ITERATIVE FOOTING AND PROMINENCE-DRIVEN STRESS IN NANTI (KAMPA)

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In this article we describe and develop an optimality-theoretic (OT) analysis of foot-level (secondary) and word-level (primary) stress in Nanti, a Kampa language of Peru. The distribution of stress in Nanti is sensitive to rhythmic factors, syllable quantity, vowel quality, and to whether a syllable is open or closed. The interaction of these independent variables produces a complex, multigrade stress scale married to an iterative stress system whose default preference is alternating, iambic rhythm. While each of the interacting factors in this system is familiar to phonologists, Nanti is special because the particular combination of influences and factors in Nanti contributes to a complexity of interactions that has not been documented in any other language to date.*

1. Introduction. Phonologists concerned with the behavior of iterative stress systems have long understood that syllables with certain special properties can attract stress out of sequence, perturbing the rhythmically alternating stress grid.[1] The most commonly encountered—and best understood—of these influences is syllable quantity: the preferential selection of heavy syllables (for example, syllables with long vowels) as hosts for stress in many metrical systems has formed the basis for many studies of quantity-sensitive stress in natural languages (Kiparsky 1973, Prince 1983, 1990, Hayes 1985 [1980], 1995, Halle & Vergnaud 1987, among many others). Much less common are systems that grade syllables into stress classes based on differences in the quality of their vowels. Some stress systems oppose peripheral and central vowels (e.g. Eastern Cheremis (Kiparsky 1973), Mari (Kenstowicz 1997), Sentani (Cowan 1965, Elenbaas 1996), Indonesian (Cohn 1989, Cohn & McCarthy 1994). The metrical systems of a few languages exploit finely graded distinctions in vowel height (e.g. Kobon (Davis 1981, Kenstowicz 1997, Elenbaas & Kager 1999; see also Gordon 1999)). Finally, a very few studies have documented the existence of stress systems with a three-way weight contrast, in which closed syllables represent an intermediate weight class between syllables with long and short vowels. In Kashmiri, for example, closed CVC syllables with a short vowel pattern as heavier than CV syllables, but lighter than any syllable with a long vowel: CVV(C) > CVC > CV (Bhatt 1989, cited in Kenstowicz 1994, Munshi & Crowhurst 2005).

Here we introduce to the phonological literature a stress system that unusually and to an unprecedented extent integrates each of the factors noted above. Nanti, a Kampa language of Peru (Beier & Michael 2001, Michael 2001), employs a multigrade stress scale according to which a syllable's stressability or metrical strength (likelihood of being stressed relative to other syllable types) is evaluated, taking into consideration:

- Vowel height (low, mid, or high)
- Whether the syllable's vocalic nucleus, if short, is a monophthong or a diphthong

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[1] In iterative metrical systems, stress is assigned on a repeating basis, though not necessarily in strict, binary alternation.

- Moraic quantity: syllables with long vowels are opposed to syllables with short vowels
- Whether the syllable is open or closed (a factor we analyze independently of a syllable's mora count).

The interaction of these independent variables—slightly different in the cases of word-level (primary) and foot-level (secondary) stress—produces complex stress scales married to an iterative stress system whose default preference is an alternating, iambic rhythm. While each of the interacting factors in this system is familiar from other languages, Nanti is special because the particular combination of influences and factors found in this language contributes to a complexity of interactions that has not been documented in any other language to date.

Nanti is a little-known language of the Kampa family, spoken by only 500 people in a small area of the Peruvian Amazon, so some preliminaries about its phonology are needed before a full description of the range of stress patterns can be undertaken; that description entails as well a discussion of secondary evidence supporting assumptions about the representation of syllables. We then develop an optimality-theoretic (OT) analysis of these stress patterns, which is an essential aspect of our analysis since we demonstrate that a purely derivational approach to the same facts fails to capture the generalizations as successfully as the OT account does. In particular, an OT analysis is more successful than derivational analyses in analyzing scalar systems such as that employed by Nanti's stress system. The ultimate value of examining the stress system of Nanti, then, is an enrichment of both typology and phonological theory.

A word about the organization of this article: the patterns described and analyzed here are complex, and much of the discussion, especially the OT analysis, is necessarily dense. Moreover, we anticipate that readers may be interested in different aspects of the article, some in the data and generalization alone, others in the formal analysis. For these reasons, we present a complete sketch of the data and generalizations first, in §§3–5, and defer the formal analysis to §6, referring back to relevant generalizations as necessary.

2. Preliminary remarks. The data cited in this paper are original data, elicited in the field by Lev Michael from 2000–2001. The data are drawn primarily from recorded texts for two reasons. First, it was critical to use only words not occurring in phrase-final position because the requirements of phrasal stress override those of word-level stress. Phrasal stress occurs on the penultimate syllable of the last word of the phrase, obscuring the regular pattern of word-level stress observed in other positions (see §4). For the same reason, citation forms cannot be used to illustrate word-stress patterns, because for some speakers, words elicited in isolation pattern as phrases for stress. Our transcriptions of word-level and foot-level stress are mainly based on the impressionistic judgments of the authors, especially of Lev Michael, who has done many years of fieldwork on Nanti and is a competent speaker. In addition, we have confirmed our stress transcriptions by referring to spectrograms, where necessary.

Nanti's vowel inventory includes the four short vowels [i, e, o, a] and the diphthong [ɯi], which patterns as a phonologically short vowel in the stress system. There are four contrastively long vowels, [ii, ee, oo, aa], and four diphthongs, [ai, ae, oi, ɯii], that pattern with them in the stress system. The phonetic inventories of vowels and consonants are shown in 1.

(1) a. Monomoraic vowels and diphthongs

i		ɯi
e		o
	a	

Bimoraic vowels and diphthongs

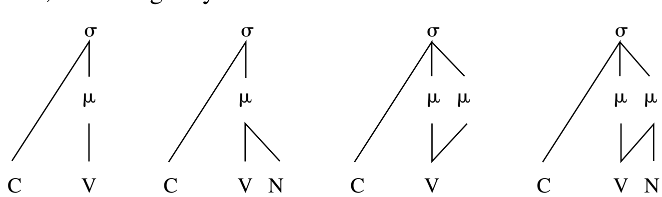
ii		ɯii
ee, ei		oo, oi
	aa, ai, ae	

b. Phonetic inventory of consonants

p b	p^j b^j	t	t^j	k g	k^j g^j	
		ts	tʃ	ks gz	kʃ gʒ	
		s	ʃ			h
m	m^j	n	n^j	ŋ		
w		r, r^j, l	j			

The Nanti syllable template is (C)V(V)(N), where VV is a contrastively long vowel or bimoraic diphthong and N is a nasal consonant. Onsets are obligatory for all syllables in Nanti, except for word-initial syllables. The presence or absence of onsets does not affect the distribution of stress. Where we refer to syllable types in this article, we use the notations CV, CVV, and so forth for all syllables with the specified rhyme structure, whether or not they have onsets. The only permissible syllable coda in Nanti is a nasal consonant, which must be homorganic to a following (voiceless) obstruent. Any syllable, independent of vowel length or whether a diphthong is present, may be closed, except for syllables at the right edge of the morphological word. (Closed syllables are presumably excluded from this position because there is no following obstruent to contribute place features for a nasal coda.[2]) We adopt the representations of syllable structure in 2, following Hayes 1989.

(2)



Note that closed CVN syllables are represented with only one mora in 2, as are light open CV syllables. The Nanti data presented below require this analysis because the open vs. closed distinction is a factor in the stress system INDEPENDENTLY of syllable quantity as it is usually defined. That is, the four-way syllable weight distinction (CVVN > CVV > CVN > CV) employed by Nanti's stress system cannot be due to mora count alone. An analysis that treats CVN syllables as light (monomoraic) is consistent with patterns found in KARINTAA, a Nanti verb art-form that counts moras. In Karintaa, CVN syllables and CV syllables pattern alike in counting as a single moraic unit, while CVV syllables count as two moras. (See Michael 2004 for a description.)

Finally, we note that the domain within which stress is assigned is not always coextensive with the morphological word. The stress domain may be followed by one or more metrically inert morphemes which are not included in the syllable count that determines the distribution of stress in the preceding string.[3] The set of

[2] Prosodic-word(PrWd)-final CVN syllables occur only when the metrically parsable string is followed by the metrically inert suffix *-mpi*. In such cases, /m/ is parsed as a coda to the last syllable of the PrWd.

[3] We use the term METRICALLY INERT MORPHEME as a more descriptively accurate alternative to the term CLITIC, which can be difficult to interpret.

metrical inert morphemes includes the person-marking suffixes *-ro* (3.NONMASC.OBJ), *-na* (1.OBJ), *-mpi* (2.OBJ), *-ri* (3.MASC.OBJ), the SUBORDINATING suffix *-ra*, and the COUNTERFACTUAL suffix *-me*. In our data set, as many as three metrically inert morphemes may follow the stress domain, so that it is possible for the rightmost stress to occur many syllables (a maximum of six) from the end of the morphological word. An example is given in 3. (In examples presenting data, the portion of a form of special interest is emphasized in bold.)

(3) tera ma.gàn.táem.pa.**ro.me.ra** → metrical parse: (ma.gàn)(táem.pa)].ro.me.ra
tera mag-ant-ah-empa-ro-me-ra
not sleep-INST-REGRESSIVE-IRREALIS.REFL-3.NONMASC.OBJ-COUNTERFACTUAL-SUBORD
'it is not the case that it would be slept in again' (said of a sleeping hut)

We take the stress domain to be the prosodic word (PrWd). In metrically parsed representations, the right edge of the PrWd is indicated with a square bracket.

3. FOOT-LEVEL STRESS. Stress assignment in Nanti is sensitive to the factors in 4, whose interaction determines the distribution of stress.[4]

(4) Properties to which Nanti stress is sensitive:

a. Rhythm	• Rhythm is iambic as opposed to trochaic, when possible. • Stress clashes are avoided when they can be.
b. Vowel quality	• Syllables with lower vowels are treated as more stressable than syllables with higher vowels, a > e,o > i. • The short [+high] diphthong [ɯi] is treated as more stressable than the [+high] monophthong [i].
c. Syllable closure	• Closed syllables are treated as more stressable than equi-moraic open syllables.
d. Syllable quantity	• Syllables with long vowels and long diphthongs are treated as more stressable than syllables with short vowels and [ɯi].

The contributions of these factors to stress placement are almost the same for word-level stress (reflected in patterns of primary stress assignment) and foot-level stress (reflected in the distribution of secondary stress). We begin with a description of the distribution of foot-level stress in Nanti in the remainder of §3. Descriptions of word stress and the influence of word-stress conditions on the syllable-to-foot parse are taken up in §4.

3.1. RHYTHM-BASED STRESS. In the absence of overriding factors (any of the factors in 4b–d), stress is assigned in iambic rhythmic alternation to Nanti words. This pattern is illustrated by the forms in 5, which contain only light open CV syllables and in which all syllables except for the last have vowels of the same height. The quality of the nucleus in a final CV syllable does not affect stress in such forms because final light syllables are never stressed in Nanti. Thus, bisyllabic CV.CV forms surface with initial stress, as in 5a,b. The examples in 5c–g show that in longer forms, stress is

[4] We refer to two syllables as EQUI-MORAIC if they have the same number of moras.

assigned to the second syllable from the left edge and alternatingly thereafter, excluding the ULTIMA (the last syllable of the phonological domain within which stress is assigned). In presentations of Nanti data throughout, phonetically transcribed representations with stress appear in the leftmost column. The prosodic parsings we assume appear in the second column. In parsed representations, parentheses enclose stress feet. (Foot boundaries coincide with syllable boundaries; otherwise, a period is used to indicate divisions between syllables.)

(5) Forms with CV syllables (] marks the right edge of the PrWd)

a. tá.ta	(tá.ta)]	'what.INTERROG'
b. ʃí.gze	(ʃí.gze)]	'run!'
c. o.gó.te.ro	(o.gó).te].ro	'she will know it'
d. no.né.he.ro	(no.né).he].ro	'I will see it'
e. i.pì.ri.ní.te	(i.pì)(ri.ní).te]	'he sits'
f. o.kò.wo.gó.te.ro	(o.kò)(wo.gó).te].ro	'she harvests it'
g. i.rì.pi.rí.ni.te	(i.rì)(pi.rí).ni.te]	'he will sit'

The distribution of stress in 5c–g is consistent with a pattern in which polysyllabic Nanti words are parsed iteratively into bisyllabic feet from the left, as shown in the second column. These examples motivate a basic preference for iambic as opposed to trochaic rhythm. The absence of stress on light ultimas and on the penult in forms of even-syllable parity is consistent with a tendency to avoid footing the ultima, that is, *(*i.rì*)(*pi.rì*)(*ni.té*)], and with a ban on DEGENERATE (monosyllabic) feet, *(*no.nè*)(*hé*)].*ro*, *(*i.rì*)(*pi.rì*)(*ní*).*te*]. Bisyllabic PrWds, with their pattern of initial stress, could be parsed either with a (universally marked) degenerate foot, for example, (*tá*).*ta*], or with a bisyllabic foot that violates the ban on PrWd-final feet, for example, (*tá.ta*)]. Anticipating the discussion in §4, we opt for the latter analysis. An observation supporting the bisyllabic parsing analysis (*tá.ta*)] is that there are no free monosyllabic forms in Nanti. (This NO-FINAL-FOOT effect is overridden not only in bisyllabic forms, but also under other circumstances to be discussed later.) This and other evidence to be discussed later are consistent with a general ban on parsing degenerate feet in Nanti.[5]

The basic pattern of left-to-right iambic stress illustrated in 5 can be overridden when a foot is immediately followed by a stressed syllable, as in 6a. Were any of the boldfaced feet (containing metrically equivalent syllables) to surface with iambic stress in these forms, the result would be a STRESS CLASH (the occurrence of adjacent stressed syllables). However, the examples in 6b show that a trochaic foot is NOT found when this alternative would produce a stress clash elsewhere at the left edge of the foot. Together, 6a and 6b show that trochaic stress may be assigned as a clash-avoidance strategy, but only if a stress clash CAN be avoided.[6]

(6) Stress clash, or potential stress clash contexts

a. Trochaic 'shift' as a clash-avoidance strategy

ò.ko.rì.kʃi.tá.ka	(**ò.ko**)(**rì.kʃi**)(tá.ka)]	'she wore a nose-disc'
nò.ko.gá.ko.ta.ro	(**nò.ko**)(gá.ko).ta].ro	'I asked about it'

b. Iambic stress when a trochaic foot would not avoid a stress clash

no.sà.me.rè.há.ka	(no.sà)(**me.rè**)(há.ka)]	'I got a blister'
no.kà.mo.sò.wá.ti	(no.kà)(**mo.sò**)(wá.ti)]	'I visited (by water)'

[5] Exceptions to the no-final-foot and no-degenerate-foot generalizations are discussed below.

