1 Metrical Incoherence: Diachronic Sources and Synchronic Analysis

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1.1 Introduction

A perennial debate in phonological theory centers around the proper representation of stress, where there is a salient divide between theories that capture stress directly in terms of prominence relations between syllables versus those that encode prominence relations through constituents, termed "feet," consisting of a metrically prominent, or "strong," syllable and one or more non-prominent, or "weak," syllables.

In the former approach, stress is represented as a grid structure (Prince 1983; Selkirk 1984; Gordon 2002), where distinctions in degree of stress are reflected in terms of differences in the number of marks in a hierarchically arranged grid structure. For example, the representation of the English word *alligator* in a grid-based approach would be as in (1).

(1) Grid-based representation of *alligator*

Level 3 (Primary stress)	x			
Level 2 (Secondary stress)	x		x	
Level 1 (Syllable)	x	x	x	x
	ˈal	li	ˌga	tor

Syllables lacking a grid mark above the syllable tier, i.e. the second and fourth syllable in *alligator*, are unstressed, whereas a syllable associated with a single grid mark above the syllable tier, i.e. the third syllable in *alligator*, has secondary stress, and one dominated by two grid marks above the syllable tier,

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i.e. the first syllable in *alligator*, carries primary stress. A distinguishing feature of grid-based theories of stress is the lack of word-internal phonological constituents larger than the syllable.

Another approach (e.g. Liberman & Prince 1977; Hayes 1980, 1995; Halle & Vergnaud 1987; Idsardi 1992, 2009; Halle & Idsardi 1995) assumes that grid marks are embedded in feet, which in most theories consist of a single strong, i.e. stressed, syllable and a single weak, i.e. unstressed syllable. The word *ˈalliˌgator* in a foot-based approach could thus be represented as in (2) using Hayes's (1995) representations.

(2) Foot-based representation of *alligator*

Word level	(x . . .)
Foot level	(x .)(x .)
	ˈal li ˌga tor

The first two syllables are grouped into one foot and the last two into another foot. Grid marks play a crucial role in distinguishing the type of foot. Feet are trochaic in (2) since the strong syllable precedes the weak one, in contrast to iambic feet, in which the prominence relations are reversed and the strong syllable follows the weak one within a foot. The higher tier of constituency is the word level, on which the first syllable is metrically strong, i.e. carries primary stress. An important well-formedness condition on feet that (2) illustrates is the requirement that every foot has exactly one head. Configurations like the one in (3) with a two-headed foot and a stressless foot are thus precluded.

(3) Ill-formed foot structure in *alligator*

Word level	(x . . .)
Foot level	(x x)(. .)
	ˈal ˌli ga tor

Although it is traditionally assumed that metrical strength, i.e. grid marks, have a phonetic exponent in terms of stress or other prominence, this is not a prerequisite for a foot-based theory. Metrical strength can be inferred from phenomena other than stress, such as segmental alternations of the type described in this chapter for certain Uralic languages (Section 1.3.1) or the placement of other prominent acoustic events that are dependent on a binary metrical parse, e.g. tonal accent in Creek (see the section on 'Metrical Incoherence in Muskogean: Synchronic Distribution and Historical Development').

Representations like the one in (2) can be supplemented with additional tiers of prosodic constituents corresponding to different levels in the prosodic hierarchy, e.g. Phonological Phrase, Intonational Phrase (see Hayes 1989 for an overview of the English prosodic hierarchy), as in (4). Each constituent in (4) contains a single syllable dominated by a grid mark, with larger constituents bearing higher-level grid marks in keeping with the cumulative nature of prominence.

(4) Hierarchical prosodic structure of *Alligator meat tastes scrumptious*

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Intonational Phrase    (                            x)
Phonological Phrase    (x          ) (              x)
Prosodic Word          (x          ) ( x )(x )  ( x)
Foot                   (x   .)(x   .) ( x )(x )  ( x      .)
                       ˈAl li ˌga tor meat tastes ˈscrumptious
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Although the prominence relations in (4) could still be encoded even if all of the constituent brackets were removed to leave only the grid marks, most of the debate about the necessity of constituent structure has centered on the lowest layer of constituency (above the syllable), the foot. Levels above the foot find support from the existence of similarly bounded (though not always isomorphic to prosodic structure) and widely accepted morphosyntactic constituents such as the morphological word, the syntactic phrase, the clause, and the sentence.

1.2 Evidence for the Foot as a Constituent

On grounds of parsimony and learnability, a grid-only theory of prominence relations is preferable to one that also employs constituent structure. However, an increasing amount of evidence suggests that foot structure may be necessary to capture certain phenomena that are not adequately analyzed with reference only to stress. I briefly discuss two representative cases here (see González 2003, 2005, 2007; Elias Ulloa 2006; Vaysman 2009; and Hermans 2011 for additional cases).

Alutiiq dialects of Yupik (Leer 1985) have a process of fortition (see Leer 1985:84–85 for a phonetic description of fortition) affecting consonants that are foot-initial in Hayes's (1995) analysis, which assumes iambic feet in which long vowels and word-initial (but not word-medial) CVC count as heavy. A key feature of stress in Alutiiq is its ternary nature when there are consecutive light syllables word-medially between the first and last foot of a word. For example, stress (indicated here uniformly as primary stress since it is unclear which stress is most prominent) falls on the first and fourth syllables in the four syllable Chugach Alutiiq word *ˈant͡ʃiquˈkut*, "we'll go out" (Leer 1985:84).

The strengthened consonant (in bold) occurs in the onset of the pretonic syllable, which is analyzed by Hayes (1995) as the first syllable in a disyllabic foot comprising the pretonic and the tonic syllable. Under his approach, which assumes that a posttonic light syllable is skipped over in the metrical parse in languages with ternary stress intervals (a phenomenon termed “weak local parsing” by Hayes), *ˈantʃ͡iquˈkut* is footed as *(ˈan)tʃ͡i(quˈkut)*. A virtue of this analysis is that fortition in Alutiiq can be characterized as a foot-initial phenomenon, thereby bringing it into line with the general cross-linguistic pattern of strengthening associated with initial position of prosodic domains (e.g. Pierrehumbert and Talkin 1992; Byrd 1994; Dilley et al. 1996; Cho and Keating 2001; Keating et al. 2003). In contrast, the locus of fortition is not easily defined with reference only to stress; it would need to be described as fortition in the onset of pretonic syllables, a context that is not traditionally associated with strengthening.

Similarly, vowel reduction in Dutch (Kager 1989; Booij 1995; van Oostendorp 1995) asymmetrically reduces unstressed vowels in certain positions to **schwa**, but fails to reduce unstressed vowels in other positions. For example, the second but not the third vowel in *ˌfonəloˈɣi* and *ˌekənoˈmi* reduces to **schwa** even though both are unstressed. This asymmetry can be understood in terms of foot structure: vowels reduce in the weak position of a foot (trochaic as parsed from left-to-right in Dutch), i.e. *(ˌfonə)lo(ˈɣi)* and *(ˌekə)no(ˈmi)*. In contrast, an analysis couched with reference only to stress could not easily account for the difference in behavior between two vowels that are both unstressed.

The Alutiiq and Dutch cases have in common that they fall out from an analysis in which grid marks are grouped into feet but not one that assumes only grid marks. A key feature of these languages is that the foot structure can be inferred from stress independently of the segmental alternations. In other words, the metrical systems driving stress in Alutiiq and Dutch, and the ones responsible for the segment-level patterns are “coherent” (Dresher and Lahiri 1991): the stress system can be used to diagnose foot structure, which in turn offers a means for analyzing alternations in consonant strength and vowel quality.

This is not the only logically possible, or even attested, relationship between stress, foot structure, and other phonological properties dependent on metrical structure. Certain languages possess phonological patterns that would appear to be metrically driven, either because their distribution is rhythmically predictable just like stress or because they involve properties that are intrinsically based on prominence, but that are not consistent with the metrical structure inferable from stress. This chapter will explore representative languages displaying this type of incoherence between the metrical structure diagnosed by stress and the metrical structure suggested by other phonological properties. Drawing on data from three language families (Uralic, Muskogean, and Northern Iroquoian) characterized by metrical inconsistency, an attempt will be made to construct a typology of the properties, both synchronic and diachronic, uniting cases of metrical incoherence. Ultimately, this typology suggests that many, if not most, cases of metrical incoherence stem from a mismatch between phrase-level and word-level metrical structure, which can be formally modeled without any additional ad hoc apparatus by referencing higher level prosodic units such as the Intonational Phrase.

1.3 Metrical Incoherence: Case Studies and Analysis

Sections 1.3.1–1.3.5 discuss data from three languages families providing insight into the structural properties of metrical incoherence, their synchronic motivations and treatments, and their historical sources. Section 1.3.1 addresses metrical patterns in two Uralic languages (Nganasan and Eastern Mari) possessing segmental alternations that display a metrically predictable distribution, but one which conflicts in large part with the metrical structure diagnosed by the stress system. Section 1.3.1 also sketches Vaysman's (2009) Optimality-theoretic analysis of the Uralic cases, in which orthogonal constraints on foot construction and grid mark placement are employed. Section 1.3.2 examines the Muskogean language family, focusing especially on Chickasaw, which provides a template for analyzing many, if not most, cases of metrical incoherence. In Chickasaw, metrical inconsistency arises when a diachronically innovative system of phrase-level prominence is overlaid on top of the inherited word-level metrical structure, creating a conflict that is effectively modeled by assuming different principles and constraints governing the placement of grid marks on the two levels of prosodic constituency. Section 1.3.3 compares the Chickasaw and Uralic cases of metrical incoherence and sketches an analysis of the Uralic data that is consistent with Gordon's (2003) pitch accentual treatment of Chickasaw. Section 1.3.4 turns to Northern Iroquoian, which provides further evidence for treating metrical incoherence as a mismatch between word and phrase-level metrical structure, but which also displays an interesting deviation from the Uralic and Muskogean cases in that the word-level metrical structure is the innovative feature whereas the phrase-level prominence is an inherited property. Section 1.3.5 summarizes the properties of metrical incoherence observed in Uralic, Muskogean, and Northern Iroquoian.

