, it is shown that the ranking Rightmost(Hd-σ) »
Leftmost(Hd-σ) correctly chooses the rightmost syllable in the head foot as
the metrically prominent position in the prosodic word.

(33) apataká 'pancake'
     Rightmost(Hd-σ) » Leftmost(Hd-σ)

Input: apataka	Rightmost(Hd-σ)	Leftmost(Hd-σ)
a. (apa)[taká]		*
b. (apa)[táka]	*!	

As so far shown, in Creek the constraints on prosodic domination in (34)
below, which are proposed by Selkirk (1995), are all inviolable and thus
always satisfied with all the actual forms.

(34) Constraints on Prosodic Domination (Selkirk 1995:443)
     (where C^n = some prosodic category)
     (i) *Layerness*: No C^i dominates a C^j, j > i,,
         e.g. "No σ dominates a FT."
     (ii) *Headedness*: Any C^i must dominates a C^{i-1} (except if C^i = σ),
         e.g. "A PWd must dominate a FT."
     (iii) *Exhaustivity*: No C^i immediately dominates a constituent C^j, j < i-1,
         e.g. "No PWd immediately dominates a σ."
     (iv) *Nonrecursivity*: No C^i dominates C^j, j = i,
         e.g. "No FT dominates a FT."

On the other hand, in the following discussion of the head determination
in Shingazidja, it is shown that there are some cases where Headedness and
Exhaustivity are violated.[10]
   In Shingazidja, where the computation of prosody occurs in the
intonational phrase, a foot is formed across a prosodic word when two
sponsors are separately located within different prosodic words and the
second sponsor is not word-initial. For instance, on the view that high tone
is placed on the rightmost vowel of every odd-numbered foot in the

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[10] Selkirk (1995) mentions that the violation of Exhaustivity and Nonrecursivity is widely
observed in various languages. In Trukenbrodt (1995), the recursive phrase structure is
observed in the violation of Nonrecursivity in Kimatuumbi and in McCarthy (2001) a member
of a consonant cluster is immediately dominated by a prosodic word in the violation of
Exhaustivity in Classic Arabic. It should be noted that in Shingazidha there are some cases
where Headedness as well as Exhaustivity is violated.

intonational phrase in Shingazidja, the actual foot structure of the phrase *magora máraru* 'three hats' should be *ma(gora má)(ra)ru* even though this foot structure violates Headedness, which forces a prosodic word to dominate a foot. Therefore, this actual foot structure is produced by ranking Headedness below Align-L(Ft, Sponsor) and PARSE-σ, as illustrated in (35).

(35) magora máraru 'three hats'
     Align-L(Ft, Sponsor) » PARSE-σ » Headedness

Input: magora mararu	Align-L (Ft, Spon.)	PARSE-σ	Headed -ness
a. ma[gora má](ra)ru		**	*
b. ma[gorá] ma(ra)ru		***!	
c. ma[gorá] (mara)ru	*!	**	

Shingazidja is also different from Creek, not only in that the footing can occur across a prosodic word, but also in that a foot is immediately dominated by a phrase-level domain, called *metrical phrase* (MPh), in the violation of Exhaustivity. Recall that in Creek the footing occurs within a prosodic word and a foot is immediately dominated by a prosodic word.

In Shingazidja, the formation of metrical phrase is formalized in terms of the ranking relationship between the following three constraints.[11]

(36) a. MPh-BIN: A metrical phrase consists of two feet.
     b. PARSE-FT(MPh): Every foot is parsed into metrical phrases.
     c. *Tri-FT-MPh: Do not have a tri-feet metrical phrase.

The ranking PARSE-FT(MPh) » MPh-BIN » *Tri-FT-MPh produces the correct grouping of feet in Shingazidja, as illustrated in (37), where the boundaries of a metrical phrase are indicated by curly brackets.

(37) nawili ráhisi 'cheap fare' bángili mbilí 'two bracelets'
     PARSE-FT(MPh) » MPh-BIN » *Tri-FT-MPh

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[11] One of the reviewers of this paper points out that it is not adequate on explanatory grounds to introduce the metrical phrase into the metrical system in that it is not universally observed. While I leave the issue of "universality of metrical phrase" for further research, I would like to say that Shingazidja exhibits a very unusual case where, as shown in this paper, high tone is present only in the odd-numbered feet of the intonational phrase. An alternative solution to this tantalizing case is to eliminate or not to form all the even-numbered feet of the intonational phrase by using stipulated constraints. Rather, by establishing a phrase-level unit (metrical phrase) for the assignment of a single high tone in Shingazidja, in this paper I attempt to capture the metrical dependency in the assignment of high tone occurring beyond the level of prosodic word.

	Input: nawili rahisi bangili mbili	PARSE-FT(MPh)	MPh-BIN	*Tri-FT-MPh
a.	na{[wili rá](hi)}si			
b.	na{[wili rá]}{[hí]}si		*!*	
a.	{[bán](gili mbi)}{[li]}		*	
b.	{[bán](gili mbi)(li)}		*	*!
c.	{[bán](gili mbi)} (li)	*!		

In the first example, two feet should be grouped together within a metrical phrase, such as $\{(\ldots)_{FT}(\ldots)_{FT}\}_{MPh}$, in the satisfaction of all the constraints PARSE-FT(MPh), MPh-BIN and *Tri-FT-MPh. In the second example, the grouping of feet should be $\{(\ldots)_{FT}(\ldots)_{FT}\}_{MPh}\{(\ldots)_{FT}\}_{MPh}$ since the grouping of all the three feet within a metrical phrase in (b) violates *Tri-FT-MPh in addition to MPh-BIN and the unparsing of the final foot in (c) fatally violates PARSE-FT(MPh). In Shingazidja, Exhaustivity is ranked below PARSE-FT(MPh) and MPh-BIN to produce the metrical phrases that immediately dominate feet.