[6] The forms in 6b are from Lev Michael's field notes, not from the main database of recorded forms used for this article. The 6b forms display a regular clause-final penult stress pattern.

The data in 6 motivate a stress scale RHYTHM, schematically represented in 7.

(7) RHYTHM: *Clash > Iambic rhythm > Trochaic rhythm

In rhythmic systems, a syllable's potential to attract stress is not associated with properties of the syllable itself, but is due instead to structural properties, such as the syllable's position in the foot. In addition to the influence of Rhythm in 7, however, Nanti's metrical system is also sensitive to phonological properties that distinguish syllable rhymes, with the result that syllables with these properties are treated as metrically stronger (i.e. more stressable) than other syllables, independent of their structural position. Ranking syllables in terms of the relative strength conferred on them as the result of extra-rhythmic, phonological properties results in a STRENGTH scale. In Nanti, Strength overrides Rhythm.

Evidence for sensitivity to extra-rhythmic phonological properties is provided by forms whose stress patterns are not consistent with the Rhythm scale. These departures are observed in cases where we find (i) feet with UNEXPECTED TROCHAIC STRESS, where trochaic stress cannot be explained as a strategy for clash avoidance (e.g. (*nò.ko*)(*gá .ko*).*ta*].*ro* in 6b), or (ii) feet with UNEXPECTED IAMBIC STRESS when a stressed syllable follows (e.g. (*ma.gàn*)(*táem.pa*)].*ro.me.ra* in 3), the context in which trochaic stress should be expected, based on the forms in 6. When a syllable in a foot attracts stress in a position not predicted to receive stress under the generalizations about rhythm just described, it is displaying greater relative strength than the other syllable in the foot. Explicit summaries of the logic for evaluating a syllable's relative metrical strength are provided in 8.

(8) a. Feet in nonclash contexts
- If in a foot, (σ_1 σ_2), σ_1 is stressed and trochaicity is unforced by independent factors (e.g. potential for stress clash), then $\sigma_1 > \sigma_2$.
- If in a foot, (σ_1 σ_2), σ_2 is stressed in the same context, we know only that $\sigma_1 \leq \sigma_2$ (i.e. $\neg$ ($\sigma_1 > \sigma_2$)) because Nanti's preferred rhythmic pattern is iambic.

b. Feet in (potential) stress clash contexts
- When a foot, (σ_1 σ_2), is followed by a stressed syllable, σ_1 is stressed when $\sigma_1 = \sigma_2$ (e.g. (o . . . o), (e . . . e)) or when $\sigma_1 > \sigma_2$.
- But if in a foot, (σ_1 σ_2), σ_2 is stressed when a stressed syllable follows, then $\sigma_1 < \sigma_2$.

In the rest of §3, we motivate the Strength scale by comparing the manner in which different qualitative and quantitative properties of syllable rhymes affect the relative strengths of syllables in nonprimary stress feet.

3.2. THE HEIGHT-BASED STRESS SCALE. The first stress-affecting property to be discussed is vowel height. When a foot combines syllables whose rhymes differ only in having vowels of different heights, stress falls on the syllable with the lower vowel. Thus, in a foot with two CV syllables, one with the rhyme [a] and the other whose rhyme contains [e, o, i], the syllable with [a] bears stress, even when this conflicts with the Rhythm scale in 7. Similarly, a syllable with a mid vowel [e, o] is stressed when the other syllable in the foot has the rhyme [i], other factors being equal. Examples illustrating these subpatterns appear in 9.[7]

[7] The notation PF after a cited form indicates phrase-final main stress (see §3.2). These forms are regular for secondary stress.

(9) a. Forms with ‘unexpected’ trochaic stress: $(\sigma_1 > \sigma_2)$
a > e nà.pʲe.ʃi.gò.pi.rè.já.kse (**nà.pʲe**)(ʃi.gò)(pi.rè)(já.kse)]
‘I rested’ (PF)
a > e à.bʲe.tsi.kái (**à.bʲe**)(tsi.kái)]
‘we.INCL made it again’
a > o à.wo.te.hái.gʒi.ri (**à.wo**)(te.hái).gʒi].ri
‘we approached him/them’
a > i à.tsi.to.ká.kse.ro (**à.tsi**)(to.ká).kse].ro
‘it crushed it’
a > i nà.bi.gʒi.tá.kse.ro (**nà.bi**)(gʒi.tá).kse].ro
‘I pick it (seed-like object) ouf of bag’
o > i nò.ʃi.po.ká.kse.ro (**nò.ʃi**)(po.ká).kse].ro
‘I doused it (a fire)’
o > i nò.gʒi.wo.tá.kse.ro (**nò.gʒi**)(wo.tá).kse].ro
‘I placed it (vessel) mouth down’

b. Iambic feet in a stress clash context: $(\sigma_1 < \sigma_2)$
a > o no.gà.pá.kɯi.ti (**no.gà**)(pá.kɯi).ti]
‘I let it go’
a > o no.tsà.róo.ga.kse (**no.tsà**)(róo.ga).kse]
‘I was startled’
a > i i.kà.mán.ta.na.ra (**i.kà**)(mán.ta)].na.ra
‘he tells me’
o > i pi.pò.ká.kse.na (**pi.pò**)(ká.kse)].na
‘you came to me’
o > i i.pò.ká.pai (**i.pò**)(ká.pai)]
‘he is coming towards’
e > i i.nè.já.ko.te.ro (**i.nè**)(já.ko).te].ro
‘he knows about it’
e > i nà.pʲe.ʃi.gò.pi.rè.já.kse (nà.pʲe)(ʃi.gò)(**pi.rè**)(já.kse)]
‘I rested’ (PF)
e > i i.nè.hái.ga.kʃi.ri.ra (**i.nè**)(hái.ga).kʃi].ri.ra
‘he saw him over there’

In each of the forms in 10, the bold-faced foot appears with trochaic stress immediately before a stressed syllable. A comparison of these forms with those seen earlier in 6 establishes that the mid vowels [e] and [o] in these CV syllables are treated as equivalently strong for stress.

(10) Mid vowels: [e] = [o]
nò.be.tá.kse.ro (**nò.be**)(tá.kse)].ro ‘I held onto it’
ò.re.wó.kʃi.ti.ro (**ò.re**)(wó.kʃi).ti].ro ‘it is wetted by rain’
(cf. no.né.he.ro (no.né).he].ro ‘I will see it’

Finally, the short diphthong [ɯi] patterns in parallel with the mid vowels [e, o] for stress. The forms in 11a show that [ɯi] concedes stress to an [a] rhyme. In 11b, we see that the short diphthong [ɯi] is treated as the metrical equivalent of [o].

(11) The short diphthong [ɯi]
a. [a] > [ɯi]
jà.mɯi.ta.kói.ga.kse.na (**jà.mɯi**)(ta.kói).ga.kse].na
‘they helped us with something else’

mɯi.tà.kói.ga.kʃim.pi.ra (**mɯi.tà**)(kói.ga).kʃim].pi.ra
'helped you with it'
i.rà.mɯi.tà.kói.ga.ksem.pa (i.rà)(**mɯi.tà**)(kói.ga).ksem].pa
'they.MASC will help someone with something'

b. [ɯi] = [o]
nò.tɯi.já.kse.ro (**nò.tɯi**)(já.kse)].ro 'I knocked it over'
nò.tɯi.gá.k^{j}e.ri (**nò.tɯi**)(gá.k^{j}e)].ri 'I blew tobacco powder into his nose'
(cf. no.tɯí.je.ro (**no.tɯí**).je].ro 'I will knock it over')

(We have no forms showing that [ɯi] is metrically equivalent to [e], or that [ɯi] is metrically stronger than [i]. However, since we have shown that [o] is metrically equivalent to both [e] and [ɯi], and that [o] > [i], it follows that [ɯi] = [e] and [ɯi] > [i] as well, assuming transitivity.)

The data in 9, 10, and 11 motivate a stress scale QUAL (for QUALITY-BASED STRESS SCALE), given in 12, which grades CV syllables with different vowel qualities into ranked stress classes. Qual subsumes two subscales: HEIGHT (12a) asserts that a syllable's strength increases as vowel height decreases. Second, DIPH (12b) expresses the subscale [ɯi] > [i]. Both [ɯi] and [i] are [+high] monomoraic vowel sequences. If [ɯi] is stronger than [i], then the difference in their metrical behavior could be attributed to differences in complexity: we hypothesize that a diphthong, consisting of a mora that branches to dominate two vowel root nodes, is stronger than a monophthong, which is dominated by a nonbranching vowel mora.

(12) QUAL scale: (a > e, o, ɯi > i)
(a) HEIGHT: LOW > MID > HIGH (e.g. a > e, o > i)
(b) DIPH: Diphthong > Monophthong (e.g. ɯi > i)
σμ > σμ
[−cons][−cons] [−cons]

Languages that employ Height scales as finely articulated as 12a are sparsely attested (but see Kenstowicz 1997). Though rare, such systems are phonetically grounded in that a vowel's height is directly related to its resonance, or intrinsic sonority. The sonority hierarchy grades vowels into classes that correspond to their natural height class: low vowels have high intrinsic sonority, mid vowels have less, and high vowels have low intrinsic sonority (Lehiste 1970, Prince & Smolensky 1993, Kenstowicz 1997). Stated a different way, the most stressable vowel [a] in Nanti is also the most sonorous vowel, and the least stressable vowel [i] is the least sonorous. The intermediate position of the mid vowels [e, o] in the Height scale is consistent with their position between low and high vowels in the sonority hierarchy. The scale Diph is plausibly grounded in phonetic generalizations as well: a complex or branching short vowel would be more phonetically salient than a short monophthong, due to the diphthong's vowel-to-vowel transitions and possibly also to its slightly greater duration. If so, then this greater salience seems to have become embedded in the Nanti grammar of stress by assigning [ɯi] greater strength than the high vowel [i].

One additional question concerns the connection between phonetic salience and stress and why a stress scale based on phonetic salience should override rhythmic requirements. The greater stressability of vowels of higher sonority or salience may be understood as a type of prominence enhancement or alignment. The head position of a metrical foot has structural prominence—a syllable with this function is prominent by virtue of its structural position independently of the syllable's physical properties. Many languages employ strategies of what we may call surface-to-structure prominence resolution: the surface (phonetic) prominence of syllables in structurally prominent positions is often enhanced, while the opposite happens in structurally weak (nonhead) positions. In English, vowels in stressed positions typically surface unreduced, while unstressed syllables undergo various processes of phonological reduction (Lehiste 1970, Pater 2000). In many languages, special (or marked) phonetic properties are restricted to positions that have structural prominence. To cite one of many examples, in Coatzospan Mixtec (Gerfen 1999), the features of nasalization, glottalization, and tone gravitate to the structurally prominent head position in a foot. The stress scales found in Nanti reflect a different type of prominence-resolution strategy: structurally prominent positions (metrical heads) gravitate to syllables whose constituents embody greater phonological prominence, the result of grammaticalizing (in the sense of incorporating into the phonological system) phonetic tendencies. The stress scales employed in Nanti do not refer to surface salience directly: contrastively long [ii] may be shorter in duration than short [a]—yet [ii] ranks higher on the stress scale by virtue of [ii]'s PHONOLOGICAL length.

3.3. BIMORAIC (HEAVY) SYLLABLES. Syllables containing contrastively long vowels and certain diphthongs attract stress out of the regular rhythmic sequence. Syllables with this property are generally analyzed as HEAVIER than the syllables they dominate in the hierarchy of stressability. We analyze the CVV syllables discussed in this section as having two moras, as opposed to the single mora assigned to CV (and CVN) syllables. The stress-attracting behavior of heavy, or bimoraic, syllables is well documented in the stress literature (e.g. Prince 1983, 1990, Hayes 1985 [1980], 1995, Halle & Vergnaud 1987, Idsardi 1992, to name a few).

As noted in §2, vowel length is contrastive in Nanti. The evidence for contrastive vowel length is that some vowels are always long, CV_iV_i, and attract stress when combined with a CV syllable, regardless of their position in a foot. The examples in 13a containing the root *-oog-* 'consume' with a contrastively long vowel demonstrate this effect. The location of (here, word-level) stress varies in these examples, depending on the CVV syllable's position in the foot. The stress behavior of forms containing the diphthongs [ai, ae, ei, oi, ɯii] is exactly parallel to the stress behavior of long-voweled syllables. Thus, we represent syllables containing these diphthongs with two moras as well, while contrastively short vowels have only one mora, on the surface as well as underlyingly. Examples illustrating the stress-attracting behavior of the diphthongs [ai] and [oi] appear in 13b.