1.3.1 Uralic

Metrical Incoherence in Nganasan

Vaysman (2009) describes several Uralic languages in which the feet necessary to account for stress are orthogonal to those required to capture segmental alternations. A representative case of one of these “metrical conflicts” occurs in the Samoyedic language, Nganasan (Tereshchenko 1979; Helimski 1998; Vaysman 2009). Nganasan has an alternation between strong and weak intervocalic consonants termed “consonant gradation.” The alternations between strong and weak consonants entail changes of various types, including the loss of prenasalization (/^{N}h/ → [h], /^{n}t/ → /t/, /^{N}k/ → [k] / ^{n}s/ → [s], /$^{\neq}$ç/ → [ç], /$^{\neq}$c/ → [c]), voicing with or without a change in manner (/t/ → [ð], /k/ → [g], /s/ → [ɟ], /ç/ → [ɟ], /c/ → [ɟ]), and a shift from /h/ to [b] and from /j/ to zero.

The appearance of strong and weak consonants in (5) is predictable from syllable count. In the onset of even-numbered syllables, the strong grade (voiceless [t] in the examples) appears, while the weak grade (voiced [ð] in the examples) appears in the onset of odd-numbered syllables. Long vowels interrupt the alternating syllable count and, as long as they are not word-initial, are always preceded by weak consonants.

(5) Nganasan consonant gradation (Vaysman 2009:43)
jamaða-**t**u ‘his/her/its animal’
Norumu-**t**u ‘his/her/its copper’
suuðəː-**ð**u ‘his/her/its lung’
Nuhu-**ð**u ‘his/her/its mitten’

As Vaysman shows, this pattern is explained if one assumes that words are parsed into binary feet starting at the left edge of words with long vowels forming monosyllabic feet and degenerate feet allowed word-finally. Data illustrating the consonant alternations for two suffixes (-**t**u/-**ð**u and -^{n}**t**ənu/-**t**ənu) and their relationship to foot structure appear in (6). The strong variant of the third person possessive suffix (beginning with [t]) in (6a) and the locative singular non-possessive suffix (beginning with a prenasalized [^{n}**t**]) in (6b) surface foot-medially, whereas the weak allophone (beginning with [ð] and plain [t] in the two suffixes, respectively) occurs foot-initially. This pattern of foot-initial weakening is striking since it is the antithesis of the Alutiiq pattern discussed in Section 1.2 involving *fortition* of foot-initial consonants.

(6) Nganasan consonant alternation and foot structure (Vaysman 2009:43,52)

(a) (jama)(ða-**t**u) ‘his/her/its animal’
(Noru)(mu-**t**u) ‘his/her/its copper’
(suː)(ðəː)(-**ð**u) ‘his/her/its lung’
(Nuhu)(-**ð**u) ‘his/her/its mitten’
(b) (baːr)(pə-^{n}**t**ə)(nu) ‘master, chief (locative sg. non-possesive)’
(hɨa)(ɟə-^{n}**t**ə)(nu) ‘thumb (locative sg. non-possessive)’
(kubu)(-**t**ənu) ‘skin, fur (locative sg., non-possessive)’
(h^{W}aː)(-**t**ənu) ‘tree (locative sg., non-possessive)’

Beyond the unusual foot-initial lenition, a further interesting feature of the Nganasan data is that stress does not always fall on syllables that are predicted to be stressed by the metrical structure diagnosed by consonant gradation. The strong grade and the weak grade may both occur in the onset of unstressed syllables meaning that stress does not predict the alternation. Primary stress is confined to a three-syllable window at the right edge of a word, falling on the final syllable if it contains a long vowel or diphthong (7a) and otherwise on either the penult or antepenult depending on vowel quality in those syllables. In the variety of Nganasan described by Vaysman (2009), if the penult contains a vowel other than the central vowels [ɨ, ə], stress falls on the penult (7b).[1] Otherwise, if the penult contains a central vowel and the antepenult contains a noncentral vowel, stress falls on the antepenult (7c). Cases involving a central vowel in both the penult and the antepenult display a more complex and variable pattern, which is discussed below.

(7) Nganasan primary stress (Vaysman 2009:23, 52)

(a) ky(ˈmaː) 'knife'
le(ˈhua) 'board'
(b) (baˈku)(nu) 'salmon'
(ˈkaðar) 'light'
(c) (kuˈbu)(-tənu) 'skin, fur (locative sg., non-possessive)'
(ˈh^{W}aː)(-tənu) 'tree (locative sg., non-possessive)'

As the forms in (7) show, some of the feet, both disyllabic and monosyllabic, diagnosed by gradation lack stress completely, while other feet vary in whether they are trochaic or iambic. This inconsistency in the relationship between stress and foot structure is also evident in forms presented earlier in (6) (without stress marked) to illustrate gradation: (baːr)(ˈpə-^{n}**t**ə)(nu) "master, chief (locative sg. non-possesive)," (hɨa)(ˈɟə-^{n}**t**ə)(nu) "thumb (locative sg. non-possessive)," (kuˈbu)(-**t**ənu) "skin, fur (locative sg., non-possessive)," (ˈh^{W}aː)(-**t**ənu) "tree (locative sg. non-possessive)."

Stress assignment in Nganasan is, however, not completely blind to the metrical structure diagnosed by consonant gradation. Secondary stress falls on odd-numbered syllables counting from the left edge of a word in keeping with the footing predicted by consonant gradation (8a). The relationship between the left-to-right footing for secondary stress and gradation is demonstrated by the last two forms in (8a), which differ in the grade of the initial consonant of the dual suffix -ði/-ti as a function of foot structure. The secondary stress, however, is subservient to the primary stress, which results in footing reversals in which secondary stressed feet are trochaic and the primary stressed foot is

[1] Helimski (1998) describes a slightly different role for vowel quality, whereby a penult containing a high or central vowel optionally cedes stress to an antepenult containing a mid or low vowel; thus, *baˈruʃi* "devil" is optionally realized as *ˈbaruʃi* (Helimski 1998:486).

iambic (8b). As the forms in (8b) also show, secondary stress fails to surface in feet to the right of the primary stress.

(8) Nganasan secondary stress (Vaysman 2009:24)

(a) (ˌbaku)(ˌnu-mə)(ˈnu-mə) 'my salmon (prolative)'
(ˌtiri)(ˌ-mi-mə)(ˈnu-mə) 'my caviar (prolative)'
(ˌɲoru)(ˈmu-ti) 'your (dual) copper' (p. 45)
(ˌkərɨ)(-ˈgəʎi)(-ði) 'your (dual) march' (p. 46)
(b) (ˌkaðar)(-məˈnu)(-mə) 'my light (prolative)'
(ˌɟemɲi)(-məˈnu)(-mə) 'my salary (prolative)'

A further context in which foot structure is relevant to stress arises in words in which both the penult and the antepenult contain a central vowel. I abstract away from cases in which the penult and antepenult contain different central vowels, a situation that gives rise to variability in the location of stress, and consider here only cases in which both the penultimate and antepenultimate syllables contain the same central vowel. In words of this profile, the penult attracts stress if it foot-initial (9a) but the antepenult carries the stress if it is foot-initial (9b).

(9) Nganasan stress in words with the same central vowel in the penult and antepenult (Vaysman 2009:36)

(a) (ˌbɨðɨ)(ˈ-tɨ-rə) 'you (sg.) are drinking (intr.)'
(ˌɲɨlɨ)(ˈ-tɨ-rə) 'you (sg.) are living'
(b) (ˈbɨnɨ)(-mə) 'my rope'
(ˌbɨðɨ-p)(ˈtɨ-tɨ)(-rə) 'you (sg.) are drinking (tr.)'

The location of stress in these words is consistent with an analysis assuming the same left-to-right metrical parse diagnosed by consonant gradation with the proviso that a stray final light syllable is unstressed.

Summarizing the Nganasan facts, the foot structure diagnosed by consonant gradation and secondary stress converge. The primary stress system, however, disrupts the trochaic parse leading to a conflict between the footing diagnosed through stress and the metrical structure suggested by gradation. The unusual feature of the Nganasan system is the "top-down" nature of primary stress assignment, whereby the principles governing primary stress operate in large part orthogonally to those constructing the metrical feet producing secondary stress. This diverges from the typologically more common type of language in which primary stress is projected in bottom-up fashion promoting one of the secondary stresses to primary stress (Liberman & Prince 1977; Selkirk 1984; Hayes 1984, etc.) The relationship between primary stress, secondary stress, and gradation can be illustrated as in (10) via foot-based metrical representations of the type used earlier to demonstrate stress in English.

(10) Metrical structure in Nganasan

Higher level	(x)
Lower level	(x⇒x)(x)
	ŋu ˈhu- ðu
	‘his/her/its mitten’

The lower tier of metrical structure in (10) consists of trochees laid down from left to right parsing a single leftover syllable at the right edge as a degenerate foot. Gradation applies based on the foot structure projected on the lower tier of metrical structure. On the higher tier, primary stress falls on a syllable that was originally in a metrically weak position, triggering a shift in foot type from trochaic to iambic. If one assumes that the introduction of primary stress to a metrically weak syllable only triggers a shift in foot type and does not trigger re-grouping of syllables into new feet, the environment for gradation is still predictable at the surface-level.

This means, as Vaysman (2009) shows, that the analysis on Nganasan can be cast in a non-serial framework like Optimality-Theory as long as one accepts separate alignment constraints for feet and grid marks. In Nganasan, feet are left-aligned whereas primary stress grid marks are right aligned at the word-level. In addition to constraints aligning upper tier (level two) grid marks to the word, Vaysman (2009) posits other grid mark alignment constraints determining the alignment of grid marks within feet. The latter constraint family thus serves the function of the foot form constraints TROCHEE and IAMB in a conventional foot-based OT account. Under normal circumstances in Nganasan, the intra-foot constraint aligning level one (secondary stress) grid marks with the left edge of a foot outranks its right aligned counterpart thereby accounting for the default trochaic pattern characteristic of secondary stress. A higher ranked constraint right-aligning a level two grid mark (primary stress), however, forces a footing reversal in a foot spanning the antepenultimate and penultimate syllable (and containing a noncentral vowel in the penult) (11).

(11)

ŋuhu-**t**u ‘his mitten’	Align-R (Grid2,Wd)	Align-L (Grid1,Ft)
☞ x . x . (ŋuˈhu)(ðu)	*	*
x x . . (ˈŋuhu)(ðu)	**!	

Acting antagonistically toward the grid mark-to-foot and grid mark-to-word alignment constraints are a series of constraints that ban grid marks in certain contexts, e.g. NONFINALITY, which prohibits word-final grid marks, *CLASH, which bans adjacent grid marks, and weight-sensitive constraints prohibiting grid marks on light syllables. For example, a constraint banning level two grid marks on central vowels drives the retraction of stress off a penult containing a central vowel onto an antepenult containing a full vowel (12). The result of the constraint interaction in (12) is a stressless foot encompassing the final two syllables.