While the head foot in the metrical phrase is determined by the ranking Leftmost(Hd-Ft) » Rightmost(Hd-Ft), in which these constraints are defined in terms of the metrical phrase, the head mora in the head foot is determined by the ranking Rightmost(Hd-μ) » Leftmost(Hd-μ), as illustrated in (38).

(38) nawili ráhisi 'cheap fare'
       Leftmost(Hd-Ft) » Rightmost(Hd-Ft)
       Rightmost(Hd-μ) » Leftmost(Hd-μ)

	Input: nawili rahisi	L-(Hd-ft)	R-(Hd-μ)	R-(Hd-ft)	L-(Hd-μ)
a.	na{[wili rá](hi)}si				
b.	na{[wíli ra] (hi)}si			*!	
c.	na{(wili ra) [hí]}si	*!			

What is finally discussed in this section is on the edge-preference in the MPh-formation in Shingazidja. The ranking PARSE-FT(MPh) » MPh-BIN » *Tri-FT-MPh predicts that there is a single-foot metrical phrase in the intonational phrases where the total number of feet is odd. In these intonational phrases, the rightmost single-foot metrical phrase is due to the fact that the right-edge of an intonational phrase in the MPh-formation is preferred to its left-edge in Shingazidja. This edge-preference is formalized in terms of the ranking relationship between the following two constraints (ALL-MPh-RIGHT » ALL- MPh-LEFT).

(39) a. ALL-MPh-LEFT
         Every metrical phrase stands at the left edge of the intonational phrase.

b. ALL-MPh-RIGHT
Every metrical phrase stands at the right edge of the intonational phrase.

Since all the feet should be parsed into metrical phrases by the inviolability of PARSE-FT(MPh) in Shingazidja, ALL-MPh-RIGHT is ranked below PARSE-FT(MPh), as illustrated in (40).

(40) bángili mbilí 'two bracelets'

Input: bangili mbili	PARSE-FT(MPh)	ALL-MPh-RIGHT	ALL-MPh-LEFT
a. {[bán](gili mbi)} {[lí]}		*	**
b. {[bán]} {[gili mbí](li)}		**!	*
c. (ban){[gili mbí] (li)}	*!		*

ALL-MPh-RIGHT is also ranked below MPh-BIN to choose $\{(\ldots)_{FT}(\ldots)_{FT}\}_{MPh}\{(\ldots)_{FT}(\ldots)_{FT}\}_{MPh}$ as optimal in the four-foot phrases, such as *tsihulu mágari maindji* 'I bought many cars,' as illustrated in (41).

(41) tsihulu mágari maindji 'I bought many cars'
      MPh-BIN » ALL-MPh-RIGHT

Input: tsihulu magari maindji	MPh-BIN	ALL-MPh-RIGHT
a. tsihu{[lumá](gari ma)} {[ín](dji)}		**
b. tsihu{[lu má](gari ma)(in)} {[djí]}	*!	*

The partial rankings of constraints presented in this section are illustrated in (42), where a semicolon indicates that there is no ranking relationship among non-conflicting constraints.

(42) a. Creek
        Leftmost(Hd-Ft) » Rightmost(Hd-Ft);
        Rightmost(Hd-σ) » Leftmost(Hd-σ)
        (The constraints on prosodic domination in (34) are all inviolable.)
     b. Shingazidja
        Leftmost(Hd-Ft) » Rightmost(Hd-Ft);
        Rightmost(Hd-μ) » Leftmost(Hd-μ);
        PARSE-FT(MPh) » MPh-BIN » *Tri-FT-MPh;
        PARSE-FT(MPh) » MPh-BIN » ALL-MPh-RIGHT » ALL-MPh-LEFT
        (While Layerness and Nonrecursivity are inviolable, Headedness and Exhaustivity are violable.)

4. Conclusion

I have examined the metrical dependency of tone placement in Creek and Shingazidja in OT. In these two languages, the determination of tone placement heavily draws on the special relationship between high tone and the metrically prominent position in the prosodic word in Creek and in the metrical phrase in Shingazidja. In Shingazidja the metrically prominent position in the metrical phrase is tonally marked by high tone whereas the metrically prominent position in the prosodic word is tonally marked by high tone in Creek. In determining the metrically prominent position, while the prosody of prosodic word is metrically computed in Creek, the prosody of intonational phrase is metrically computed in Shingazidja. The ranking FT-BIN, *tri-μ-FT » PARSE-σ formalizes the weight effect of heavy syllables on the foot formation in Creek and the ranking Align-L(Ft, Sponsor) » PARSE-σ » Align-R(Ft, Sponsor) formalizes the sponsoring effect of specific segments on the foot formation in Shingazidja. In Creek, feet are grouped within a prosodic word in the unbounded way with the satisfaction of all the constraints on prosodic domination and the left-edge of a prosodic word in footing is preferred to its right-edge. On the other hand, in Shingazidja, feet are grouped within a metrical phrase in the binary way in the violation of Exhaustivity and the right-edge of an intonational phrase in the MPh-formation is preferred to its left-edge. In the metrical phrase in Shingazidja, the metrically prominent position is occupied by the rightmost vowel of its leftmost foot whereas the metrically prominent position is occupied by the rightmost vowel of the rightmost foot in the prosodic word in Creek.

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