(13)	a.	i.róo.ga.ksèm.pa.ro	(i.róo)(ga.ksèm).pa].ro	'he will have consumed it'
		nóo.ga.ksem.pa.ro	(nóo.ga).ksem.pa].ro	'I will have consumed it'
	b.	jo.bìi.kái.ga.kse	(jo.bìi)(kái.ga).kse]	'they.MASC drank'
		ja.máa.ta.kòi.ga.nà.kse	(ja.máa)(ta.kòi)(ga.nà).kse]	'they.MASC floated it away'

Thus, in all feet (primary and non-word-level) combining a light (CV or CVN) and a heavy syllable (CVV), the heavy syllable is given priority for stress. This generalization is captured by a new scale, QUANT (for QUANTITY-BASED STRESS), in 14.

(14) QUANT: $\sigma\mu\mu > \sigma\mu$

Note that in the form *jo.bìi.kái.ga.kse* in 13b, a heavy syllable *bii* combines with a light syllable *jo* in a non-word-level stress foot, demonstrating that a CV syllable concedes stress to a CVV syllable with a weaker vowel. This effect shows that Quant outranks the scale Qual motivated earlier.[8]

3.4. Closed syllables and the foot-level stress scale. Closed syllables containing a short vowel (CVN) also attract stress out of the usual sequence. Specifically, CVN syllables are given priority for stress over light CV syllables. However, this is not a heavy syllable effect such as that discussed in the last section: while CVN syllables make better stress peaks than CV syllables, they cede stress to CVV syllables. Thus, the stress behavior of CVN syllables cannot be accounted for by assigning them the same mora count as CVV syllables; we analyze CVN as monomoraic, parallel with CV syllables. The intermediate position of CVN syllables between CVV and CV syllables results in a multigrade stress hierarchy (CVVN) > CVV > CVN > CV, a highly unusual, perhaps hithertofore undocumented effect.

The examples in 15 illustrate the coda effect in non-word-level stress feet combining a CV and a CVN syllable: here, stress invariably falls on the closed syllable, even when the CV syllable contains a stronger vowel. Critically, the examples motivating *aN > a*, *oN > a*, and *iN > a* show that any CVN syllable is stronger than a CV syllable containing the strongest vowel, [a].[9]

(15) Closed syllables are treated as stronger than open syllables for foot-level stress

aN > a	àn.ta.mi.já.ta.kse 'it (underbrush) grew up'	(**àn.ta**)(mi.já).ta.kse]
aN > a	ma.gàn.táem.pa.ro.me.ra 'it (sleeping hut) would be slept in again'	(**ma.gàn**)(táem.pa)].ro.me.ra
oN > a	o.tá.sòŋ.ka.kse.ro 'she blew on it'	(o.tá)(**sòŋ.ka**).kse].ro
oN > o	òŋ.ko.wo.gó.te.ro 'she will harvest it'	(**òŋ.ko**)(wo.gó).te].ro
oN > e	kòn.te.ja.tá.gze.ta 'departed separately'	(**kòn.te**)(ja.tá).gze.ta]
iN > a	pìŋ.ka.mo.sói.ga.kse 'you.PL will have visited'	(**pìŋ.ka**)(mo.sói).ga.kse]
iN > e	ìŋ.kse.ma.wáe.ro 'he will listen attentively to it'	(**ìŋ.kse**)(ma.wáe)].ro
iN > e	pìŋ.kse.ma.wáa.kse.ro 'you will have listened attentively to it'	(**pìŋ.kse**)(ma.wáa).kse].ro

[8] We have no examples showing how stress behaves in (CVV.CVV) feet. Based on the behavior of (CV.CV) and (CVN.CVN) stress feet, however, we expect that stress assignment in a (CVV.CVV) foot would follow the same generalizations: stress should appear on the strongest vowel, if there is one; otherwise, rhythmic requirements should prevail.

[9] The form *(o.tá)(sòŋ.ka).kse].ro* has a different stress pattern than others seen so far, with primary stress assigned to a nonfinal foot *(o.tá)* (see §3.2). In this case, the critical observation is that the syllable *sòŋ* receives stress in trochaic position even though this results in a stress clash to the left, not the right, as in other forms seen earlier.

We have not unequivocally demonstrated that eN > a according to our criteria, but given the patterns established earlier, and given what we are able to show here, we assume that eN > a.

We treat the coda effect illustrated in 15 as an effect of the scale CODA, in 16, which is independent of both Qual and Quant. The stress behavior of CVN—weaker than CVV, but stronger than CV—motivates the meta-scale Quant > Coda > Qual in Nanti.[10] In 17, we see that when both syllables in a nonprimary stress foot are closed either (a) stress assignment is congruent with Qual (12), so that the peak coincides with the syllable containing the strongest vowel, or (b) stress is congruent with Rhythm (7) when the CVN syllables contain vowels of equivalent strength.

(16) CODA: CVN > CV

(17) a. (CVN.CVN) feet: stress is congruent with Qual

aN > oN	noŋ.kàn.tái.ga.kse 'we will have said'	(noŋ.kàn)(tái.ga).kse]
aN > iN	piŋ.kàn.tái.ga.kʲe.ri 'you.PL will have said to him'	(piŋ.kàn)(tái.ga).kʲe].ri
aN > iN	iŋ.kàn.tái.ga.kʃi.ri 'they.MASC will have told him'	(iŋ.kàn)(tái.ga).kʃi].ri
eN > iN	iŋ.ksèn.tá.kse.ro 'he will have pierced it (with an arrow)'	(iŋ.ksèn)(tá.kse)].ro

b. (CVN.CVN) feet: stress is congruent with Rhythm

oN = eN	nòŋ.ksen.tá.kse.ro 'I will have pierced it (with an arrow)'	(nòŋ.ksen)(tá.kse)].ro

To summarize, the evidence in §3.4 has been used to motivate the stress scale Coda (CVN > CV, a closed syllable is more stressable than an equi-moraic open syllable) and the meta-scale Quant > Coda > Qual for foot-level (nonprimary) stress. When stress assignment within a foot is not decided solely based on Coda because the foot contains two CVN or two CV syllables, the tie is resolved by Qual (especially Height). In feet whose syllables are not distinguished by Qual, stress is congruent with Rhythm.

3.5. SUMMARY AND PREDICTIONS: NONPRIMARY STRESS. We have described in this section the distribution of stress in nonprimary stress feet. If foot-level stress and word-level stress represent the realization of metrical prominence at distinct levels of structure, the foot and word levels, then stress in nonprimary stress feet unambiguously reflects constraints on metrical structure at the foot level. We have focused on patterns found in nonprimary stress feet in this section because, as we show in §4, foot-level metrical requirements can be overridden by conditions on stress assignment at the word level.

So far, we have shown that the parse in Nanti proceeds iteratively from left to right. Although iterative, the foot parse is generally not exhaustive: Nanti avoids assigning a foot at the right edge of the prosodic word and avoids degenerate feet. The dispreference for a final foot is overridden in bisyllabic words, for which we posit the parsing (σ́.σ)], and in other cases discussed in §4.

We have motivated the Rhythm scale, *Clash > Iambic > Trochaic, for Nanti: rhythm is iambic, unless a different result is required to satisfy overriding conditions.

[10] In truth, we have shown that Coda > Height. However, since the Diph scale is embedded in Qual, and Coda > [a], we assume that Coda trumps Qual.

Iambic rhythm is overridden when iambic stress would produce a stress clash. In these cases, stress may be assigned trochaically—unless the anti-clash requirement is overridden by an even stronger requirement, encoded in the Strength scale in 18. Strength subsumes four subscales. Height asserts that lower vowels are stronger than higher vowels, while Diph states that a (monomoraic) diphthong is more stressable than a monophthong. Together, Height and Diph form Qual, a stress scale based on vowel quality. Qual requirements override Rhythm. On the Strength scale, Qual is in turn overridden by Coda and Quant, whose requirements are summarized in 18.

(18) Integrated Strength scale (interim version)

STRENGTH			>	RHYTHM
QUANT $\sigma\mu\mu > \sigma\mu$		QUAL		
CODA CVN > CV	>	HEIGHT a > e, o > i DIPH ɯi > i	>	RHYTHM *Clash > Iambic > Trochaic

The integrated Strength scale in 18 is given as an interim version; its completion depends on data and arguments presented in §4. In particular, due to gaps in the foot-level stress data, we have not been able to rank Quant and Coda on the strength scale (i.e. show that CVN patterns as WEAKER than CVV), nor have we been able to demonstrate stress patterns in feet combining two CVV syllables.

To pin down firmly the prosodic behavior of CV, CVN, and CVV syllables in Nanti, and to posit representations consistent with this behavior, two points must be established. The first is that some prosodic phenomena in Nanti grade CV, CVN, and CVV syllables into two weight classes, with CV and CVN patterning as monomoraic, as opposed to bimoraic CVV. Second, even though CV and CVN syllables are moraically equivalent in our analysis, the stress system uses a more finely graded weight scale in which CVN is treated as stronger than CV but weaker than CVV. These arguments are completed based on word-level stress assignment patterns described in the next section. The result is a stress scale that captures the generalizations about the distribution of both foot-level and word-level stress in Nanti (§3 above and §4 below).

4. WORD-LEVEL STRESS. We complete the Nanti syllable Strength scale (18) based on patterns of word-level stress assignment in this section. In addition, we clarify the influence of word-level stress requirements on the metrical foot parse.

The simplest generalization that can be made is that word-level stress is assigned to the strongest syllable in the PrWd, if there is only one. Examples are given in 19.

(19) Primary stress on the strongest syllable, but not on a final light syllable

a. CV is strongest; the height-based scale decides

pi.ká.bi.rì.ti	(pi.ká)(bi.rì).ti]	'you get going/working'
i.nò.ʃi.já.g^{j}e.ti	(i.nò)(ʃi.já).g^{j}e.ti]	'he pulled multiple things'
no.n^{j}è.bi.tá.kse	(no.n^{j}è)(bi.tá).kse]	'I requested'

b. CV_iN is stronger than CV_i (co-indexing indicates metrically equivalent vowels)

na.mám.pi.jà.kse (na.mám)(pi.jà).kse]
'I helped/guided along (someone)'

i.páŋ.kʃi.wò.ha.tà.kse (i.páŋ)(kʃi.wò)(ha.tà).kse]
'he placed the house support' (lit. 'he planted the trunk')

c. Any CVV is stronger than any CV

nóo.ga.ka.ro	(nóo.ga).ka].ro	'I consumed it'
jóo.ga.kse.ro	(jóo.ga).kse].ro	'he consumed it'
i.róo.ga.ksèm.pa.ro	(i.róo)(ga.ksèm).pa].ro	'he will have consumed it'
i.róo.ga.ksèm.pa.ra	(i.róo)(ga.ksèm).pa].ra	'he will consume'
nóo.ka.na.kse.ro	(nóo.ka).na.kse].ro	'I discarded it'
i.pái.ta.kʃi.ri	(i.pái).ta.kʃi].ri	'he named him'
i.tì.sa.ráa.kse.ro	(i.tì)(sa.ráa).kse].ro	'he tore it'
no.kà.rái.ga.kse	(no.kà)(rái.ga).kse]	'we numbered'
nò.be.mái.ga.kse.ro	(nò.be)(mái.ga).kse].ro	'I folded it up'
mɯi.tà.kói.ga.kʃim.pi.ra	(mɯi.tà)(kói.ga).kʃim].pi.ra	'helped you with it'

d. CV_iVN is stronger than CV_iV

o.sà.ráan.tai.ga.kse	(o.sà)(ráan.tai).ga.kse]	'they.MASC tore it with a purpose'

The only exception to the STRONGEST generalization is that light ultimas (CV, CVN) are not stressed. The examples in 20 show that when a light ultima is the strongest syllable, word stress falls on the strongest syllable to the left.

(20) Light ultimas are not stressed

ì.ri.nó.ri.je	(ì.ri)(nó.ri).je]	'he will lie down'
no.tém.pa.ro	(no.tém).pa].ro	'I will inhabit it'
ná.sin.tem.pa.ra	(ná.sin).tem.pa].ra	'I will own'

In general, when two or more syllables tie for strongest in a PrWd, the rightmost is stressed, excluding a light ultima (21).[11]

(21) Rightmost nonfinal strongest wins

i.rò.gɯi.só.te	(i.rò)(gɯi.só).te]	'he will tie (it) together'
o.kò.wo.gó.te.ro	(o.kò)(wo.gó).te].ro	'she harvests it'
pa.mà.gze.tá.kse.na	(pa.mà)(gze.tá).kse].na	'you brought several to me'
iŋ.kàn.tán.ta.ksem.pa.ra	(iŋ.kàn)(tán.ta).ksem.pa].ra	'he will say that for a reason'

4.1. REFINING THE STRENGTH SCALE. Based on the generalization that word-level stress seeks out the strongest available syllable in a PrWd and based on the data in 19–21, we can refine the Strength scale introduced earlier by adding the following steps.

- Quant > Coda: The example *(i.róo)(ga.ksèm).pa].ra* in 19c shows that heavy open syllables pattern as stronger than light closed syllables, CVV > CVN.[12]
- CVVN > CVV: The example *(o.sà)(ráan.tai).ga.kse]* in 19d shows that heavy closed syllables pattern as stronger than heavy open syllables, establishing a four-step weight scale based on syllable structure alone: CVVN > CVV > CVN > CV.

[11] Forms such as *(sá.bi).ta.ka]* and *(no.nʲé).he.ri]* in 23 below present a different kind of exception to the Rightmost generalization.