(12)

kubu-^{n}tənu ‘skin, fur (loc. sg., non-poss)’	*Grid2/ə, ɨ	Align-L (Grid1, Ft)
☞ x . x . . (kuˈbu)(tənu)		*
x x . x . (ˌkubu)(ˈtənu)	*!	

Although this is not an exhaustive analysis of Nganasan metrical structure, it illustrates some of the key components of Vaysman’s theory, in particular, the distinction between alignment constraints aligning grid marks with feet and those aligning grid marks with word edges and the competition between constraints aligning grid marks to feet and constraints militating against grid marks.

Metrical Incoherence in Eastern Mari

Vaysman (2009) discusses another case of metrical incoherence in the Uralic language Eastern Mari. Abstracting away from polymorphemic words, stress in Eastern Mari falls on the rightmost full, i.e. non-schwa, vowel in roots (13a) and otherwise on the initial syllable in morphologically simple words containing only reduced vowels underlyingly (13b). I return later to cases in which an underlying schwa alternates with a full vowel on the surface.

(13) Eastern Mari stress (Vaysman 2009:62–64)

(a) koŋˈga ‘oven’
ʃerˈge ‘comb’
køgørˈtʃen ‘dove’
ˈteŋgəz ‘sea’
ˈolək ‘meadow’
ˈjoŋələʃ ‘mistake’
puˈʃaŋgə ‘tree’

(b) ˈβəɲər 'canvas'
ˈəʃkəl 'step'
ˈləβə 'butterfly'

The stressed syllable also serves as the launching site for a rightward rounding harmony process. For example, the third person possessive suffix surfaces as [ʃe] when the stressed vowel is unrounded (14a) but as [ʃø] or [ʃo] when the stressed vowel is a rounded vowel (14b). (Note that the backness of the rounded allophone is conditioned by an orthogonal process of front-back harmony that spreads rightward from the initial syllable.)

(14) Eastern Mari rounding harmony (Vaysman 2009:92)

(a) ˈergə-ʃe 'his/her/its boy'
yˈremə-ʃe 'his/her/its street'
pykʃerˈme-ʃe 'his/her/its walnut tree'
(b) ˈʃyrə-ʃø 'his/her/its soup'
kəʎˈmo-ʃø 'his/her/its shovel'
ˈʃoʃə-ʃo 'his/her/its spring'

Although the stress system and the process of rounding harmony suggest an analysis employing variable-length unbounded feet (Hayes 1995), there is additional evidence from an alternation between schwa and full (i.e. non-schwa) vowels suggesting that feet are in fact binary in Eastern Mari. Underlying reduced vowels surface as full vowels in absolute word-final position, i.e. not in final closed syllables, under conditions that Vaysman argues are metrically governed. Vaysman shows that the fortition of schwa to a full vowel can be characterized as a foot-final alternation if one assumes that feet are parsed in binary fashion from left-to-right and a stray syllable left at the end of the word remains (unlike in Nganasan) unparsed.

The surface quality of the full vowel resulting from fortition is determined by both front/back and rounding harmony. The examples in (15) illustrate the fortition of schwa foot-finally (15a) and the preservation of schwa in metrically unparsed final syllables (15b).

(15) Eastern Mari vowel fortition (Vaysman 2009:83)

(a) (ˈtaŋ-se) 'the one who is a friend'
(ˈmy-sø) 'the one that is honey'
(ˈjoŋə)(ləʃ-sõ 'the one that is a mistake'
(puˈʃaŋ)(gə-sõ 'the one that is a tree'
(b) (ˈjeŋə)-sə 'the one who is human'
(okˈsa)-sə 'the one that is money'
(oˈla)-sə 'the one that is a city'
(puʃaŋ)(gə-ˈna)-sə 'the one that is our tree'
(pare)(ŋə-ˈna)-sə 'the one that is our potato'

As the forms indicate, there is no consistent relationship between stress and the feet predicting the alternation between schwa and a full vowel. Stress may surface on either the first or the second syllable of the feet needed to account for the vowel alternations and some feet completely lack stress.

That we are dealing with fortition of schwa rather than lenition of full vowels to schwa is demonstrated by the patterning of alternating schwas as light syllables in the stress system. Thus, vowels that are underlyingly schwa pass stress on to a preceding full vowel even if they wind up as full vowels due to foot-final fortition (16).

(16) Eastern Mari rejection of stress by alternating schwa (Vaysman 2009:79)

ˈsusko ‘scoop’ *susˈko (cf. ˈsuskəm ‘scoop’ accusative sg.)
ˈmuno ‘egg’ *muˈno (cf. ˈmunə ‘egg’ accusative sg.)
ˈjeŋe ‘human’ *jeˈŋe (cf. ˈjeŋəʒ ‘human’ lative sg.)

In summary, as in the case of Nganasan consonant gradation, the segmental alternation in Eastern Mari between schwa and a full-vowel is predictable from a left-to-right iterative metrical parse consisting of binary feet. Furthermore, as in Nganasan, this parse into binary feet bears no consistent relationship with the stress system. In fact, the divergence between stress and the foot structure on which the segmental alternation is dependent is even greater in Eastern Mari, where there is no secondary stress to provide any independent evidence for the foot structure diagnosed by the alternations affecting schwa. As in Nganasan, primary stress is also weight-sensitive in Eastern Mari and oriented toward the right edge, at least in words with a heavy syllable. Finally, Eastern Mari resembles Nganasan in showing elements of left-oriented stress; in the case of Eastern Mari, this leftward orientation is evident in words consisting of only light syllables.

The Historical Origin of Metrical Mismatches in Uralic

The segmental alternations in Eastern Mari and Nganasan are likely artifacts of the original left-oriented trochaic stress system reconstructed for proto-Uralic (Sammallahti 1988). A binary trochaic stress system is preserved in many languages throughout the family (e.g. Sámi languages, the Balto-Finnic languages, Hungarian in the Ugric branch of the family), including Nganasan, at the level of secondary stress. The branch of the family displaying the least evidence for trochaic foot structure is Volga-Finnic, which includes Mari and Mordvin, another language with vowel-quality sensitive stress (Kenstowicz 1997; Vaysman 2009). Despite their sensitivity to vowel quality, both the Mari and Mordvin stress systems have initial stress as the default case in words lacking a post-initial heavy syllable, a shared property that suggests its inheritance from proto-Volga-Finnic. In fact, Bereczki (1988) reconstructs initial stress for as late as pre-Mari on the basis of vowel reduction shifts occurring in noninitial syllables.

The stress systems of Eastern Mari and Nganasan presumably once transparently reflected the same foot structure driving the alternations that are no longer predictable from the metrical structure diagnosed through stress. The phonological and morphological alternations in these three languages have become entrenched artifacts of the original trochaic footing algorithm, while new weight-sensitive prominence systems have supplanted or modified (in different ways depending on the language) the original quantity-insensitive trochaic footing inherited from the proto-language. The introduction of weight-sensitivity in both Eastern Mari and Nganasan is perhaps not surprising given their introduction of new types of vowel distinctions (phonemic length in Nganasan and full versus reduced vowel contrasts in Mari) not present in proto-Uralic.

What is less clear from the literature on Eastern Mari and Nganasan is the level at which the newly introduced weight-sensitivity applies. Although described as stress, it is conceivable that the prominence is a phrase-level phenomenon, akin to an intonational pitch accent.[2] More generally, it is uncertain how much of the cross-linguistic stress typology reflects true word-level stress as opposed to phrasal pitch accent (see Gordon 2014 for discussion). It is plausible that many of the stress descriptions serving as the basis for typological generalizations are based on words uttered in isolation, where the word is equivalent to a larger prosodic constituent that is the domain of intonational events such as pitch accents and boundary tones. This hypothesis is supported by asymmetries between the left and right edge in the relative prevalence of different stress sites: penultimate stress is cross-linguistically common but its left-edge counterpart, peninitial stress, is rare (Hyman 1977; Gordon 2002; van der Hulst & Goedemans 2009). As Hyman (1977) suggests (see also Gordon 2000, 2014 for further elaboration), the widespread occurrence of penultimate stress makes sense in terms of the functional role of stress as a marker of constituent boundaries coupled with intonational factors unique to the right edge of an utterance. The default terminal pitch contour at the end of a statement involves a pitch fall in most languages while pitch accents characteristically involve raised pitch. In order to avoid "crowding" the high pitch target associated with stress and the low utterance-final pitch target onto a single syllable, it is natural for languages to instead spread the high-to-low pitch excursion over two syllables by retracting the stress onto the penult. Conversely, the left edge of an utterance is not canonically associated with lowered pitch in most

[2] The intonational pitch accent referred to here is not the lexical pitch accent often used to describe prominence in hybrid prosodic systems sharing some features with tone languages and others with stress languages.

languages so there is less pressure for a high pitch accent to shift rightward onto the second syllable.

Returning to the issue of metrical incoherence, it is conceivable that the newly introduced weight-sensitive prominence in Nganasan and Eastern Mari is a phrase-level pitch accent rather than word-level stress. The orientation of the prominence toward the right-edge is consistent with this hypothesis since pitch accents cross-linguistically tend to gravitate toward the end of an utterance in the default case (Ladd 1996). In the next section, more direct evidence for this proposal is presented from Chickasaw, a Muskogean language instantiating metrical incoherence that can be clearly attributed to an innovative right-edge oriented pitch accent system functioning orthogonally to the inherited left-to-right binary stress pattern of the proto-language.

1.3.2 Muskogean

Although the reconstruction of the prosodic system of proto-Muskogean is less secure than that of proto-Uralic, there is evidence in certain Muskogean language of metrical incoherence with similar origins to those in Uralic: the overlaying of a new prosodic system on top of a preexisting binary foot structure. The Muskogean cases are potentially instructive for at least two additional reasons.

First, the metrical mismatch in one of the relevant Muskogean languages, Chickasaw, does not involve a conflict between a productive new stress system and a vestigial segmental alternation as in Uralic. Rather, in Chickasaw, both the old and the new metrical systems are productive and relevant for prominence, i.e. stress and pitch accent.

Second, in certain Muskogean languages, evidence for the inherited prosodic system is limited to particular morphological paradigms. The morphologization of the original prosodic structure reflects one possible final destination for once productive phonological alternations that have become obfuscated by chronologically subsequent metrical shifts.

Metrical Incoherence in Chickasaw *Chickasaw (Munro & Ulrich 1984; Munro & Willmond 1994; Gordon et al. 2000; Gordon & Munro 2007, etc.) is a Muskogean language with a left-to-right quantity sensitive (CVX heavy) iambic stress system with lengthening of stressed vowels (indicated by an IPA half-length symbol ˑ) in nonfinal open syllables (17). Stray final light syllables are parsed into monosyllabic feet. Primary stress at the word-level falls on the final syllable in words lacking a pre-final long vowel. In words with a single long vowel, the long vowel carries primary stress. In words with more* *than one long vowel, there is variation in which long vowel carries primary stress (Gordon 2004).*

(17) Iambic rhythm and stress in Chickasaw (Gordon & Munro 2007)

(t͡ʃiˌtʃoˑ)(ˌkoʃ)(koˈmoˑ)(ˌt͡ʃi) 'S/he makes you play'
(t͡ʃoˌkoʃ)(koˈmoˑ)(ˌtok) 'S/he played'
(saˌhaˑ)(ˈʃaː) 'I am angry'
(haˈʃaː) 'S/he is angry'
(t͡ʃiˌkiˑ)(siˈliˑ)(ˌtok) 'S/he bit you'
(kiˈsiˑ)(liˌtok) 'S/he bit it'
(aˌsaˑ)(biˈkaˑ)(ˌtok) 'I was sick'
(aˈbiˑ)(kaˌtok) 'S/he was sick'

Chickasaw displays other segmental diagnostics of metrical structure besides iambic lengthening, two of which I mention here (see Munro & Willmond 1994 for others). The strident-coronal rule (Munro & Willmond 1994:xxxvi) deletes an unstressed vowel between a coronal strident (s, ʃ, ɬ, tʃ) and a non-strident coronal (t, n, l, tʃ) with a resulting preconsonantal affricate simplifying to a fricative: e.g. /pisat°ʃitok/ → *(piˈsaˑʃ)(ˌtok)* "S/he made her/him look at it" (cf. *(saˌpiˑ)(saˈt͡ʃiˑ)(ˌtok)* "S/he made me look at it"). Another more register-dependent process optionally devoices unstressed high vowels between voiceless consonants in casual speech (Gordon 2003): /pisa/→ *(pi̥ˈsa)* "S/he looks at it" (cf. *(saˈpiˑ)(ˌsa)* "S/he looks at me."

Turning to the relationship between foot-level metrical structure and other higher level prominence, the primary stress at the word-level adheres to a typical bottom-up pattern, whereby a syllable that is prominent at the lowest metrical level is promoted to primary word-level stress, either the final syllable or a pre-final syllable containing a long vowel. The metrical incoherence in Chickasaw emerges in phrase-final words, which carry a pitch accent on one syllable but not necessarily the syllable carrying primary stress at the word-level. Abstracting away from forms containing a lexical accent or ending in multiple verbs (see Gordon 2005 for discussion), there is one pitch accent per Intonational Phrase and this accent falls within the final word of the phrase. A syllable carrying the pitch accent also carries primary stress in its word, as evidenced by the fact that pitch-accented syllables are associated with all the prosodic characteristics of a primary stressed syllable, i.e. increased duration and greater intensity along with higher pitch (Gordon 2003).

Statements are straightforward in that the pitch accent falls on the final syllable (18a), a syllable that is already stressed by virtue of Chickasaw's parsing of the final syllable into a foot. Phonological conditions in questions, however, often place the pitch accent on a nonfinal syllable. In questions, the pitch accent falls on a final syllable only if it contains a long vowel (18b).

Otherwise, a heavy (=CVː, CVˑ or CVC) penult (18c) or the first syllable in a disyllabic word (18d) receives the accent. If the final syllable does not contain a long/lengthened vowel and the penult is not heavy, the antepenult carries the accent (18e).

(18) Chickasaw pitch accent

(a) (saˌhaˑ)(ˈʃáː) ‘I’m angry’
(maˌliˑ)(ˈlí) ‘S/he is running’
jammakot (aˌkan)(ˈkáʔ) ‘That’s a chicken’
(b) katiːmihta): (saˌhaˑ)(ˈʃáː) ‘Why am I angry?’
nantaːt (ˌok)(ˈtáːk) ‘What is a prairie?’
kataːt (ˈjáː) ‘Who is crying?’
nantaːt (ʃiˈwáː) ‘What is striped?’
(c) (ˌiʃ)(maˈlíˑ)(ˌtam) ‘Did you run?’
nantaːt (haˈtáː)(ˌt͡ʃim) ‘What turned color?’
nantaːt (tʃiˈlák)(ˌbi) ‘What is dry and cracked?’
nantaːt (ˌis)(ˈtók)(ˌtʃank) ‘What’s a watermelon?’
katiːjakta (aˈkán)(ˌkaʔ) ‘Where’s the chicken?’
kataːt (ˌbaː)(ˈtám)(ˌbiʔ) ‘Who’s Baatambi’?’
(d) nantahta): (ˈpí̩ˌsam) ‘What does s/he see?’
nantaːt (ˈtí̩ˌjak) ‘What is a pine tree?’
(e) (ˈmál)(liˌtam) ‘Did s/he jump?’
(ˈʃíː)(paˌta) ‘Is it stretchy?’
nantaːt (aˈbóː)(koˌʃiʔ) ‘What’s a river?’

In most words, the pitch accent in Chickasaw falls on a syllable that is already metrically prominent (i.e. has either primary or secondary stress) by virtue of the word-level iambic parse. In some cases, the pitch accent falls on a syllable that carries primary word-level stress, whereas in other cases, the pitch accent falls on a secondary stressed syllable. The attraction of the pitch accent by syllables that have some degree of word-level stress is reminiscent of the typologically common scenario entailing promotion of a word-level stress to pitch accent status (see Section 1.3.3 for discussion).

There are questions, however, in which the pitch accent docks on a syllable that is unstressed according to the iambic parse, potentially leading to a situation entailing metrical incoherence. We consider one of these cases here; the other arises in morphologically complex forms (see Gordon 2003). In disyllabic words in which the first syllable is light (CV) and the second contains a short vowel (CV or CVC), the first syllable carries the pitch accent even though it is not predicted to be metrically prominent by the left-to-right iambic parse responsible for word-level stress. In fact, initial vowels that may be devoiced or syncopated because they occur in weak position of an iambic foot end up bearing the pitch accent in disyllabic words of the shape CVCV(C) in question-final position. For example, the first vowel in *(pi̥ˈsa)* “S/he looks at it” is unstressed and subject to devoicing, whereas it is stressed and thus not devoiced in the question *katahtã: (ˈpísa)* “Whom is s/he looking at?.” Metrical representations illustrating the shift in stress triggered by the pitch accent in questions are shown in (19).

(19) Metrical representations for statement-final and question-final words in Chickasaw

	Statement-final	Question-final
Pitch accent	(x)	(x)
Primary stress	(x)	(x⇐x)
Secondary stress	(. x)	(x⇐x)
	pi̥ ˈsá	katahtã: ˈpí sa
	‘S/he looks at it’	‘Who is s/he looking at?’

In the form on the left, the pitch accent docks on a syllable that is in a metrically strong position at both word levels of metrical representation. In the form on the right, on the other hand, the pitch accent falls on the metrically weak initial syllable, thereby triggering a leftward shift in the two tiers of word-level grid marks and the blocking of high vowel devoicing.

The relationship between the pitch accent and iambic footing crucially differs between Chickasaw and the Nganasan case discussed earlier. Whereas in Nganasan the left-to-right binary parse driving consonant gradation remains intact regardless of the location of the prominence oriented toward the right edge, in Chickasaw, the left-to-right parse is adjusted in response to the placement of the pitch accent. A syllable that is predicted to be metrically weak by the iambic parse thus winds up in a metrically strong position if it carries a pitch accent. We can thus say that Chickasaw averts metrical incoherence on the surface by shifting the word-level foot structure in response to the phrase-level pitch accent in certain cases, an instance of “top-down” prominence. Nganasan, on the other hand, retains the word-level foot structure even in the face of a pitch accent whose location potentially conflicts with the position of metrically strong syllables according to the foot structure.

Gordon (2003) develops an OT analysis of top-down prominence in Chickasaw that is similar in spirit to Vaysman’s analysis of Nganasan in assuming separate alignment constraints for different levels of prominence. However, unlike in Vaysman’s approach, the relevant alignment constraints responsible for the upper tier of prominence in Gordon’s analysis refer to phrase-level pitch accents rather than grid marks projected at the word-level.

Gordon (2003) develops his account within a grid-based framework, although his analysis can easily be recast in foot-based terms following the discussion of Chickasaw in this section. A highly ranked constraint pulls the pitch accent rightward within the Intonational Phrase. Even higher ranked constraints, however, requiring the tone-bearing unit to be a vocalic mora and banning the crowding of a pitch accent and a boundary tone onto a single tone-bearing unit push the pitch accent off the final syllable unless it contains a long vowel (20).

(20)

haʃaːtam 'Was s/he angry?'	TBU $\mu_{[+vocalic]}$	*CROWD	ALIGN (T*, R, IP)
☞ H* L% (haˈʃaː)(ˌtam)			*
H* L% (haˈʃáː)(ˈtam)		*!	
H* L% (haˈʃáː)(ˈtam)	*!		

The anti-tonal crowding constraint produces footing reversals in some cases. Thus, in the question *ˌnanˌtahˈtãː (ˈpíˌsam)* "What does s/he see?" the disyllabic verb has an initial pitch accent that attracts stress, thereby inducing a shift from an iambic to a trochaic foot.

The bottom-up component of the Chickasaw prosodic system comes into play when an anti-clash constraint further retracts the pitch accent off a light penult to the antepenult, which is heavy before a light syllable by virtue of either being closed or targeted by iambic lengthening. Because the stress docks on the same syllable as the pitch accent, assigning the pitch accent to a light penult would create a stress clash (21).

(21)

mallitam L% 'Did s/he jump?'	*CLASH	ALIGN (T*, R, IP)
☞ H* L% ˈmálliˌtam		**
H* L% ˌmálˈlíˌtam	*!*	*

To summarize, in the Chickasaw analysis, the constraints yielding metrical incoherence are constraints on pitch accent. This differs from Vaysman's (2009) account of Nganasan in which the mapping between feet and the grid marks capturing stress flexibly adjusts according to the ranking of the constraint governing the alignment of grid marks within feet.