[12] A form consistent with this scale, though not conclusive, is *(i.kà)(man.tái).ga.kse].na* 'they.MASC told me'.

First, *(i.róo)(ga.ksèm).pa].ra* shows unequivocally that CVV syllables are stronger than closed syllables, motivating Quant > Coda. The choice between *róo* and *ksèm* is not determined by Height, since *róo* and *ksèm* both contain mid vowels, but rather by the Quant scale $\sigma\mu\mu > \sigma\mu$, if CVN syllables are analyzed as monomoraic. However, *(o.sà)(ráan.tai).ga.kse]* shows that Coda makes a difference when the choice is between heavy syllables with vowels of equivalent strength. Based on these forms, we can now generalize that a syllable coda adds weight to a syllable, but not as much weight as a mora. That is, CVN syllables are metrically stronger than CV syllables but not as strong as CVV syllables, while CVVN syllables are descriptively even stronger than CVV syllables.

Finally, the examples in 22 are consistent with the generalization that when a PrWd contains two heavy syllables, word-level stress falls on the syllable with the vowel ranking highest on the strength scale. But stress falls on the CVV syllable even when a light CV syllable with a stronger vowel is available (e.g. *(i.róo)(ga.ksèm).pa].ra*, not **(i.ròo)(gá.ksem).pa].ra*). This pattern shows that Quant > Qual for word- as well as foot-level stress.

(22) Quant > Qual: Vowel quality determines choice between CVV syllables

aa > oi	ja.máa.ta.kòi.ga.nà.kse 'they.MASC floated [it] away'	(ja.máa)(ta.kòi)(ga.nà).kse]
aa > ii	i.tìŋ.ka.ráa.ʃii.gʒi 'they harvested thatch' (lit. 'they broke leaves')	(i.tìŋ)(ka.ráa).ʃii.gʒi]
ai ≥ ii	i.rò.bii.kái.ga.kse 'they.MASC will have drunk'	(i.rò)(bii.kái).ga.kse]
ai ≥ ii	jo.bìi.kái.ga.kse 'they.MASC drank'	(jo.bìi)(kái.ga).kse]
ai ≥ oo	noo.gái.ga.ro 'we ate it'	(noo.gái).ga].ro

In all other respects but one, the stress scale established earlier for foot-level stress is reflected in word-level stress patterns. The examples in 23 show more completely that in choosing between syllables containing different vowels but whose rhyme structures are otherwise equivalent, word-level stress assignment employs the Qual scale motivated for foot-level stress.[13] Note that the last two forms in 23a clearly establish that the light diphthong [ɯi] is equivalent to [o] on the word-level strength scale: the choice between one or the other in these forms depends on position.

(23) Qual decides (and if not Qual, then Rhythm)

a. CV syllables

a > o	nò.ko.gá.ko.ta.ro	(nò.ko)(gá.ko).ta].ro	'I asked about it'
a > o	ò.gɯi.sá.kse	(ò.gɯi)(sá.kse)]	'she lit a fire'
a > e	ná.me.kse.ro	(ná.me).kse].ro	'I will sharpen it'
a > ɯi	já.nɯi.ti	(já.nɯi).ti]	'he walked'
a > ɯi	sá.gɯi.te	(sá.gɯi).te]	'splash (it)!'
a > i	sá.bi.ta.ka	(sá.bi).ta.ka]	'fell/settled down (subject omission)'
o > i	ì.ri.nó.ri.je	(ì.ri)(nó.ri).je]	'he will lie down'
o > i	ì.ri.pó.kse	(ì.ri)(pó.kse)]	'he will come'
e ≥ o	no.nʲé.he.ri.ro	(no.nʲé).he.ri].ro	'I will definitely see him'
o = ɯi	no.tɯí.je.ro	(no.tɯí).je].ro	'I will knock it over'
o = ɯi	i.pó.kɯi.ti	(i.pó).kɯi.ti]	'he came briefly (then returned)'

[13] Some forms in 23 are parsed with a PrWd-final foot. Parsing issues are taken up below.

b. CVN syllables

a > o	òn.ta.ráŋ.ka.kse 'it (earth) will have slid'	(òn.ta)(ráŋ.ka).kse]
e ≥ o	noŋ.ksén.te 'I will pierce (with an arrow)'	(noŋ.ksén).te]

Incorporating the refinements just introduced, then, we may assume that the stress scales for foot- and word-level stress share the steps Quant > Qual > Rhythm.

The harmony scales for foot- and word-level stress differ only in the manner in which Coda (CV(V)N > CV(V)) interacts with Qual. In §3.4, we demonstrated that for foot-level stress, any closed CVN syllable patterns as stronger than any CV syllable, regardless of the qualities of their vowels (e.g. *(pìŋ.ka)(mo.sói).ga.kse]* in 15). Based on this pattern, we argued that Coda > Qual. This relationship between conflicting requirements is reversed in the case of word stress. The examples in 19b showed that a CVN syllable is assigned word stress instead of a CV syllable when their vowels are metrically equivalent (e.g. *(na.mám)(pi.jà).kse]* (22b), *(i.kà)(mán.ta)].na.ra)* (9b)). In contrast, 24 shows that in a PrWd containing a CV syllable whose vowel is stronger than that in CVN, CVN concedes word-level stress to CV.

(24) Qual > Coda: CV$_j$ > CV$_i$N when V$_j$ ≥ V$_i$

a > eN	á.p^{j}e.ʃi.jèm.pa.ra	(**á**.p^{j}e)(ʃi.**jèm**).pa].ra	'it (thatch) will decay'
a > eN	tso.tèŋ.ka.ná.ka.ra	(tso.**tèŋ**)(ka.**ná**).ka].ra	'(it) was finished up'
a > eN	nòŋ.ksen.tá.kse.ro	(nòŋ.ksen)(tá.kse)].ro	'I will pierce it (with an arrow)'
a > oN	òm.pi.tá.kse	(òm.pi)(tá.kse)]	'she will stay'
a > oN	nòm.pi.tá.kse	(nòm.pi)(tá.kse)]	'I will stay'
a > iN	pìŋ.ki.sá.kse.ra	(pìŋ.ki)(sá.kse)].ra	'you will hit'

Thus, the open-closed distinction is relevant for word-level stress patterns but is overridden by Qual. Since one condition cannot both override and be overridden by another requirement, we distinguish foot- and word-level versions of the Qual scale, Qual$_{PW}$ and Qual$_{FT}$, and rank them above and below Coda: Qual$_{PW}$ > Coda > Qual$_{FT}$.

Foot- and word-level stress requirements conflict in word-level stress feet combining a CVN syllable, the choice for foot stress, with a CV syllable that best satisfies the word-stress requirement. In such cases, word-level conditions prevail: the forms in 25 show that in word-level stress feet combining CV and CVN syllables, CV is stressed if its vowel is stronger.

(25) Word-level stress requirements take priority over foot-level stress requirements

iŋ.kó.gze	(iŋ.kó).gze] *(íŋ.ko).gze]	'he will want'
im.pó.kse	(im.pó).kse] *(ím.po).kse]	'he will come'
tsoŋ.ká.ta.ka	(tsoŋ.ká).ta.ka] *(tsóŋ.ka).ta.ka]	'(it is) finished up'

The point that foot-level stress requirements give way to word-level requirements is reinforced by stress alternations that depend on a form's phrasal position. In clause-final (CF) forms, the regular pattern of word-level stress is overridden by a phrasal pattern in which main stress is placed on the penultimate syllable of the morphosyntactic word. (In contrast to the word-level stress patterns discussed throughout this section, metrically inert suffixes are counted for phrasal stress.) The non-clause-final (NCF) version in 26a displays the expected pattern of word-level stress: in this form's only foot, the CVN syllable *ben* is rejected as a site for word-level stress in favor of *ná*, which has a stronger vowel. But in the CF form, where the main stress is penultimate, the foot (*na.bèn*) is demoted to nonprimary status and surfaces with stress on *bèn*. The pair in 26b shows that, as we would expect, when both the word-level and foot-level stress scales pick the same (CVN) syllable for stress, there is no difference in the rhythmic structure of the foot.

(26) Clause-final vs. non-clause-final stress

a.	NCF:	ná.ben.tem.pa.ro	(ná.ben).tem.pa].ro	'I will remain with it'
	CF:	na.bèn.tem.pá.ro	(na.bèn).tem.(pá)].ro)	
b.	NCF:	ko.gán.ta.ro	(ko.gán).ta].ro	'want it because (subject omission)'
	CF:	ko.gàn.tá.ro	(ko.gàn)(tá].ro)	

As a final example, 27 shows that foot-level stress requirements are not always overridden. In this example, the syllables *ta* and *ka* tie for strongest status. Assigning main stress to the rightmost of the two, *ka*, would not be consistent with the foot-level condition preferring CVN to CV as a stress peak.

(27) Foot-level stress requirements > rightmost stress
o.tá.sòŋ.ka.kse.ro (o.tá)(**sòŋ.ka**).kse].ro 'she blew on it'

The example in 27 shows that under these circumstances, foot-level stress requirements are preserved at the expense of rightmostness.

To conclude this section, we now propose the integrated stress scale for both foot- and word-level stress in 28.

(28) Integrated foot- and word-level stress scale

		STRENGTH					**>**	RHYTHM
								*Clash
		QUAL$_{PW}$				QUAL$_{FT}$		>
QUANT		HEIGHT$_{PW}$		CODA		HEIGHT$_{FT}$		Iambic
σμμ > σμ	**>**	Lo > Mid > Hi	**>**	VN]$_{\sigma}$	**>**	Lo > Mid > Hi	**>**	>
		DIPH$_{PW}$		>V]$_{\sigma}$		DIPH$_{FT}$		Trochaic
		Diph > Mon				Diph > Mon		

4.2. Word-level stress requirements and the foot parse. Having completed Nanti's stress scale (to the extent possible at present), we turn now to the influence of word-stress requirements on the foot parse.

We established at the beginning of §3.2 that word-level stress falls on the strongest syllable in the PrWd if there is a unique strongest syllable (e.g. (*no.nʲè*)(*bi.tá*).*kse*], (*i.páŋ*)(*kʃi.wò*)(*ha.tà*).*kse*]). The exception to this generalization, that light ultimas are not stressed (e.g. (*i.rì*)(*pi.rí*).*ni.te*], not *(*i.rì*)(*pi.rì*)(*ni.té*)]), suggests that stress on PrWd-final syllables is avoided (we refer to this ban as no-final-stress). Second, when there are multiple contenders for word stress, the examples in 21 display a bias for stressing the rightmost (excluding a light ultima).

In the forms of even-syllable parity in 29, the strongest syllable occurs to the left of the penult. Neither of the last two syllables of the PrWd is stressed in these examples, even though they could be parsed to a canonical bisyllabic secondary stress foot. This pattern suggests that Nanti avoids assigning not only stress but also foot structure at the right edge of a PrWd (an independent though related restriction, NO-FINAL-FOOT).

(29) No-Final-Foot

i.nò.ʃi.já.gʲe.ti	(i.nò)(ʃi.já).gʲe.ti]	'he pulled multiple things'
i.róo.ga.ksèm.pa.ro	(i.róo)(ga.ksèm).pa].ro	'he will have consumed it'
nóo.ka.na.kse.ro	(nóo.ka).na.kse].ro	'I discarded it'
i.pái.ta.kʃi.ri	(i.pái).ta.kʃi].ri	'he named him'
i.tìŋ.ka.ráa.ʃii.gʒi	(i.tìŋ)(ka.ráa).ʃii.gʒi]	'they harvested thatch'
i.rò.bii.kái.ga.kse	(i.rò)(bii.kái).ga.kse]	'they.MASC will have drunk'
iŋ.kàn.tán.ta.ksem.pa.ra	(iŋ.kàn)(tán.ta).ksem.pa].ra	'he will say that in order to'
o.sà.ráan.tai.ga.kse	(o.sà)(ráan.tai).ga.kse]	'they.NONMASC tore it with a purpose'

The enforcement of a No-Final-Foot ban is confirmed by examples representing an exception to the RIGHTMOST generalization. We have seen that in forms in which there is no unique strongest syllable, the rightmost bears word stress. However, the forms in 30 show that if assigning word-level stress to the rightmost strongest syllable would require assigning a foot at the right edge of the PrWd, then a syllable of equivalent strength further to the left is stressed instead.

(30) The rightmost strongest is not stressed if a word-final foot can be avoided

sá.bi.ta.ka	(sá.bi).ta.ka]	'fell/settled down (subject omission)'
no.né.he.ri.ro	(no.né).he.ri].ro	'I will definitely see him'
i.rì.pi.rí.ni.te	(i.rì)(pi.rí).ni.te]	'he will sit'
i.tò.gá.be.ta.ka	(i.tò)(gá.be).ta.ka]	'although he felled (a tree)'
ì.ti.má.ʃi.ta.kʲe.ri	(ì.ti)(má.ʃi).ta.kʲe].ri	'he ambushed him'
pá.tsi.pe.rè.ja.ka	(pá.tsi)(pe.rè).ja.ka]	'you suffered'
o.mòŋ.kse.já.ta.kse.ra	(o.mòŋ)(kse.já).ta.kse].ra	'where it (the river) is deep'

In contrast, penultimate stress in 31 is evidence that a PrWd-final foot is present. In these cases, the penult is stronger than any syllable further to the left, leading us to conclude that Strength overrides No-Final-Foot. The examples in 31b provide further evidence for No-Final-Stress: when the ultima and penult tie for strongest, stress is assigned to the penult.