Metrical Incoherence in Muskogean: Synchronic Distribution and Historical Development

There are two recurring metrical characteristics in Muskogean that are diagnosed through various synchronic patterns and diachronic changes: one is penultimate prominence and the other is iambic rhythm. Booker (2005) reconstructs penultimate stress for proto-Muskogean on the basis of the distribution of several historical processes: vowel lengthening in Mikasuki (see below), final vowel deletion in Chickasaw and Choctaw, and various consonant lenition and assimilation patterns throughout the family. Martin (1996) offers a complementary proposal, reconstructing an iambic metrical system for proto-Muskogean where the rightmost stress is the primary. In order to accommodate the evidence for penultimate prominence, he suggests that final stress avoidance motivates a footing reversal in final position such that a foot encompassing the penultimate and final syllable is trochaic rather than iambic. This postulated footing reversal is reminiscent of those found synchronically under certain conditions in Chickasaw, Nganasan, and Eastern Mari.

As Martin (1996) shows, the reconstruction of iambic rhythm is supported to various degrees by data from all languages in the family but is most pervasive and productive in Chickasaw, Choctaw, and Creek. These three languages differ, however, in how the iambic rhythm is phonologically manifested and in the morphological domain over which it is calculated.

The Western Muskogean languages, Chickasaw (Munro & Ulrich 1984; Munro & Willmond 1994, 2005; Gordon et al. 2000; Munro 2005; Gordon & Munro 2007, etc.) and Choctaw (Munro & Ulrich 1984; Broadwell 2005, 2006), have robust iambic lengthening patterns in nonfinal open syllables where strong syllables (at least in Chickasaw) are stressed (see the section on Chickasaw).

Creek (Haas 1977; Hayes 1995; Martin and Johnson 2002; Martin 2011) also has an iambic metrical system (encompassing certain prefixes that fall outside the iambic domain in Choctaw and Chickasaw) that is manifested primarily in terms of tonal docking and spreading patterns. In words lacking lexical tone, a high tone plateau extends from the first to the last metrically strong syllable according to the iambic parse (22).

(22) Tonal accent in Creek (Martin 2011:77–78)

(ifá) ‘dog’
(nokó)si ‘bear’

(nokó)(sótʃĩ) 'bear cub'
(awá)(náyí)ta 'to tie to'
(wáː)ka 'cow'
(sók)ha 'hog'
(íː)(káná) 'land'
(honán)wa 'male'
(tapás)(sóːla) 'daddy longlegs'

There are also vestiges of iambic rhythm in the form of certain morphological alternations throughout much of the family. For example, Martin (1996) describes vowel length alternations in the formation of causatives in Alabama and Koasati and in verbs containing non-agentive prefixes in Mikasuki that are consistent with a left-to-right iambic parse in which heavy syllables are CVC and CVV. For example, in Koasati, causatives trigger lengthening of a preceding stem-final short vowel in a metrically strong syllable, e.g. causative (hi.tʃâː)-tʃĩ-lahõ "S/he will show it" (cf. non-causative (hi.tʃ**â**)-lahõ 'S/he will see'). This lengthening only occurs, however, if the syllable before the stem-final vowel is light. There is thus no lengthening after a heavy syllable, e.g. (hom.m**a**)-tʃĩ-lahõ "S/he will redden it."

Interestingly, in Koasati at least (probative prosodic data is lacking for Alabama and Mikasuki), iambic rhythm is not a general feature of the prosodic system outside of the morphologically circumscribed case of causative formation. Rather, the initial syllable in a Koasati word typically carries primary stress and rhythm impressionistically is trochaic (Gordon et al. 2015). The pattern of vowel lengthening in causatives is thus not attributable to general rhythmic properties of Koasati. Koasati appears to be an outlier in the family in displaying trochaic rhythm suggesting that its prosodic system is a relatively recent innovation and that the iambic vowel lengthening found in the causative is a relic of an earlier stage in the history of the language when iambic rhythm was still at least reasonably productive.

1.3.3 The Typology of Metrical Incoherence: Uralic and Muskogean

Chickasaw and Nganasan display a mismatch between higher level and lower level metrical structure such that the higher-level structure induces in "top-down" fashion a restructuring of the lower tier of structure. The existence of top-down systems like those of Chickasaw and Nganasan is consistent with, and indeed predicted by, van der Hulst's hypothesis (van der Hulst 1996, 2012, 2014; van der Hulst & Goedemans 2014) that primary stress is assigned "prior," in derivational terms, to rhythmic secondary stresses. The Chickasaw and Uralic cases differ, however, from the typologically more common scenario, found for example in English, in which the higher and lower tiers of metrical structure do not conflict. Derivational theories differ in whether this harmonious relationship between metrical tiers results from "bottom-up" projection of higher level from lower level metrical structure or "top-down" placement of higher level metrical structure followed by a lower tier that "respects" (in van der Hulst's terms) the already imposed higher layer. Interestingly, even Chickasaw and Nganasan display a modicum of mutual sensitivity between different metrical tiers. In Chickasaw, the pitch accent in statements and in most questions falls on a syllable that is already metrically prominent according to the lower tier of metrical structure. In Nganasan, secondary stress fails to surface when it would clash with the primary stress. Furthermore, the choice in Nganasan of whether to stress a reduced vowel in the penult or antepenult is a function of the lower level of metrical structure.

Crucially though, the respect between different metrical tiers only goes so far in Chickasaw and Nganasan. In Chickasaw, the pitch accent in questions can thus wind up on a syllable that is predicted to be metrically weak by the foot-level parse. Similarly, in Nganasan, the primary prominence of a word often falls on syllables that are metrically weak according to the footing algorithm.

Chickasaw and Nganasan differ in their response to these metrical conflicts. In Chickasaw, the phrasal pitch accent triggers in certain word shapes a restructuring of word-level metrical structure. In Nganasan, on the other hand, consonant gradation continues to obey the metrical parse responsible for secondary stress regardless of the location of primary stress.

Eastern Mari differs from Chickasaw and Nganasan in displaying evidence only for foot structure and not for foot type. Whereas secondary stress argues for an iambic parse in Chickasaw and a trochaic one in Nganasan, the only evidence for feet in Eastern Mari comes from vowel alternations that are compatible with either foot type as long as it is binary. Primary prominence in Eastern Mari thus does not strictly conflict with foot structure, but rather is simply blind to it.

One lurking issue for Nganasan and Eastern Mari is the level at which the primary prominence operates. One possibility is that it refers to primary word-level stress following Vaysman's (2009) analysis of both languages. An alternative possibility, however, is that the prominence in Nganasan and Eastern Mari is actually a phrasal pitch accent as in Chickasaw. This option is particularly enticing because of the strong parallels between the Nganasan and Chickasaw in their assignment of higher-level prominence. In both languages, the only final syllable that can carry prominence is CVV, and in both languages, syllables that are intermediate in weight (CVC in Chickasaw, peripheral vowels in Nganasan) are prominent in penultimate position. In both languages, the parallel behavior of intermediate weight syllables falls out from foot formation constraints with the proviso that higher ranked pitch accent constraints can trigger footing reversals under certain circumstances. A similar approach is potentially tenable for Eastern Mari, which like Nganasan and Chickasaw, displays weight-sensitive prominence that is oriented toward the right edge. The default placement of stress on the initial syllable of words containing only schwa in Eastern Mari is consistent with a trochaic foot structure for Eastern Mari as in Nganasan.

This reanalysis would assume that the binary foot structure in both Nganasan and Eastern Mari reflects word-level metrical structure, as in Chickasaw, whereas the upper tier of prominence is indicative of phrase-level pitch accent. This account makes the prediction that the secondary stresses associated with metrically strong syllables at the foot level would emerge in words removed from final position of a phrase where the prominence of the pitch accent likely renders any secondary prominences difficult to perceive. It is plausible that examination of non–phrase-final words would also allow for differentiation of primary and secondary word-level stress, which in Chickasaw is an acoustically subtle distinction (Gordon 2004). Given the left-to-right nature of foot structure in both Nganasan and Eastern Mari and the reconstruction of initial stress for proto-Uralic, a plausible working hypothesis is that the stress on the first syllable is the primary one for words not in phrase-final position.

The representations proposed for Nganasan and Eastern Mari words in phrase-final position (with a pitch accent) and their counterparts in non-phrase-final position (without a pitch accent) are summarized in (23).

(23) Hypothesized metrical structure in non-phrase-final and phrase-final words in two Uralic languages

Nganasan

	Non-phrase final	Phrase-final
Pitch accent	NA	(x)
Primary stress	(x)	(x⇒⇒⇒ x)
Secondary stress	(x.)(. x)(x)	(x .)(. x)(x)
	(ˈkaðar)(məˌnu)(ˌmə)	(ˌkaðar)(məˈnu)(ˌmə)

‘my light (prolative)’

Eastern Mari

	Non-phrase final	Phrase-final
Pitch accent	NA	(x)
Primary stress	(x)	(x⇒⇒⇒ x)
Secondary stress	(x .)(. x)	(x.)(. x)
	(ˈpuʃaŋ)(ɡəˌna)sə	(ˌpuʃaŋ)(ɡəˈna)sə

‘the one that is our tree’

The metrical structures assumed in (23) for Nganasan and Eastern Mari are quite similar and closely mirror the earlier analysis of Chickasaw except for the foot type. The foot structure associated with the secondary stress tier in both Nganasan and Eastern Mari is typically trochaic (as opposed to iambic in Chickasaw) but both allow for conversions to an iambic pattern in order to avoid placing a schwa in a strong position as in the second foot in the examples in (23). The primary stress at the word-level in both languages falls on the first syllable in non-phrase-final position, but shifts to the penult phrase-finally to coincide with the location of the pitch accent. As in Chickasaw, this shift results in only a change in foot type but does not induce a redrawing of foot boundaries. The only difference between the two preceding examples is the degenerate foot in word-final position that is allowed in Nganasan but not Eastern Mari.

Assuming that the pitch accentual analysis of Nganasan and Eastern Mari is viable, a similar type of OT analysis proposed for Chickasaw can be adopted for both languages, where constraints relevant to pitch accent placement interact with those referring to foot structure and word-level stress. The net result is an analysis that is similar in spirit to Vaysman's (2009) analysis in employing orthogonal constraints on both foot structure and grid marks. Unlike in Vaysman's account of Nganasan and Eastern Mari, however, constraints governing the top tier of grid marks in the pitch accentual theory of metrical incoherence refer to pitch accent rather than word-level stress.

One virtue of an account attributing metrical incoherence to a conflict between rhythmic metrical structure and an orthogonal pitch accent system as opposed to an orthogonal system of word-level stress is the greater parsimony of the former approach. The facts from Chickasaw suggest that an analysis of top-down pitch accent placement is independently needed, whereas it is unclear whether it is also necessary to appeal to top-down word-level stress to derive the Nganasan and Eastern Mari data. To the extent introducing another source of metrical incoherence into the analysis can be avoided, metrical stress theory is more restrictive.

Ultimately, the determination of whether Nganasan and Easter Mari are amenable to an analysis in terms of pitch accent rather than primary stress is an empirical question that can only be settled through closer investigation of prominence patterns in different phrasal contexts. In the next section we turn to another language family displaying metrical incoherence that is potentially also due to top-down pitch accent placement.

1.3.4 Northern Iroquoian

Another family in which languages have undergone extensive prosodic restructuring resulting in metrical incoherence is Northern Iroquoian. As in Uralic and Muskogean, there is a segmental alternation in these languages that once was transparently motivated by metrical structure, but which has since been obscured by metrical innovations overlaid on top of archaic prosodic features inherited from the protolanguage.

Northern Iroquoian is reconstructed as having penultimate stress with lengthening of vowels in open penults except before laryngeal consonants (e.g. Chafe 1977; Foster 1982; Michelson 1988), a system that is still largely preserved in Mohawk (Chafe 1977) and Tuscarora (Williams 1976). The incoherence of the prosodic systems found in certain Northern Iroquoian languages stems from the preservation, albeit in slightly modified form, of the process of penultimate vowel lengthening even as a new left-to-right binary metrical structure has been introduced. In a foot-based analysis, the original penultimate stress and the associated lengthening of the penultimate vowel would typically be assumed to reflect a trochaic foot at the right edge of a word. In the next two subsections, we discuss two Northern Iroquoian languages, Cayuga and Seneca, which have introduced left-to-right iambic systems while still preserving certain elements of the original penultimate prominence and vowel lengthening. This historical path of development is essentially the antithesis of the situation in Uralic and Muskogean. Rather than the single prominence at the right edge being an innovation, the left-oriented binary foot structure is the innovative property in Northern Iroquoian.

Cayuga

Cayuga, which is discussed in Chafe (1977), Foster (1982), Michelson (1988), Doherty (1993), and Dyck (2009), preserves the lengthening of vowels in open penults even extending the definition of open syllables in certain contexts to encompass syllables that were closed in the protolanguage. Even more strikingly, Cayuga has introduced an iambic system counting from the left where the position of the penult within the foot conditions whether it carries stress and whether it undergoes vowel lengthening.

Abstracting away from certain chronologically newer long vowels that pattern as disyllabic, if the penult falls in an even-numbered syllable counting from the left, it carries primary stress with a secondary stress falling on other even-numbered syllables (24a). Odd-numbered penults are stressed only if they contain a vowel that is lengthened by virtue of being in an open syllable (24b). If an odd-numbered penult is stressed, the preceding vowel, stressed by virtue of falling in an even-numbered syllable, is lengthened provided it is not followed by a laryngeal consonant (24c). If a penult in an odd-numbered syllable is closed (which means that it contains a short vowel because lengthening targets open penults), the stress falls on the preceding even-numbered antepenult (24d).

(24) Primary stress in Cayuga (Foster 1982:61–63) (Syllable boundaries for penult indicated)

(a) ẽˌkataˌtõkwʔeˈtõː.njẽʔ ‘I will make some people for myself’
otˈhoː.weʔ ‘it is cold’
ẽˌhẽnaˈtoː.wat ‘they will hunt’

a ˈkjẽː.thoʔ ‘I planted it’
ka ˈnes.taʔ ‘board’
(b) a ˌhi ˈhoː.wiʔ ‘I told him’
ka ˌnõh ˈsoː.tõh ‘several houses’
(c) a ˌhawa ˌjẽː ˈnẽː.taʔ ‘he completed it’
hah ˌjaː ˈkwiː.jot ‘his toe’
(d) te ˌwaka ˈtawẽn.jeʔ ‘I’m moving about’
ẽ ˈwakes.hoʔ ‘I smelled it’

The Cayuga system is unusual because the penult retains its original metrically privileged status in that it preferentially attracts stress even if it is does not fall in a metrically prominent syllable as determined by the left-to-right iambic rhythm. However, this penultimate prominence is sensitive in certain respects to whether it falls in a metrically strong syllable based on the left-to-right iambic rhythm. This sensitivity manifests itself in multiple ways. First, vowel lengthening in an *odd-numbered* penult is limited to open syllables as defined by the narrow syllabification criteria applicable in the protolanguage according to which a syllable is closed by the first consonant of a cluster or by an intervocalic laryngeal: compare *a ˌhi ˈhoː.wiʔ* “I told him” (Foster 1982:62) and *ka ˌnõh ˈsoː.tõh* “several houses” with penultimate lengthening versus *te ˌwaka ˈtawẽn.jeʔ* “I’m moving about” and *a ˈkeka.haʔ* “my eye” (p. 63) without lengthening. In contrast, lengthening of the vowel in an *even-numbered* penult occurs in open syllables based on an innovative and more liberal definition according to which a syllable is open unless it is followed by a laryngeal or by a cluster consisting of /s/ followed by an oral stop: compare *tẽkata ˈwẽː.njeːʔ* “I’ll move about” (cf. *te ˌwaka ˈtawẽn.je/* “I’m moving about” without lengthening), *ak ˈjẽː.thoʔ* “I planted it” and *õ ˈkeː.shoʔ* “I smelled it” with lengthening versus *o ˈhah.aʔ* “road” and *ka ˈnes.taʔ* “board” (Foster 1982:62) without lengthening. More strikingly, even when it is stressed, an odd-numbered penult “shares” prominence with a rhythmically strong antepenult, which undergoes vowel lengthening but only before a stressed penult. In a sense, words with a stressed penult in an iambically weak position are conflicted in their prosodic behavior: on the one hand, the penult is prominent by virtue of its vowel length but, on the other hand, the antepenult is prominent because it falls in a rhythmically strong position and is made even more prominent through vowel lengthening when competing with a long vowel in the penult.

As in Nganasan and Eastern Mari, a segmental diagnostic, vowel lengthening in the case of Cayuga, is contingent upon a chronologically earlier metrical parse that was later supplanted by a different parse originating from the opposite edge of the word. Unlike in Nganasan and Eastern Mari, though, the original metrical system consisted of a single stress oriented toward the right edge in proto-Northern-Iroquoian while the novel metrical parse in Cayuga propagates iteratively rightward from the left edge.

A further complication in Cayuga is that the stress patterns described here thus far are characteristic of phrase-final words. Phrase-internally, primary stress falls on the final syllable (Dyck 2009). This asymmetry is similar to the difference between phrase-internal words in Chickasaw, which have final primary stress (assuming there is no pre-final long vowel), and their question-final counterparts, which have a pitch accent on a syllable to the left of the ultima in words with a short vowel in the final syllable. It is thus plausible, perhaps even likely, that the primary stress in phrase-final words in Cayuga is a pitch accent as in Chickasaw.

It is not entirely clear how the prominence in Cayuga phrase-final words should be analyzed synchronically. One possibility is to recapitulate history in assuming a single trochaic foot at the right edge and binary iambic feet originating at the left edge as in (25) (see Hayes 1995 for an alternative analysis assuming a purely left-to-right iambic parse). Under this approach, the Cayuga system entailing a left-to-right iambic parse and a single trochaic foot at the right edge, in fact, is essentially the same as the one found in Southern Paiute (Sapir 1930).

(25) Metrical structure in Cayuga

Primary prominence	(x)	(x)
Secondary stress	(. x)(x .)	(. x)(x.)
	aˌhi ˈhoː.wi/	ẽˈwa kes.hoʔ
	‘I told him’	‘I smelled it’

In Cayuga words with mixed iambic and trochaic feet, there is a clash between the antepenult and the penult, one of which receives primary prominence depending on the structure of the penult. If the penult contains a vowel that is eligible to be lengthened by virtue of occurring in an open syllable, it receives the prominence, as in the first form in (25). A closed penult, on the other hand, is not sufficiently heavy to attract prominence because it contains a short vowel, thereby allowing the primary stress to shift leftward to the antepenult, as in the second form.

An interesting issue arises in odd parity words where it is phonetically indeterminate whether the penult is the strong syllable of a left-aligned iamb or a right-aligned trochee. For example, the word *akˈjẽːthoʔ* “I planted it” could reflect the parse *(aˈkjẽː)thoʔ* or the parse *a(ˈkjẽːthoʔ)*. One argument in favor of the iambic analysis is that criteria for establishing the openness of a syllable for purposes of lengthening are more lenient when the penult falls in an even-numbered position than when it is an odd-numbered syllable, an asymmetry that could be attributed to a more general cross-linguistic bias in favor of lengthening in iambic as opposed to trochaic feet (Hayes 1985, 1995).

The analysis of Cayuga sketched here should be regarded as a tentative and incomplete proposal that glosses over certain properties of the stress system. For example, the fact that stress is confined to one of the last three syllables of the word must be accounted for. Additional features to analyze include, among others, the lengthening of the pretonic vowel in even-numbered antepenults before a stressed penult, the absence of stress reported for disyllabic words, and asymmetries in the behavior of long vowels depending on their source (see Chafe 1977; Foster 1982; and Michelson 1988 for discussion of the data). Regardless of the synchronic analysis ultimately adopted, it is clear that the coexistence of metrical systems from different time periods has led to a form of metrical incoherence in Cayuga.

As a final note, in the analysis sketched afore, feet are sufficient to account for stress without appealing to grid marks under the assumption that all the metrical strong syllables carry some degree of stress. In most cases, the syllables predicted to be stressed by the metrical parse are described in the primary literature as being prominent. The one exception is the metrically strong penult following an antepenult that carries the primary prominence, e.g. the penultimate syllable in (ẽˈwa)(keshoʔ) "I smelled it." As in Chickasaw and the Uralic languages discussed earlier, the thorny issue of posttonic secondary stresses is at stake here. In the case of Cayuga, where the primary prominence is likely a pitch accent, the perceptibility of an immediately posttonic secondary stress is especially likely to be a subtle matter.

Seneca

Like Cayuga, Seneca has introduced an iambic stress system counting from the left but with a different weight criterion. Furthermore, as in Cayuga, penultimate syllables are prone to lengthening with historically new criteria (but different from those in Cayuga) predicting lengthening. Unlike Cayuga, however, penultimate syllables in Seneca do not have a special status in the accentual system. Rather, whether they lengthen or not has become a function of their rhythmic position as counted from the left.

Prominence (most saliently a pitch accent) in Seneca falls on nonfinal even-numbered syllables that are themselves closed (26a) or immediately followed by a nonfinal closed syllable (26b). Speakers vary but the rightmost prominence is characteristically the perceptually most prominent one and, for certain speakers, may be the only one (Chafe, personal communication); it is accordingly marked in (26) with a pitch accent in addition to primary stress.