(31) Penultimate stress in a PrWd-final foot

a. Penult is strongest

ò.gɯi.sá.kse	(ò.gɯi)(sá.kse)]	'she lit a fire'
pìŋ.kʃi.sá.kse.ra	(pìŋ.kʃi)(sá.kse)].ra	'you will have hit'
i.kà.mán.ti	(i.kà)(mán.ti)]	'he told'
nòŋ.ka.mán.te	(nòŋ.ka)(mán.te)]	'I will tell'
ì.ti.mái.gʒi	(ì.ti)(mái.gʒi)]	'they.MASC live/exist'
i.kà.rái.gʒi	(i.kà)(rái.gʒi)]	'they.MASC measure (intransitive)'
nò.nʲe.bíi.gʒi.ri	(nò.nʲe)(bíi.gʒi)].ri	'we.EXCL request from him'
nò.ʃi.gà.ʃi.gáa.ta	(nò.ʃi)(gà.ʃi)(gáa.ta)]	'I ran away'

b. Penult = ultima; final stress is avoided

ì.ri.pó.kse	(ì.ri)(pó.kse)]	'he will come'
i.pè.gá.ka	(i.pè)(gá.ka)]	'he changed'
i.pò.kái.gai	(i.pò)(kái.gai)]	'they.MASC came back'
ì.ʃi.gái.gai	(ì.ʃi)(gái.gai)]	'they.MASC ran back'

The facts we have assembled in this section suggest the following generalizations, beginning with the foot parse. Footing is bisyllabic and iterative, but not exhaustive, as Nanti enforces restrictions against (i) degenerate feet (No-Degenerate-Foot, e.g. (*i.rì*)(*pi.rí*).*ni.te*] (5) not *(*i.rì*)(*pi.rì*)(*ní*).*te*]) and (ii) PrWd-final feet (e.g. *(*i.rì*)(*pi .rì*)(*ni.té*)]). This generalization can be expressed as No-Degenerate-Foot, No-Final-Foot > Exhaustivity. No-Final-Foot is sacrificed, if parsing a final foot allows word stress to be placed on the strongest syllable in the PrWd (cf. (*i.pè*)(*gá.ka*)]) (31b) suggesting that Strength > No-Final-Foot. However, even though No-Final-Foot gives way to Strength, an independent restriction against placing stress on PrWd-final syllables is more resistant: even in forms with a final foot, main stress falls on the penult rather than on the ultima (e.g. (*i.pè*)(*gá.ka*)]). And forms like (*i.rì*)(*pi.rí*).*ni.te*] show that an ultima repels stress, even when it is the strongest syllable in the PrWd.

However, the No-Final-Stress generalization does have regular exceptions, some of which appear in 32. These examples show that main stress is REGULARLY assigned to a CVV ultima when it is the strongest syllable in the PrWd. In the examples in 32a, the stressed CVV syllable is the ultima of a PrWd of even-syllable parity and can therefore be parsed to a canonical bisyllabic foot. In 32b, in contrast, the stressed CVV syllable terminates an ODD-syllable-parity PrWd; the metrical parse in these cases must allow a degenerate (monosyllabic) foot—a pattern not seen until now.

(32) Primary stress on final CVV, CVVN

a. PrWds of even-syllable parity: no degenerate feet

po.kái	(po.kái)]	'came back'
à.bʲe.tsi.kái	(à.bʲe)(tsi.kái)]	'we.INCL made again (transitive)'
i.ʃì.ga.nái	(i.ʃì)(ga.nái)]	'he ran away'
ìŋ.kse.ma.báe.ro	(ìŋ.kse)(ma.báe)].ro	'he will listen to it'
nò.pi.ga.nái.ro	(nò.pi)(ga.nái)].ro	'I return it'
nà.wo.wɯi.tái.ro	(nà.wo)(wɯi.tái)].ro	'I re-sew it'
i.nè.ja.wáim.pi.ra	(i.nè)(ja.wáim)].pi.ra	'he sees you.FOCUS' (= 'he bids you farewell')

b. PrWds of odd-syllable parity: a degenerate foot is required

gái.ro.me	(gái)].ro.me	'(someone) would take it back'
ì.pi.gái	(ì.pi)(gái)]	'he returns'
pò.wo.tʲéi	(pò.wo)(tʲéi)]	'you shoo away (an animal)'
nòm.pi.gáe	(nòm.pi)(gáe)]	'I will return'
i.tsà.hái.ro	(i.tsà)(hái)].ro	'he reties it'
ìm.po.kái.ra	(ìm.po)(kái)].ra	'he will come back'
nò.ne.háem.pi	(nò.ne)(háem)].pi	'I will see you again'
i.rò.wà.ti.káe.ni	(i.rò)(wà.ti)(káe)].ni	'he will build her (a house)'
nò.gʒi.wò.re.hái.ro	(nò.gʒi)(wò.re)(hái)].ro	'I turned it (a vessel) back upright'

The appearance of final stress in 32 is not due to a requirement that heavy syllables in general should receive stress. Sequences of heavy syllables are not stressed in Nanti unless they occur in different feet (e.g. (*jo.bìi*)(*kái.ga*).*kse*] (22)). Forms such as (*i.rò*) (*bii.kái*).*ga.kse*] (22) and (*ì.ʃi*)(*gái.gai*)] (31b) have shown that when CVV syllables cooccur in a foot, only one is stressed. Moreover, in (*i.tìŋ*)(*ka.ráa*).*ʃii.gʒi*] (22) the heavy penult does not receive even foot-level stress when a stronger syllable to the left takes main stress, consistent with our generalization that PrWd-final foot structure is not assigned unless compelled by overriding factors discussed above.

As a concluding comment before leaving this section, we note that many of the examples we saw in §3, for example, (*i.rò*)(*bii.kái*).*ga.kse*], (*o.sà*)(*ráan.tai*).*ga.kse*] (19d), and (*ì.ʃi*)(*gái.gai*)], emphasize an interesting fact about Nanti's rhythmic structure: Nanti is an atypical iambic stress language in at least three ways. First, trochaic feet are routinely tolerated, under conditions described earlier. Second, foot parsing is QUANTITY-INSENSITIVE, in that footing is rigidly bisyllabic, even if this means tolerating a heavy syllable in both branches of a foot. In typical iambic languages (including Asheninca Kampa; Payne 1990), a form like (*i.rò*)(*bii.kái*).*ga.kse*] would be parsed as *(*i.rò*)(*bìi*)(*kái*).*ga.kse*], with a foot boundary after each heavy syllable. And third, while the assignment of headship within the foot is QUANTITY-SENSITIVE in that heavy syllables are assigned stress regardless of their position within the foot, Nanti does not display the effect of vowel lengthening under stress (IAMBIC LENGTHENING) found in many iambic stress languages (Hayes 1995, Buckley 1998): the phonological weight of light syllables with stress is not augmented on the surface in Nanti. The Nanti foot is a poor fit with the universal inventory of foot structures proposed by Hayes (1995), conforming to neither the Hayesian iamb nor the bisyllabic trochee. If Hayes's foot inventory (the bisyllabic trochee ($\acute{\sigma}\ \sigma$), moraic trochee ($\acute{\mu}\ \mu$), and uneven iamb ($\sigma\mu$ $\sigma\mu\acute{\mu}$)) is viewed as an inventory of UNMARKED—as opposed to the only possible—foot structures, then the Nanti foot appears as a highly marked alternative. Explanations as to why Hayes's feet occur so much more commonly than other kinds of feet are offered by Hayes 1995 and Kager 1994, 1999, among other works.

5. SUMMARY OF PATTERNS. Before moving on to the analysis in §6, we pause to review the stress and parsing patterns described in §§3 and 4, beginning with a summary of foot-level stress patterns.

Stress is assigned to the strongest syllable in a foot, whatever its position, where syllable strength is defined by the stress scale Strength (33). Strength breaks down into three subscales: Quant (a scale based on syllable quantity), Coda (strength is determined by the presence or absence of a syllable coda), and Qual_{FT} (a scale grounded in vowel quality). Qual subdivides further into two subscales, $\text{Height}_{\text{FT}}$ and Diph_{FT} (for DIPHTHONG).

(33) Foot-level Strength scale

QUANT		CODA			QUAL_{FT}
$\sigma\mu\mu > \sigma\mu$	**>**	$\text{VN}]_\sigma > \text{V}]_\sigma$	**>**	$\text{HEIGHT}_{\text{FT}}$	Low > Mid > Hi
				DIPH_{FT}	Diph > Mon

The schematic Strength scale in 33 expands to the full scale in 34. Although we are not able to provide direct evidence for every grade in 34, all of them are predicted.

(34) Expanded foot-level Strength scale

CaaN		CeeN, CeiN				Caa		Cee, Cei		
CaVN	>	CooN, CoiN	>	CiiN	>	CaV	>	Coo, Coi	>	Cii
		CɯiiN						Cɯii		

				CeN						Ce		
>	CaN	>		CoN	>	CiN	>	Ca	>	Co	>	Ci
				CɯiN						Cɯi		

The scales in 33 and 34 are a refinement of the interim scale in 17: they grade bimoraic CVV syllables as stronger than monomoraic closed CVN syllables based on the behavior of CV syllables in the stress system, as we have seen. CVVN syllables are graded as stronger than CVV syllables based the selection of *ráan* instead of *tai* for word stress in (*o.sà*)(*ráan.tai*).*ga.kse*].[14]

When neither syllable in a foot is stronger than the other, foot-level stress is distributed according to rhythmic principles. Nanti generally prefers iambic to trochaic rhythm, but this preference is overridden by an anti-clash requirement. These generalizations are expressed as the Rhythm scale, repeated in 35a. Merging Rhythm with Strength describes the complete foot-level stress scale, shown in 35b.

(35) a. Rhythm
*Clash > Iambic rhythm > Trochaic rhythm
b. Foot-level stress scale (ultimate): Strength and Rhythm
Strength > Rhythm

Word-level stress is assigned to the rightmost strongest syllable in the PrWd. The scale that grades syllables for word stress overlaps almost completely with the foot-level Strength scale. The difference is that for word stress, vowel quality is more important than whether or not a coda is present. Closed syllables pattern as stronger than equi-moraic open syllables only when they contain vowels of equivalent strength. The result can be understood by comparing the expanded word-stress scale in 36 with the corresponding foot-level scale in 34.

(36) Expanded word-level Strength scale

CaaN		Caa		CeeN, CeiN		Cee, Cei				
CaiN	>	Cai	>	CooN, CoiN	>	Coo, Coi	>	CiiN	>	Cii
CaeN		Cae		CɯiiN		Cɯii				

					CeN		Ce					
>	Can	>	Ca	>	CoN	>	Co	>	CiN	>	Ci	
					CɯiN		Cɯi					

We captured this difference between the foot- and word-level Strength scales by ranking foot- and word-level versions of Qual above and below Coda in Strength. The resulting scale, 37, represents the integrated foot- and word-level Strength scale. (The internal structure for each component of Strength has been defined elsewhere.) This ranking is also consistent with the fact that word-stress conditions override foot-stress conditions when there is a conflict.

(37) Integrated foot- and word-level Strength scales
$\text{Quant} > \text{Qual}_{\text{PW}} > \text{Coda} > \text{Qual}_{\text{FT}}$

[14] As we have no reason to assume that the word- and foot-level stress scales treat CVVN and CVV differently, we assume that CVVN > CVV for both.

In the assignment of word-level stress, a number of regular exceptions to the Strongest and Rightmost subgeneralizations are taken as responses to positional and parsing requirements. The generalizations discussed in §4 are as follows. Syllables are exhaustively parsed to feet, but a PrWd-final foot is avoided: No-Final-Foot > Exhaustive footing. However, we do find a PrWd-final foot when one is needed to place word stress on the strongest syllable: Qual$_{PW}$ > No-Final-Foot. Even when a bisyllabic final foot is present, though, stress tends to fall on the penult; a light ultima is not stressed, even when it is the strongest syllable in the PrWd: No-Final-Stress > Qual$_{PW}$. However, a heavy ultima does receive word stress when it is the strongest syllable in the word: Quant > No-Final-Stress. Finally, when more than one syllable in a PrWd is eligible for word stress (based on Strength), word stress falls on the rightmost, but not if this would require parsing a foot at the right edge of the PrWd: No-Final-Foot > Rightmost. The metrical priorities reflected by these generalizations are captured by the scale in 38.

(38) Parsing, word-stress position, and Strength

Quant	>	No-Final-Stress	>	Qual$_{PW}$	>	No-Final-Foot	>	Exhaustive footing, Rightmost

In the next section, we develop a formal analysis of the metrical patterns described and summarized in §3.

6. An optimality-theoretic analysis of Nanti stress rhythms. As we have seen, generalizations about the distribution of foot- and word-level stress are naturally expressed by referring to a number of stress scales, rhythmic constraints, and a complex set of hierarchically organized interactions that hold among these various components of the metrical grammar. The analysis developed in this section employs the framework of optimality theory because the architecture of this model is especially well suited for characterizing scalar systems in which some phonological requirements override others. We emphasize that with the exception of Coda, none of the scales assumed by our analysis is new: each is robustly supported in the literature on stress and syllable structure (Dell & Elmedlaoui 1985, Prince & Smolensky 1993, Kenstowicz 1997). Moreover, most of the constraints employed in our analysis have been proposed in the OT and pre-OT literature, although the form in which some of these constraints appear may differ. What is new is the evidence that the diverse set of stress scales we discuss and analyze are all necessary and interact in a particular and previously undocumented way in a single stress system. Thus, the description and analysis presented in this article both support and build on earlier work.

We begin in §6.1 with an analysis of Nanti's foot-level stress patterns, including the basic rhythmic properties of iambic prominence and clash avoidance and the conditions on stress that override these basic requirements. Patterns of word-level stress assignment are analyzed in §6.2. As we have shown, some aspects of the metrical foot parse are determined by top-down constraints on word stress. For this reason, a treatment of the foot parse is postponed until §6.3, following the analysis of word stress, to facilitate its exposition.