(26) Pitch accent in Seneca (Michelson 1988) (Syllable boundaries for tonic and posttonic syllables indicated)

(a) taˌwakahˈsíʔ.tyaʔk 'I stumbled'
niˈwát.kwenjõs 'How much is possible?'
akẽniˈjás.tajẽʔ 'I have it on me'
skaˌtatheˈwát.haʔ 'I repent'

(b) haˈjátoʔ.kwas 'He's digging a hole'
ẽˈjé.tak.heʔ 'She'll be running'

Penultimate lengthening is still observed but has a different distribution from the protolanguage sensitive now to whether the potential target occurs in an even- or odd-numbered syllable as counted from the left. Lengthening has become more restricted in odd-numbered penults in that the failure of epenthetic /a/ to lengthen in the protolanguage was extended to all instances of /a/ in noninitial syllables: compare no lengthening of penultimate /a/ in *waʔagwagẽʔ* "we (pl. exclusive) saw it" (<**waʔakwáːkẽʔ*) versus lengthening of initial /a/ in *haːdõh* "he says" (Chafe 1996:558). On the other hand, lengthening has expanded in even-numbered penults to encompass vowels in syllables that were originally closed, i.e. before consonant clusters (but not before laryngeals and sporadically not before /sd/ clusters): compare lengthening in *odeː.khaʔ* "it burns, fire" (<**oték.haʔ*) and *onõː.kdaʔ* "space" (<**onák.taʔ*) versus no lengthening in *onís.daʔ* "corn on the cob" (Chafe 1996:559). Following Chafe (1996), one can assume that the new vowel lengthening is attributed to resyllabification of the coda consonant in the penult to the onset of the ultima since the newly lengthened vowels fail to attract stress. This resyllabification has resulted in a paradox: on the one hand, the expansion of lengthening to new even-numbered penults can be attributed to a strengthening effect in a metrically prominent position (the second syllable of an iamb), yet on the other hand, this lengthening is associated with loss of the accent since a coda consonant and not vowel length attracts an accent. The result is a foot lacking an accent, a feature that is more generally found in all feet in Seneca lacking a closed syllable in a metrically strong position or in the immediately following weak syllable. Besides the rejection of stress by lengthened vowels, another unusual feature of Seneca under an iambic analysis is that a closed syllable in a weak position triggers an accent in an immediately preceding strong syllable belonging to a different foot. This property serves as the impetus for Melinger's (2002) alternative account of Seneca, which assumes that the first syllable is extrametrical and that trochaic rather than iambic feet are constructed from left to right. Under Melinger's reformulation of foot structure, the ability of a closed syllable to attract accent to an immediately preceding syllable becomes a foot-bounded phenomenon rather than a transpodal feature.

1.3.5 Uralic, Muskogean, and Northern Iroquoian: A Summary

In summary, the Cayuga and Seneca metrical systems bear certain resemblances to the cases of metrical incoherence in Uralic and Muskogean. As in Uralic and Muskogean, vestiges of the original metrical system have been preserved in the guise of a segmental alternation, vowel lengthening in the case of Northern Iroquoian. Parallel to Uralic and Muskogean, a chronologically later system of metrical prominence has been overlaid on top of the original prosodic system. As in Uralic and Muskogean, the result of the interaction between the inherited and the innovated systems are, in certain cases in Seneca, feet that are no longer diagnosed through stress but only through segmental alternations. It is unclear how or why the new binary parse developed in Cayuga and Seneca, though there is evidence from elsewhere in the language family for an incipient prominence on the second syllable that perhaps predated the dissolution of the protolanguage. Onondaga, which predominantly has penultimate accent with vowel lengthening as in the protolanguage, displays a process of pretonic lengthening in even-numbered syllables (Chafe 1977; Michelson 1988) that parallels the analogous pattern described for Cayuga in the previous subsection. Furthermore, the vowel of the second syllable lengthens under certain conditions (Michelson 1988:97). Taken together these lengthening phenomena are suggestive of a system of iambic rhythm (Michelson 1988:98), albeit one that is less-fully developed than its counterparts in Cayuga and Seneca.

There are some important differences, however, between the metrical mismatches found in Northern Iroquoian as opposed to those in Uralic and Muskogean. In the Northern Iroquoian languages Cayuga and Seneca, the original metrical system entailed a single prominent syllable at the right edge while a binary iambic foot pattern originating at the left edge was innovated. This contrasts with the Uralic languages Nganasan and Eastern Mari and the Muskogean language Chickasaw, all of which originally possessed binary foot structure propagating from the left edge before introducing a new single higher-level prominence at the right edge. Interestingly, despite introducing a chronologically later system of left-oriented foot structure, Cayuga and Seneca both display rightward orientation of primary stress when weight is controlled for, parallel to both Chickasaw and the Uralic languages discussed here (in words with at least one heavy syllable).

Certain of the Uralic, Muskogean, and Northern Iroquoian prosodic systems are potentially problematic for a theory employing only feet without orthogonal grid marks. However, the finding that the metrical incoherence observed in Chickasaw is attributed to a mismatch not between primary and secondary stress but between phrasal pitch accent and word-level stress provides a template for possible reanalysis of other cases of metrical conflicts that have motivated Vaysman's (2009) theory invoking constraints on both feet and grid marks.

1.4 Metrical Incoherence in Other Languages

There are other cases of metrical incoherence in the literature that are found outside of the Uralic, Muskogean, and Northern Iroquoian language families that have been the subject of discussion in this chapter. The diverse nature of the metrical mismatches discussed in this section is representative of the heterogeneous character of those found cross-linguistically. Nevertheless, there are certain threads that appear to unite virtually all if not all cases of metrical incoherence with the caveat, of course, that the set of languages from which to draw generalizations is relatively small.

1.4.1 Tiberian Hebrew

The Uralic and Muskogean systems in which segmental diagnostics of metrical structure are projected from an iterative binary parse that conflicts with a "top-down" system of prominence have an analog in Tiberian Hebrew. A process of vowel deletion in Tiberian Hebrew (Prince 1975; McCarthy 1979; Dresher 1980, 1994, 2009; Rappaport 1984; Churchyard 1989) applies iteratively to the weak syllable in iambic feet constructed from right-to-left, whereas primary stress in prepausal forms is based on the construction of a trochee at the right edge of a word. Strikingly, a rule of vowel lengthening applies to the primary stressed vowel in prepausal words resulting in alternations between vowels that delete phrase-internally but are long prepausally. For example, the second vowel in the underlying form *ʔhaːr**a**guʔ* is deleted phrase-internally, i.e. *(hɔːr)(∅ɣúː)*, but is long phrase-finally, i.e. *(hɔː)(rɔ́ːɣuː)* "slew + 3pl" (Dresher 2009:217).

The Tiberian Hebrew case resembles Chickasaw (but differs from Nganasan and Eastern Mari) in that the segmental correlates of metrical structure shift in response to the top-down imposition of metrical structure. The confinement of metrical incoherence to prepausal forms in Tiberian Hebrew suggests that it is also related to a pitch accent as in Chickasaw.[3] The Tiberian Hebrew facts differ, however, from Chickasaw, Nganasan, and Eastern Mari in that both the prepausal prominence and the iterative metrical structure are oriented toward the same edge, the right edge in Tiberian Hebrew.

1.4.2 Huariapano

A metrical conflict that more closely mirrors the Nganasan and Eastern Mari cases is found in the Panoan language Huariapano (Parker 1994, 1998; González 2003, 2005, 2007; Bennett 2013a,b), in which primary stress is projected from a trochaic foot at the right edge of a word but a process of coda /h/ epenthesis before voiceless onsets (i.e. preaspiration) augments open odd-numbered syllables counting from the left edge. The foot structure suggested by epenthesis cannot be linked transparently to stress since the relationship between stress and epenthesis is not consistent. Epenthesis applies in all words even though secondary stress is lexically determined, falling on odd-numbered syllables in

[3] Dresher (2009) offers an account of the Tiberian Hebrew facts within a derivational framework using the simplified bracketed grid theory of Idsardi (1992, 2009) and Halle and Idsardi (1995).

certain words, e.g. *ˌpih.ko.ˈkaŋ.ki* "(they) left, went out" (Parker 1994:102), but on even-numbered syllables in other words, e.g. *ih.ˌkaʂ.tʃaŋ.ˈka.ti* "(you) would shake with fear" (Parker 1994:102). Furthermore, epenthesis applies in all odd-numbered syllables before the primary stress even in immediate pretonic position where an overarching ban on stress clash ensures that there is no secondary stress, e.g. *hæ.ˌjæ.jih.ˈkaŋ.ki* "(they) possessed, had" (Parker 1994:101).

Bennett (2013a,b) develops a synchronic analysis of Huariapano using only feet without recourse to orthogonal grid marks. He proposes that h-epenthesis is a process of fortition applying in the first syllable of a foot along the lines of foot-initial fortition in Alutiiq Yupik (see Section 1.2). To account for the fact that both words with alternating secondary stress on odd-numbered syllables and words with alternating stress on even-numbered syllables display the same distribution of epenthesis, Bennett proposes that feet may be either iambic or trochaic depending on the lexical item. In the default case, trochaic feet are constructed from left-to right, but lexical stress may override the trochaic preference. The same foot boundaries obtain in both cases: trochaic feet in (*ˌpih.ko.*)(*ˈkaŋ.ki*) "(they) left, went out" (Parker 1994:102) versus iambic feet in *(βis.ˌma.)(noh.ˌko.)(ja.ˈmaj)* "I have forgotten" (Bennett 2013a:376). Despite the difference in foot headedness, the process of h-epenthesis can be characterized as foot-initial for both stress patterns.

Assuming a shift in foot type, however, is inadequate to account for forms in which h-epenthesis applies in a syllable that is trapped between two flanking feet, e.g. *(hæ.ˌjæ.)jih.(ˈkaŋ.ki)* "(they) possessed, had" (Parker 1994:101). To handle these cases, Bennett proposes that the unparsed syllable is recursively adjoined to the following foot, i.e. *(hæ.ˌjæ.)(jih.(ˈkaŋ.ki)).* Under this approach, h-epenthesis can still be described as a foot-initial process as long as the foot referenced by the process is a maximal foot, i.e. a foot not-dominated by another foot.

Although this account handles the Huariapano data, it has mixed results in treating other cases of metrical incoherence. Setting aside Chickasaw, which demonstrably requires a pitch accentual analysis, and Hebrew, whose analysis is complicated by opacity attributed to vowel syncope, let us consider how Bennett's approach could be adapted to handle the other cases of metrical incoherence discussed in this chapter.