6.1. Strength and rhythm: foot-level stress requirements. In this section, generalizations about a syllable's relative suitability to serve as the peak of a foot (as compared with other syllables) are expressed in terms of stress scales. For example, the Rhythm scale most recently seen in 35a asserts that *Clash > Iambic rhythm > Trochaic rhythm. In the analysis to follow, stress scales are implemented using subhierarchies of ranked peak-prominence or rhythm constraints. To distinguish the stress scales in §§3 and 4 (which express descriptive generalizations) from the formal analysis, constraint subhierarchies are given names matching the corresponding scale, followed by PK (for PEAK). Thus, the Rhythm scale corresponds to the constraint subhierarchy RHYTHMPK.

RHYTHM. A standard OT analysis of the Rhythm scale employs the constraints FOOTFORM(IAMB) (39a), FOOTFORM(TROCHEE) (39b), and *CLASH.[15] The constraint rankings required for Nanti produce the subhierarchy RHYTHMPK.

(39) RHYTHMPK: *CLASH » IAMB » TROCH
Effect: clashing stress is avoided, even at the expense of iambic rhythm, which is otherwise more optimal than trochaic rhythm.
a. FOOTFORM(IAMB): ALIGN-RIGHT(Foot, Head(Ft)) (a.k.a. IAMB)
The right edge of every foot coincides with the same edge of its head. (one * for every foot whose head is not aligned with the right edge)
b. FOOTFORM(TROCHEE): ALIGN-LEFT(Foot, Head(Ft)) (a.k.a. TROCH)
The left edge of every foot coincides with the same edge of its head. (one * for every foot whose head is not aligned with the left edge)
c. *CLASH: Stressed syllables do not occur adjacently. (one * for every pair of adjacent, stressed syllables)

The tableau for (*i.rì*)(*pi.rí*).*ni.te*] in 40a illustrates the analysis of iambic footing in a no-clash context, while that for (*ò.ko*)(*rì.kʃi*)(*tá.ka*)] in 40b shows trochaic footing in the clash context.

(40) RHYTHMPK: *CLASH » IAMB » TROCH

a. Iambic rhythm

i.ri.pi.ri.ni.te]	*CLASH	IAMB	TROCH
i. ☞ (i.rì)(pi.rí).ni.te]			**
ii. *(ì.ri)(pi.rí).ni.te]		*!	*
iii. *(ì.ri)(pí.ri).ni.te]		*!*	

b. Trochaic stress as a clash-avoidance strategy

o.ko.ri.kʃi.ta.ka]	*CLASH	IAMB	TROCH
i. ☞ (ò.ko)(rì.kʃi)(tá.ka)]		***	
ii. *(o.kò)(ri.kʃì)(tá.ka)]	*!	*	**
iii. *(o.kò)(rì.kʃi)(tá.ka)]	*!	**	*

Note that (*ò.ko*)(*rì.kʃi*)(*tá.ka*)] (6a) displays a DOUBLE-BUMP phenomenon in which clash-avoiding trochaic stress in the first two feet is conditioned by trochaic stress in the third foot. By contrast, in a form such as (*no.kà*)(*mo.sò*)(*wá.ti*)] (6b), Strength precludes trochaic stress in the first foot, so that a stress clash cannot be avoided. In

[15] IAMB, TROCH, *CLASH, and other similar OT constraints (see e.g. Prince & Smolensky 1993, McCarthy & Prince 1993a, Kager 1999) have antecedents in Prince 1983, Hammond 1984, Hayes 1985, Halle & Vergnaud 1987, Kager 1989, and other early work in metrical theory.

this case, the second foot surfaces as iambic, because a trochaic second foot would do nothing to minimize violations of *CLASH (41).

(41) a. RHYTHMPK: Iambic rhythm when avoiding a clash is not possible

no.ka.mo.so.wa.ti]	*CLASH	IAMB	TROCH
i. ☞ (no.kà)(mo.sò)(wá.ti)]	*	*	**
ii. *(no.kà)(mò.so)(wá.ti)]	*	**!	*

b. Ranking arguments:

IAMB » TROCH (i.rì)(pi.rí).ni.te], not *(ì.ri)(pí.ri).ni.te], (no.kà)(mo.sò)(wá.ti)], not *(no.kà)(mò.so)(wá.ti)]

*CLASH » IAMB (ò.ko)(rì.kʃi)(tá.ka)], not *(o.kò)(ri.kʃì)(tá.ka)]

VOWEL QUALITY AND FOOT-LEVEL STRESS. Next, we turn to an analysis of the qualitative and quantitative influences on foot-level stress expressed in the Strength scale in 33. Our analysis employs constraints in the PEAK PROMINENCE family (Prince & Smolensky 1993, Kenstowicz 1997), each an instantiation of the schema in 42.

(42) Peak-prominence schema

*P/α: Stress peaks with property α are forbidden. (one * per stressed σ with property α)

As noted earlier, the portion of the Strength scale based on vowel quality, Qual_{FT}, should be formally separated into two subscales. The $\text{Height}_{\text{FT}}$ scale is implemented by $\text{HEIGHTPK}_{\text{FT}}$, using the constraints and rankings in 43. Using natural height classes allows us to represent the scale Low > Mid > High as a continuum of discrete, graded categories using binary features.

(43) $\text{HEIGHTPK}_{\text{FT}}$: *P_{FT}/HI » *P_{FT}/MID » *P_{FT}/LO

Stress on a high vowel is less optimal than stress on a mid vowel; stress on a mid V is less optimal than stress on a low vowel.

a. *P_{FT}/HI: No foot peak has a [+high, −low] vowel. (one * per stressed [i] in a foot)

b. *P_{FT}/MID: No foot peak has a [−high, −low] vowel. (one * per stressed [e,o] in a foot)

c. *P_{FT}/LO: No foot peak has a [−high, +low] vowel. (one * per stressed [a] in a foot)

The second subscale subsumed by Qual_{FT}, Diph_{FT}, encodes a generalization that light diphthongs, in this case [ɯi], are stronger than light monophthongs. In our analysis, the corresponding subhierarchy, $\text{DIPHPK}_{\text{FT}}$, employs the constraints *P_{FT}/MON and *P_{FT}/DIPH in 44. The analysis is based on the hypothesis that a mora that branches to dominate a sequence of vowels should be more phonetically salient than a mora dominating only one vowel root node.

(44) $\text{DIPHPK}_{\text{FT}}$: *P_{FT}/MON » *P_{FT}/DIPH

Effect: Stress on a monophthong is less optimal than stress on a diphthong.

a. *P_{FT}/MON: No foot peak has a nuclear mora dominating a single [−consonantal] root node. (one * per stressed monophthong, e.g. [i], in a foot)

b. *P_{FT}/DIPH: No foot peak has a nuclear mora dominating two [−consonantal] root nodes. (one * per stressed light diphthong, in this case [ɯi], in a foot)

The Height and Diph scales are phonetically grounded in generalizations about sonority, and our analysis employs peak-prominence constraints and rankings that reproduce the relevant portions of the sonority hierarchy. Sonority-based peak-prominence constraints were originally proposed by Prince and Smolensky (1993:129ff.) to account for sonority-driven syllabification in Imdlawn Tashlhiyt Berber (Dell & Elmedlaoui 1985). Kenstowicz (1997) was the first to extend this type of peak-prominence hierarchy (or at least, the appropriately elaborated vocalic end of it) to the domain of the foot.[16]

HEIGHTPK$_{FT}$ in 43 defines the high vowel [i] as a less optimal foot peak than a mid vowel [e, o] and either of these, in turn, as less optimal foot peaks than the low vowel [a]. The tableau in 45 for *(no.ʃi)(po.ká).kse].ro* shows how HEIGHTPK$_{FT}$ selects the lowest vowel in a foot as the stress peak.

(45) HEIGHTPK$_{FT}$: *P$_{FT}$/HI » *P$_{FT}$/MID » *P$_{FT}$/LO

no. ʃi.po.ka.kse].ro	*P$_{FT}$/HI	*P$_{FT}$/MID	*P$_{FT}$/LO
a. ☞ (nò. ʃi)(po.ká).kse].ro		*	*
c. *(nò. ʃi)(pó.ka).kse].ro		**!	
b. *(no. ʃì)(po.kà).kse].ro	*!		*

The tableau in 46 shows that DIPHPK$_{FT}$ (44) selects [ɯi] as the stress peak in a foot whose syllables have the rhymes [ɯi] and [i].[17]

(46) DIPHPK$_{FT}$: *P$_{FT}$/MON » *P$_{FT}$/DIPH

(ɯi … i)	*P$_{FT}$/MON	*P$_{FT}$/DIPH
a. ☞ (ɯ́i … i)		*
b. *(ɯi … í)	*!	

Next, we argue that the interaction of HEIGHTPK$_{FT}$ and DIPHPK$_{FT}$ produces the subhierarchy QUALPK$_{FT}$ in 47.

(47) QUALPK$_{FT}$: {*P$_{FT}$/HI, *P$_{FT}$/MON} » {*P$_{FT}$/MID, *P$_{FT}$/DIPH} » *P$_{FT}$/LO

Feet combining [ɯi] and [i] offer no assistance in clarifying the interaction between DIPHPK$_{FT}$ and HEIGHTPK$_{FT}$ (that is, the point at which these hierarchies intersect): since both syllables have [+high] nuclei in (*ɯi . . . i*) and (*i . . . ɯi*) feet, DIPHPK$_{FT}$ optimizes [ɯ́i], no matter where *P$_{FT}$/MON and *P$_{FT}$/DIPH are ranked in the broader hierarchy. Instead, we look to feet combining syllables with [ɯi] and a [−high] nucleus. Recall that (i) in feet combining [ɯi] and [a], stress falls on [a] (e.g. (*mɯi.tà*) (*kói.ga*).*kʃim*].*pi.ra* (11a)), and (ii) in feet containing syllables with a [ɯi] and a mid vowel [e, o] rhyme, stress can fall on either, depending on rhythmic factors (cf. (*nò.tɯi*)(*já.kse*)].*ro* and (*no.tɯí*).*je*].*ro* (11b)).

[16] The peak-prominence hierarchy employed by Kenstowicz (1997) for Kobon is *P/ə » *P/ɨ » P/i,u » P/e,o » P/a. This breaks down to HEIGHTPK (43) and a scale that defines central vowels, [ɨ ə] as less harmonic stress peaks than peripheral vowels, [i u e o a]. The Kobon meta-hierarchy would be HEIGHTPK » PERIPHPK (*P/CENTRALV » *P/PERIPHV).

[17] We have no examples that directly show [ɯi] to be stronger than [i] for secondary stress, although in §3 we made an argument based on transitivity to support this claim.

That [a] and not [ɯi] is assigned stress in a (*ɯi . . . a*) or (*a . . . ɯi*) foot requires that *P_{FT}/MON NOT be ranked above *P_{FT}/HI (i.e. *P_{FT}/MON ¬» *P_{FT}/HI). This point is illustrated in tableau 48a. (The critical portion of the tableau is outlined in boldface.) As long as *P_{FT}/MON ¬» *P_{FT}/HI, 48b shows that the attested outcome with stress on [á] is selected if both *P_{FT}/MON and *P_{FT}/DIPH outrank *P_{FT}/LO. Under this ranking, it is better to stress a [+low] monophthong than a [+high] rhyme, even if the latter is a diphthong.

(48) a. Critical *P_{FT}/MON ¬» *P_{FT}/HI (*P_{FT}/MON » *P_{FT}/HI yields unattested results)

(ɯi … a)	*P_{FT}/MON	*P_{FT}/HI	*P_{FT}/MID	*P_{FT}/DIPH	*P_{FT}/LO
a. (ɯi … á)	*!				*
b. ☟ *(ɯ́i … a)		*		*!	

b. QUALPK$_{FT}$ (DIPHPK$_{FT}$ and HEIGHTPK$_{FT}$): *P_{FT}/HI, *P_{FT}/MON » *P_{FT}/MID, *P_{FT}/DIPH » *P_{FT}/LO

(ɯi … a)	*P_{FT}/HI	*P_{FT}/MON	*P_{FT}/MID	*P_{FT}/DIPH	*P_{FT}/LO
a. ☞ (ɯi … á)		*			*
b. *(ɯ́i … a)	*			*!	

Not only is it critical that *P_{FT}/MON ¬» *P_{FT}/HI, it is also crucial that *P_{FT}/MON not be ranked BELOW *P_{FT}/HI. When for two constraints, A and B, it is crucial that neither outrank the other, we say that A and B are critically unranked, or CO-RANKED. From now on, pairs of co-ranked constraints are enclosed in curly brackets, for example, {*P_{FT}/MON, *P_{FT}/HI}, in ranking statements. The tableau in 48b presents two constraint pairs, {*P_{FT}/HI, *P_{FT}/MON} and {*P_{FT}/MID, *P_{FT}/DIPH}, as being co-ranked. Co-ranking is necessary for these constraint pairs in order to account for stress patterns in feet combining [ɯi] and a mid vowel. In (*ɯi . . . o/e*) and (*o/e . . . ɯi*) feet, stress can fall on either syllable. For this to be possible, it cannot be the case that *P_{FT}/HI acts to exclude stress on [ɯi] or that *P_{FT}/MON acts to exclude stress on [e, o]. If *P_{FT}/HI and *P_{FT}/MON are co-ranked with one another, but both are ranked above *P_{FT}/MID, then a violation of either *P_{FT}/HI or *P_{FT}/MON is equivalent and this pair fails to choose between the candidates (*ɯ́i . . . o*) and (*ɯi . . . ó*), so that the decision is passed down. We have argued independently that *P_{FT}/MID and *P_{FT}/DIPH are both ranked above *P_{FT}/LO. But for either (*ɯ́i . . . o*) or (*ɯi . . . ó*) to be possible, it cannot be the case that *P_{FT}/MID acts to exclude (*ɯi . . . ó*) or that *P_{FT}/DIPH acts to exclude (*ɯ́i . . . o*). If this pair is also co-ranked, then the QUALPK$_{FT}$ hierarchy fails to choose between these outcomes, and the decision must fall to lower-ranked constraints. The tableau in 49 shows that QUALPK permits either (*ɯ́i . . . o*) or (*ɯi . . . ó*).

(49) QUALPK$_{FT}$: {*P_{FT}/HI, *P_{FT}/MON} » {*P_{FT}/MID, *P_{FT}/DIPH} » *P_{FT}/LO

(ɯi … o)	*P_{FT}/HI	*P_{FT}/MON	*P_{FT}/MID	*P_{FT}/DIPH	*P_{FT}/LO
a. ☞ (ɯ́i … o)	*			*	
b. ☞ (ɯi … ó)		*	*		

The decision between (*ɯ́i . . . o*) and (*ɯi . . . ó*) is determined by the RhythmPk subhierarchy (39). In (*nò.tɯi*)(*já.kse*)].*ro*, trochaic stress on [ò] is determined by *Clash, while iambic stress in (*no.tɯ́i*).*je*].*ro* is determined by Iamb. The tableaux for these examples appear in 50. (Co-ranked constraints are shown in the same cell.) The tableau for (*no.tsà*)(*róo.ga*).*kse*] in 50c more precisely shows that *Clash is critically ranked below *P$_{FT}$/Mid, but is not critically ranked with *P$_{FT}$/Lo.

(50) a. QualPk$_{FT}$ » RhythmPk (clash-avoiding trochaic stress)

no.tɯi.ja.kse].ro	*P$_{FT}$/Hi *P$_{FT}$/Mon	*P$_{FT}$/Mid *P$_{FT}$/Diph	*P$_{FT}$/Lo	*Clash	Iamb
i. ☞ (nò.tɯi)(já.kse)].ro	* (Mon)	* (Mid)	*		*
ii. *(no.tɯ̀i)(já.kse)].ro	* (Hi)	* (Diph)	*	*!	*

b. QualPk$_{FT}$ » RhythmPk (iambic stress, in a no-clash context)

no.tɯi.je].ro	*P$_{FT}$/Hi *P$_{FT}$/Mon	*P$_{FT}$/Mid *P$_{FT}$/Diph	*P$_{FT}$/Lo	*Clash	Iamb
i. ☞ (no.tɯ́i).je].ro	* (Hi)	* (Diph)			
ii. *(nó.tɯi).je].ro	* (Mon)	* (Mid)			*!

c. *P$_{FT}$/Mid » RhythmPk

no.tsa.roo.ga.kse]	*P$_{FT}$/Mid	*P$_{FT}$/Lo	*Clash	Iamb
i. ☞ (no.tsà)(róo.ga).kse]	*	*	*	*
ii. *(**nò.tsa**)(róo.ga).kse]	**!			**

The ranking arguments used to motivate QualPk$_{FT}$ and its position in relation to RhythmPk are summarized in 51.

(51) Ranking arguments:

HeightPk$_{FT}$

*P$_{FT}$/Hi » *P$_{FT}$/Mid (**nò.ʃi**)(po.ká).kse].ro, not *(**no.ʃì**)(po.ká).kse].ro

*P$_{FT}$/Mid » *P$_{FT}$/Lo (**no.gà**)(pá.kɯi).ti], not *(**nò.ga**)(pá.kɯi).ti]

DiphPk$_{FT}$

*P$_{FT}$/Mon » *P$_{FT}$/Diph Predicted: (ɯ́i . . . i), not (ɯi . . . í)

QualPk$_{FT}$: the interaction of HeightPk$_{FT}$ and DiphPk$_{FT}$

$\begin{Bmatrix} \text{*P}_{FT}\text{/Hi} \\ \text{*P}_{FT}\text{/Mon} \end{Bmatrix} » \begin{Bmatrix} \text{*P}_{FT}\text{/Mid} \\ \text{*P}_{FT}\text{/Diph} \end{Bmatrix}$ Critical nonranking: (ɯ́i . . . o) or (ɯi . . . ó) is possible (the choice depends on Rhythm)

*P$_{FT}$/Diph » *P$_{FT}$/Lo (**mɯi.tà**)(kói.ga).kʃim].pi.ra, not *(**mɯ̀i.ta**)(kói.ga).kʃim].pi.ra

QualPk$_{FT}$ and RhythmPk

*P$_{FT}$/Mid » *Clash (**no.tsà**)(róo.ga).kse], not *(**nò.tsa**)(róo.ga).kse]

QuantPk: the syllable-internal mora count and foot-level stress. Recall from §4 that in feet combining a light and a heavy syllable, the heavy syllable is stressed regardless of the quality of the vowels (e.g. (*jo.bìi*)(*kái.ga*).*kse*] 'they.MASC drank'). The stress-attracting behavior of heavy syllables in Nanti is consistent with the well-established generalization that quantity-sensitive metrical systems optimize stress on heavy syllables when the alternative is stress on a light syllable. In this analysis, the relative metrical strengths of light and heavy syllables are attributed to the QuantPk subhierarchy in 52, which employs the peak-prominence constraints *P/σμ and *P/σμμ, defined in 52a,b. *P/σμ is satisfied when no light syllable in the output is stressed, *P/σμμ when no heavy syllable is stressed.

(52) QuantPk: *P/σμ » *P/σμμ

Effect: Monomoraic syllables are less optimal stress peaks than bimoraic syllables.

a. *P/σμ: No foot peak consists of a light syllable. (one * per foot peak with σμ)

b. *P/σμμ: No foot peak consists of a heavy syllable. (one * per foot peak with σμμ)

Like the sonority-based stress scales analyzed above, the generalization that heavy syllables—in this case, syllables with bimoraic vowels or diphthongs—make better stress peaks is phonetically grounded: phonological vowel length enhances the surface prominence or phonetic salience of a syllable's rhyme.

That (CV.CVV) feet surface with iambic stress under clash in forms like (*jo.bìi*)(*kái .ga*).*kse*] shows that *P/σμ outranks not only *P/σμμ, as shown in 53a, but also *P$_{FT}$/Hi, as in 53b. (And since *P$_{FT}$/Hi dominates *Clash in the hierarchy, so do all constraints ranked above *P$_{FT}$/Hi, by transitivity.)

(53) a. QuantPk: *P/σμ » *P/σμμ

jo.bii.kai.ga.kse]	*P/σμ	*P/σμμ
a. ☞ (jo.bìi)(kái.ga).kse]		**
b. *(jò.bii)(kái.ga).kse]	*!	*

b. *P/σμ » *P$_{FT}$/Hi » *P$_{FT}$/Mid

jo.bii.kai.ga.kse]	*P/σμ	*P$_{FT}$/Hi	*P$_{FT}$/Mid
a. ☞ (jo.bìi)(kái.ga).kse]		*	
b. *(jò.bii)(kái.ga).kse]	*!		*

As long as *P/σμ » *P/σμμ (presumably, a universal ranking), and as long as *P/σμ » *P$_{FT}$/Hi (possibly not a universal ranking), it makes no difference where *P/σμμ is ranked in the hierarchy to produce the effects found in Nanti.

Thus, quantitative requirements outrank QualPk$_{FT}$. However, when *P/σμ is not at stake, as when both of a foot's syllables are heavy, our analysis predicts that stress assignment should be determined by QualPk$_{FT}$, and if QualPk$_{FT}$ fails to act, then by RhythmPk. Due to gaps in our data, we cannot demonstrate what happens in nonprimary (CVV.CVV) feet. However, as the generalizations about QualPk$_{FT}$ are the same for foot- and word-level stress, the tableau for (*noo.gái*)

.ga].*ro* in 54 is used to illustrate the analysis of stress assignment in a (CVV.CVV) foot with word-level stress.

(54) In (CVV.CVV) feet, QUALPK$_{FT}$ decides

noo.gai.ga].ro	*P/σμ	*P$_{FT}$/HI	*P$_{FT}$/MID *P$_{FT}$/DIPH	*P$_{FT}$/LO	IAMB
a. ☞ (noo.gái).ga].ro				*	
b. *(nóo.gai).ga].ro			*!		*

The ranking arguments used to motivate QUANTPK and its position in relation to QUALPK$_{FT}$ are summarized in 55.

(55) Ranking arguments:
QUANTPK
*P/σμ » *P/σμμ (jo.bìi)(**kái.ga**).kse], not *(jò.bii)(**kái.ga**).kse]
QUANTPK and QUALPK$_{FT}$
*P/σμ » *P$_{FT}$/HI (**jo.bìi**)(kái.ga).kse], not *(**jò.bii**)(kái.ga).kse]

CODAPK: CLOSED VS. OPEN SYLLABLES AND FOOT-LEVEL STRESS. All that remains to complete our analysis of foot-level stress requirements is to account for the behavior of closed syllables. In nonprimary stress feet, CVN syllables pattern as stronger than CV syllables: stress always falls on the closed syllable in a nonprimary stress foot combining a CV and a CVN syllable, even when the CV syllable contains a stronger vowel (e.g. (*o.tá*)(*sòŋ.ka*).*kse*].*ro* (15)). CVN syllables also pattern as weaker than CVV syllables: when CVN and CVV combine in a foot, CVV is always assigned stress (this is true for both word-level and nonprimary feet).

The analysis we propose to capture the three-way strength gradation between CVV, CVN, and CV syllables in Nanti assumes the syllable structures introduced in 5, which represent codas as non-weight-bearing dependents of the rightmost mora of the syllable (Hayes 1989; see also Hyman 1985). That is, the rightmost mora of a CVN or CVVN syllable branches to dominate more than one segment, [VC]μ. To capture the fact that closed syllables are preferred to open syllables as stress peaks in Nanti, we propose the CODAPK subhierarchy in 56, built on the constraints *P$_{FT}$/MON, defined in 44, and *P/VC-μ in 56. CODAPK expresses the generalization that a stressed syllable with a branching VC mora is a better stress peak than a syllable with only nonbranching V moras.

(56) CODAPK: *P$_{FT}$/MON » *P/VC-μ
A closed syllable, ending in a branching VC mora, is a more optimal stress peak than a syllable ending in a nonbranching [−consonantal] mora.

*P/VC-μ: No foot peak has a branching mora dominating a [−consonantal] and a [+consonantal] root node. (one * per branching mora dominating a VC sequence in a stressed syllable)

The tableau for (*òŋ.ko*)(*wo.gó*).*te*].*ro* in 57a shows that in feet parsing syllables with vowels of equivalent strength, a CVN syllable is selected over CV as long as *P$_{FT}$/MON is ranked above both *P/VC-μ and IAMB. The tableaux for (*ma.gàn*)(*táem.pa*)].*ro.me.ra* and (*o.tá*)(*sòŋ.ka*).*kse*].*ro* in 57b shows that *P$_{FT}$/MON outranks *CLASH. Together, these tableaux illustrate the effect of CODAPK's dominant ranking above RHYTHMPK in Nanti's constraint hierarchy.

(57) CODAPK » RHYTHMPK

a. *P_{FT}/MON » *P/VC-μ, IAMB

oŋ.ko.wo.go.te].ro	*P_{FT}/MON	*P/VC-μ	IAMB
i. ☞ (òŋ.ko)(wo.gó).te].ro	*	*	*
ii. *(oŋ.kò)(wo.gó).te].ro	**!		

b. *P_{FT}/MON » *P/VC-μ, *CLASH

	*P_{FT}/MON	*P/VC-μ	*CLASH
ma.gan.taem.pa].ro.me.ra			
i. ☞ (ma.gàn)(táem.pa)] …		**	*
ii. (mà.gan)(táem.pa)] …	*!	*	
o.ta.soŋ.ka.kse].ro			
iii. ☞ (o.tá)(sòŋ.ka).kse].ro	*	*	*
iv. *(o.tà)(soŋ.ká).kse].ro	**!		

CODAPK predicts that CVVN should also trump CVV, and indeed, we find this effect in word-level stress feet (e.g. (*o.sà*)(*ráan.tai*).*ga.kse*] (19d)).

The foot-level stress pattern treats CVN as stronger than CV regardless of vowel quality; this is possible if the dominant constraint in CODAPK, *P_{FT}/MON, is ranked above QUALPK$_{FT}$ in Nanti. The tableaux in 58 for (*o.tá*)(*sòŋ.ka*).*kse*].*ro* and (*pìŋ.ka*)(*mo.sói*).*ga.kse*] (from 15)) show that this ranking produces the attested results. However, a couple of finer points need to be established. First, we argued earlier that the constraints *P_{FT}/HI and *P_{FT}/MON are critically unranked, but that *P_{FT}/MON must outrank *P_{FT}/MID. The tableaux in 58 confirm this analysis: the tableau for (*o.tá*)(*sòŋ.ka*).*kse*].*ro* shows that *P_{FT}/MON » *P_{FT}/MID; otherwise, we would find a foot *(*soŋ.ká*). The tableau for (*pìŋ.ka*)(*mo.sói*).*ga.kse*] establishes two rankings: first, *P_{FT}/HI CANNOT be ranked above *P_{FT}/MON; if it were, then we should find a foot *(*piŋ.kà*) instead of (*pìŋ.ka*). Second, if *P_{FT}/HI and *P_{FT}/MON are co-ranked, as we have argued they are, then the ranking *P_{FT}/LO » *P/VC-μ is also critical; under the alternative ranking, *P/VC-μ would exclude stress on *pìŋ* in favor of *ka*. The critical portions of these tableaux are highlighted.