The Eastern Mari and the Northern Iroquoian data (at least some features of the data) are potentially amenable to an approach similar to Bennett's (2013a,b) account of Huariapano. Taking the Eastern Mari case as representative, one could assume that the foot containing the stressed syllable in Eastern Mari shifts its headedness in response to the location of the stress. For example, the foot type is trochaic in *(ˈjeŋə)-sə* "the one who is human" but iambic in *(okˈsa)-sə* "the one that is money."[4]

Potentially more problematic for Bennett's theory are the Nganasan data, since it is unclear how the foot structures necessary to account for the gradation alternations would be generated. The stress pattern suggests a right-to-left parse as in Huariapano, but this would yield the same foot structure at the right edge of both odd-parity and even-parity words consisting of all short noncentral vowels, even though the weak grade appears in the former and the strong grade in the latter: e.g. *ŋu(ˈhu-ðu)* "his/her/its mitten" versus *(ˌjama)(ˈða-tu)* "his/her/its animal." If a left-to-right parse with either recursive footing or a stray unparsed syllable were instead assumed, it would not be clear how to generate the difference in foot headedness between the two forms, i.e. the trochaic feet in *(ˌjama)(ˈða-tu)* versus the iambic foot in *(ŋuˈhu)-ðu* (with an unparsed syllable) or *((ŋuˈhu)-ðu)* (with recursive adjunction of the final syllable).

1.4.3 Typological Restrictions on Metrical Incoherence

Huariapano shares with the Uralic, Muskogean, and Northern Iroquoian cases discussed in this chapter a bidirectional metrical system combining a binary parse initiating at one edge with a single foot oriented toward the opposite edge. This split in directionality of metrical structure assignment is characteristic of most types of metrical incoherence, with the Tiberian Hebrew case being exceptional in orienting both metrical systems toward the right edge. Another possible instance of metrical incoherence attributed to two parses originating at the same edge is found in Southern Waskashan languages such as Makah (Werle 2002), in which two potentially different foot types located at the left edge govern stress and certain segmental alternations. However, the Southern Wakashan cases are plausibly amenable to a reanalysis that assumes a single foot-type for both stress and segmental properties if one allows for variable foot-headedness along lines similar to Bennett's (2013a) analysis of metrical conflicts in Huariapano.[5]

[4] A potential drawback to this analysis is that, if there is a single stress per word as Vaysman (2009) assumes, it requires stressless feet: e.g. the second foot of *(ˈjoŋə)(ləʃ-so)* "the one that is a mistake" and *(puˈʃaŋ)(gə-so)* "the one that is a tree." The adoption of stressless feet is shared with Vaysman's (2009) account.

[5] In and of itself the bidirectional nature of prosodic systems displaying metrical incoherence is not particularly unusual cross-linguistically, as there are many bidirectional stress systems in languages of the world. Goedemans (2010:661) reports a substantial minority of languages, 39 (8%), in the 510-language StressTyp database that assign primary and secondary stress from opposite edges of the word. Rather, the complexity of the systems entailing metrical incoherence stems from the fact that the orthogonal prosodic parses interact with each other to create alternations in one of the two systems of metrical structure. This contrasts with the more prototypical bidirectional systems in which the two metrical parses do not overlap.

Although there are apparently isolated cases, e.g. in Tiberian Hebrew and Southern Wakashan, of orthogonal metrical systems oriented toward the same edge, even these have in common with other incoherent systems their employment of only a single iterative metrical parse. What appear to be virtually unattested are systems with iterative foot construction simultaneously from both edges.[6] One language that has been described as potentially fitting this profile, Tübatulabal (Voegelin 1935; Heath 1977, 1981; Manaster Ramer 1992; Aion 2003; Bennett 2013b), appears to have only one productive iterative parse, the iambic parse originating at the right edge that is responsible for stress. A rhythmic vowel lengthening process that appears to be sensitive to a trochaic parse propagating from the left edge is subject to rampant exceptions and is rendered opaque by various other processes. As Bennett (2013b) suggests, the exceptions and the opacity effects cast doubt on the synchronic productivity of rhythmic vowel lengthening in Tübatulabal and suggest that the only productive metrical system in Tübatulabal is the right-to-left iambic parse. Indeed, Bennett (2013b) hypothesizes that a nonlocal alternation governed by iterative footing may be unlearnable as a phonological process if the foot structure that renders it recoverable diverges from the metrical system predicting stress. Under this view, the rhythmic lengthening pattern in Tübatulabal, which Heath (1977, 1981) argues is a vestige of an earlier left-to-right stress system, would be doomed to succumb to exceptions and opacity effects once a novel rhythmic stress system initiating at the opposite edge of the word were introduced. The difficulty of acquiring coexisting metrical systems may similarly have contributed to the morphologization of iambic lengthening in Koasati once a trochaic stress system was introduced.

I am aware of only one language, Jarawara (Dixon 2004), in which apparently productive segmental alternations are sensitive to feet originating at one edge (the left edge) while the stress system adheres to a (trochaic) parse propagating from the other (the right) edge. For example, Dixon (2004) describes an alternation between /i/ and /e/ in several suffixes and a handful of verbs, such that /i/ occurs in odd-numbered syllables, whereas /e/ occurs in even-numbered syllables (subject to certain other allomorphic complications). Thus, the suffix meaning "water" is realized as [fi] in the third syllable in *tokí**fi**wáhamáka* "he is now going away back to the water" but as [fe] in the second syllable in *kí**fe**wáma* "she is now going back to the water" (p. 40). The alternation cannot be explained in terms of the right-to-left trochaic parse governing stress since both occurrences of the morpheme are in unstressed syllables. Dixon

[6] There are languages, e.g. Lenakel (Lynch 1978), in which different words classes have different directions of iterative parsing but this cross-category (and thus cross-lexeme) inconsistency differs descriptively from the cases of word-internal incoherence discussed in this chapter and also likely presents less acute learnability challenges.

suggests that the metrically driven segmental alternations are a preservation of the original metrical system which is still the productive one for stress in Jarawara's close linguistic relatives, Jamamadí and Banawá, regarded by Dixon as "closely related dialects of a single language" sharing 95 percent of their vocabulary and very similar grammatical properties (p. 8). Assuming that the shift from a rightward to a leftward parse for stress is a recent innovation in Jarawara, one might predict that the segmental alternations that reflect vestiges of the original left-to-right footing system will become increasingly less productive and transparent over time. Indeed, there is some evidence for this progression already, as the /i/ versus /e/ alternation is confined to only a lexically marked subset of morphemes.

Regardless of the ultimate fate of the metrically driven segmental alternations, the existence of a language like Jarawara suggests that it is possible for speakers to acquire competing metrical parses originating at different edges of the word, even if such conflicted systems are cognitively dispreferred. The Jarawara system also constitutes the strongest piece of evidence in favor of a theory incorporating both feet and an orthogonal tier of grid marks since both the segmental alternations and stress are consistent with an iterative parse. In Jarawara, the feet yielding the segmental alternations are left aligned whereas the grid marks responsible for stress are laid down rhythmically, reflecting a combination of highly ranked anti-lapse and anti-clash constraints. The iterative nature of the stress pattern and the fact that Dixon explicitly states that the stress rule is bounded by the phonological word (p. 29) also make the prominence that is described as stress an unlikely candidate for re-analysis a pitch accent.

1.6 Conclusions

Although languages displaying metrical incoherence constitute a heterogeneous set in terms of their properties, there are nevertheless certain recurring traits found in many conflicted metrical systems. A definitional feature shared by all of them is the coexistence of orthogonal metrical systems, one for secondary stress and/or segmental alternations and one for a higher level of prominence. It is not clear in many cases whether this higher tier of prominence is primary word-level stress or phrasal pitch accent, though in the better documented cases of metrical incoherence (e.g. Chickasaw, Northern Iroquoian, and Tiberian Hebrew) there is evidence that the higher degree of prominence corresponds to a phrasal pitch accent. A topic for further research would involve exploration of other less well-described systems entailing metrical incoherence to determine whether the source of the conflict is also a mismatch between word-level metrical structure and phrasal pitch accent.

Another common feature of many conflicted metrical systems is their diachronic origin stemming from a prosodic shift in which an earlier metrical system has been supplemented by a newer one. This chain of events can be documented on the basis of comparative evidence for the three language families focused on in this chapter, Uralic, Northern Iroquoian, and Muskogean, as well as for at least certain other cases of metrical incoherence, e.g. Jarawara and Tübatulabal.

Languages diverge in their response to mismatched prominence systems. In certain languages, such as Chickasaw and Tiberian Hebrew, non-prosodic (segmental and/or morphological) correlates of metrical structure shift in response to the contextual variation in prominence. In other languages, such as the Uralic languages discussed here, as well as Huariapano and Jarawara, they remain linked to a single metrical system even when the prominence underlying this system shifts. Still other languages occupy a middle ground, in which the segmental properties simultaneously show sensitivity to both metrical systems. Thus, vowel lengthening in Cayuga and Seneca is still associated with the original locus of stress in Northern Iroquoian, the penultimate syllable, but also is sensitive to whether the penult occupies a metrically strong position according to the iambic system introduced later.

Cases of metrical incoherence also diverge in the types of metrical systems that are in competition with each other. In most cases, the divergent metrical systems are oriented toward the opposite edge of the word, an exception to this generalization being Tiberian Hebrew (and potentially Southern Wakashan) in which both word-level footing and phrasal accent are right-edge oriented. Furthermore, in most languages, only one of the competing metrical systems is iterative while the other consists of a single prominence. Presumably because of their reduced learnability, systems entailing two iterative parses appear to be quite rare and particularly prone to loss of productivity in the form of opacity, exceptions, and morphologization of properties attributed to one of the metrical systems.

It is precisely these vanishingly rare cases of multiple iterative parses that provide the strongest support for theories such as Vaysman's (2009) incorporating both constraints referring to feet as well constraints referencing the alignment of grid marks within feet and within words. The more common cases of metrical incoherence in which there is a single prominence oriented toward one edge coexisting with an iterative parse governing segmental or morphological alternations are potentially amenable to a reanalysis, as in Chickasaw, appealing to word-level feet and phrasal pitch accent. The extent to which a Chickasaw-type reanalysis is applicable to other cases of metrical incoherence remains an open issue requiring close phonetic and phonological investigation of individual languages. This examination would appear to be worthwhile since it has the potential to result in a simpler metrical theory employing ingredients that are already generally accepted.

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