(58) CODAPK » QUALPK$_{FT}$: {*P_{FT}/HI, *P_{FT}/MON} » {*P_{FT}/MID, *P_{FT}/DIPH} » *P_{FT}/LO » *P/VC-μ

a. Critical ranking: *P_{FT}/MON » *P_{FT}/MID

o.ta.soŋ.ka.kse].ro	*P_{FT}/ HI	*P_{FT}/ MON	*P_{FT}/ MID	*P_{FT}/ DIPH	*P_{FT}/ LO	*P/ VC-μ
i. ☞ (o.tá)(sòŋ.ka) …		*	*		*	*
ii. *(o.tà)(soŋ.ká) …		**!			**	

b. Critical ranking: *P_{FT}/Hi is NOT ranked above *P_{FT}/Mon

piŋ.ka.mo.soi.ga.kse]	*P_{FT}/ Hi	*P_{FT}/ Mon	*P_{FT}/ Mid	*P_{FT}/ Diph	*P_{FT}/ Lo	*P/ VC-μ
i. ☞ (pìŋ.ka)(mo.sói) …	*	*	*			*
ii. *(piŋ.kà)(mo.sói) …		**	*		*!	

Consistent with patterns found in (CV.CV) feet analyzed earlier, forms like (*noŋ.kàn*)(*tái.ga*).*kse*] (17) attest that in (CVN.CVN) feet, the outcome is decided by QualPk$_{FT}$; and the example (*nòŋ.ksen*)(*tá.kse*)].*ro* (17a) shows that when QualPk$_{FT}$ cannot act, the selection is made by RhythmPk. The tableaux for these forms appear in 59.

(59) (CVN.CVN) feet

a. QualPk$_{FT}$ decides

noŋ.kan.tai.ga.kse]	*P_{FT}/ Hi	*P_{FT}/ Mon	*P_{FT}/Mid *P_{FT}/Diph	*P_{FT}/ Lo	*P/VC-μ
i. ☞ (noŋ.kàn)(tái.ga).kse]		*		**	*
ii. *(nòŋ.kan)(tái.ga).kse]		*	*! (Mid)	*	*

b. RhythmPk: *Clash decides

noŋ.ksen.ta.kse].ro	*P_{FT}/Hi *P_{FT}/Mon	*P_{FT}/Mid *P_{FT}/Diph	*P_{FT}/ Lo	*P/ VC-μ	*Clash
i. ☞ (nòŋ.ksen)(tá.kse)].ro	* (Mon)	* (Mid)	*	*	
ii. *(noŋ.kèn)(tá.kse)].ro	* (Mon)	* (Mid)	*	*	*!

Finally, a word about a connection between the constraints forming the scales DiphPk$_{FT}$ and CodaPk. DiphPk$_{FT}$ and CodaPk are sister subhierarchies in the sense that *P_{FT}/Mon is the dominant constraint in both subhierarchies: *P_{FT}/Mon » *P_{FT}/Diph, and *P_{FT}/Mon » *P/VC-μ. We have established no necessary interaction between *P_{FT}/Diph and *P/VC-μ. However, as we have argued for the rankings *P_{FT}/Diph » *P_{FT}/Lo and *P_{FT}/Diph » *P/VC-μ, then it must be the case that *P_{FT}/Diph » *P/VC-μ by transitivity. Our database contains no examples containing a foot combining syllables with the light diphthong [ɯi] and a rhyme *iN*. Tableau 60 shows that in such a case, this analysis predicts that stress would fall on the closed syllable.

(60) QualPk$_{FT}$: *P_{FT}/Hi, *P_{FT}/Mon » *P_{FT}/Mid, *P_{FT}/Diph » *P_{FT}/Lo

(in … ɯi)	*P_{FT}/Hi *P_{FT}/Mon	*P_{FT}/Mid	*P_{FT}/Diph	*P_{FT}/Lo	*P/VC-μ
a. ☞ (ìn … ɯi)	* (Hi)				*
b. *(in … ɯ̀i)	* (Hi)		*!		

The ranking arguments for CodaPk are summarized in 61.

(61) Ranking arguments:

CodaPk

*P$_{FT}$/Mon » *P/VC-μ (**òŋ.ko**)(wo.gó).te].ro, not *(**oŋ.kò**)(wo.gó).te].ro

CodaPk and HeightPk$_{FT}$

{*P$_{FT}$/Hi, *P$_{FT}$/Mon} . . . *P$_{FT}$/Lo » *P/VC-μ (**pìŋ.ka**)(mo.sói).ga.kse], not *(**piŋ.kà**)(mo.sói).ga.kse]

(If *P$_{FT}$/Hi and *P$_{FT}$/Mon are critically unranked so that *P$_{FT}$/Mon's ability to act is neutralized, then *P$_{FT}$/Lo » *P/VC-μ predicts CVN > CV.)

CodaPk and DiphPk$_{FT}$

*P$_{FT}$/Diph » *P/VC-μ Predicted: (ìn . . . ùi), not *(in . . . ùi)

To conclude this section, Figure 1 provides a Hasse diagram showing the final version of the constraint hierarchy required to account for the effects of vowel quality, syllable quantity, and syllable closure on foot-level stress.[18]

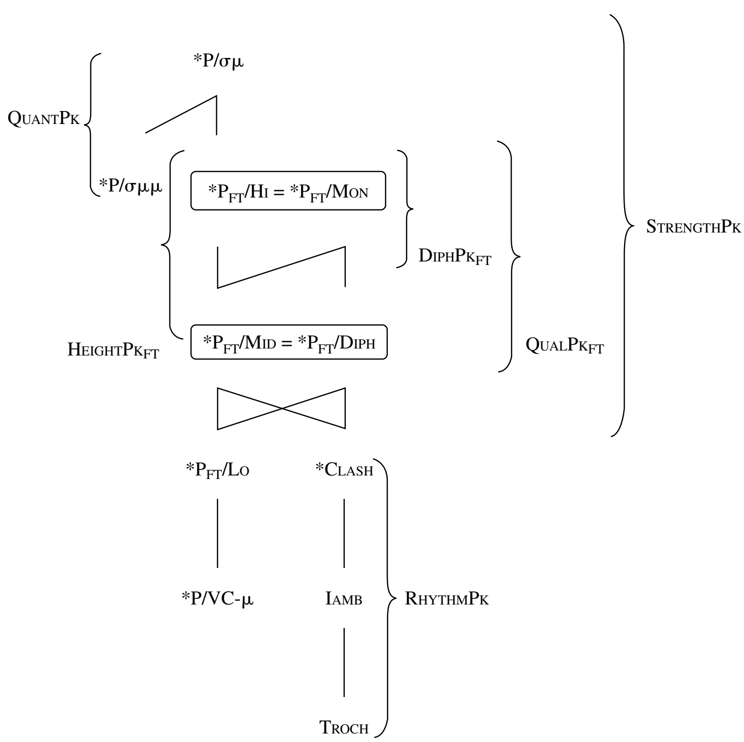


Figure 1. Hasse diagram.

[18] A Hasse diagram is a two-dimensional display of critical rankings among OT constraints, in which a given constraint appears on a line above any constraints it has been shown to dominate. Hasse diagrams provide more precise representations of hierarchical relationships among constraints than do linear ranking statements. That is, a linear ranking statement A, B » C, D, in which no critical ranking can be established for constraints in the pairs {A, B} and {C, D}, is ambiguous: it is unclear whether both A and B dominate both C and D; whether only A dominates both C and D; or whether A, B, C, and D interact (or fail to interact) in some other way not precisely expressed in the statement A, B » C, D.

6.2. COMPLETING THE STRENGTH SCALE: EVIDENCE FROM WORD STRESS. We now complete the formal analysis of the integrated Strength scale that determines the distribution of foot- and word-level stress in Nanti. In particular, we account for the following generalizations:

- Coda is relevant for word stress as well as foot stress: closed syllables are stronger than equi-moraic open syllables when their vowels are metrically equivalent; for example, (*na.mám*)(*pi.jà*).*kse*] (19b), and (*o.sà*)(*ráan.tai*).*ga.kse*] (19d).
- When vowels differ, Qual_{PW}, not Coda, determines the location of word-level stress; for example, (*á.pʲe*)(*ʃi.jèm*).*pa*].*ra* (24).
- When foot- and word-level conditions conflict and there is no choice of sites for word stress, word-level conditions prevail; (*ná.ben*).*tem.pa*].*ro* (26).
- In general, when multiple equivalent sites are available, word stress surfaces on the rightmost. But if this would result in a violation of foot-level stress requirements, word stress is assigned to a position further to the left; for example, (*o.tá*)(*sòŋ.ka*).*kse*].*ro* (27), not *(*o.tà*)(*soŋ.ká*).*kse*].*ro*.

As we demonstrated in §4, word stress employs the Qual and Quant scales used for foot-level stress and assigns them the same priorities: Quant > Qual. Word-level stress differs from foot-level stress in the interaction of Coda and Qual scales: word-level stress requires Qual > Coda, while foot-level stress requires Coda > Qual. We resolved this apparent paradox in §4 by ranking foot- and word-level versions of Qual, Qual_{PW}, and Qual_{FT} above and below Coda on the Strength scale in 37.

The Coda subhierarchy $*\text{P}_{\text{FT}}$/MON » *P/VC-μ (partly embedded in the foot-level QUALPK subhierarchy) accounts for the effect of codas in selecting foot-level peaks (see 58) and in selecting word-level peaks when candidate syllables are metrically equivalent in other respects (e.g. (*o.sà*)(*ráan.tai*).*ga.kse*], (*na.mám*)(*pi.jà*).*kse*]). The fact that closed syllables concede word stress to equi-moraic open syllables with stronger vowels can be accounted for by inserting a second subhierarchy of QUALPK constraints whose domain is the PrWd above $*\text{P}_{\text{FT}}$/MON in the constraint hierarchy. A second set of $\text{HEIGHTPK}_{\text{PW}}$ constraints is required independently of the Coda issue: in (*á.pʲe*)(*ʃi.jèm*).*pa*].*ra*, the stressed syllable in each foot is the strongest syllable in the foot—by foot-level standards. However, nothing in the analysis so far accounts for the selection of the head of the first foot as the head of the word (cf. (*tso.tèŋ*)(*ka.ná*).*ka*].*ra*, with word-level stress on the rightmost foot). The constraints and subhierarchy required by our analysis are defined in 62.

(62) a. $\text{QUALPK}_{\text{PW}}$: {$*\text{P/HI}_{\text{PW}}$, $*\text{P}_{\text{PW}}$/MON} » {$*\text{P}_{\text{PW}}$/MID, $*\text{P}_{\text{PW}}$/DIPH} » $*\text{P}_{\text{PW}}$/LO
A high vowel is a less optimal work peak than a mid vowel, which is a less optimal word peak than a low vowel.

b. Schema for word-level peak prominence constraints
$*\text{P}_{\text{PW}}/\alpha$: No word peak has a vowel characterized by property α.

The tableau for (*á.pʲe*)(*ʃi.jèm*).*pa*].*ra* in 63a shows that the subhierarchy $\text{QUALPK}_{\text{PW}}$ correctly selects an output in which word stress is on the syllable with the lowest available vowel. The tableau for (*o.sà*)(*ráan.tai*).*ga.kse*] in 63b shows that when competing open and closed syllables have a nuclear vowel of the same height, the closed syllable is selected for word stress.[19] In this case, $\text{QUALPK}_{\text{PW}}$ cannot act, and so the outcome is determined by CODAPK.

[19] The vowel dominated by the first mora of the syllable.

(63) QualPk$_{PW}$ and CodaPk: {*P/Hi$_{PW}$, *P$_{PW}$/Mon} » {*P$_{PW}$/Mid, *P$_{PW}$/Diph} » *P$_{PW}$/Lo, {*P$_{FT}$/Hi, *P$_{FT}$/Mon} » {*P$_{FT}$/Mid, *P$_{FT}$/Diph} » *P$_{FT}$/Lo » *P/VC-μ

a. Open > closed (no conflicts between foot- and word-level requirements)

a.p^{j}e.ʃi.jem.pa].ra	*P$_{PW}$/Hi	*P$_{PW}$/Mid	*P$_{PW}$/Lo	*P$_{FT}$/Hi *P$_{FT}$/Mon	*P$_{FT}$/Mid *P$_{FT}$/Diph	*P$_{FT}$/Lo	*P/VC-μ
i. ☞ (**á**.p^{j}e)(ʃi.**jèm**).pa].ra			*	* (Mon)	* (Mid)	*	*
ii. *(**à**.p^{j}e)(ʃi.**jém**).pa].ra		*!		* (Mon)	* (Mid)	*	*

b. Closed > open (no conflicts between foot- and word-level requirements)

o.sa.raan.tai.ga.kse]	*P$_{PW}$/Hi	*P$_{PW}$/Mid	*P$_{PW}$/Lo	*P$_{FT}$/Hi *P$_{FT}$/Mon	*P$_{FT}$/Mid *P$_{FT}$/Diph	*P$_{FT}$/Lo	*P/VC-μ
i. ☞ (o.sà)(ráan.tai).ga.kse]			*	* (Mon)		**	*
ii. *(o.sà)(raan.tái).ga.kse]			*	**! (Mon)		**	

c. Ranking arguments:

- *P$_{PW}$/Mid » *P$_{PW}$/Lo (**á**.p^{j}e)(ʃi.**jèm**).pa].ra, not *(**à**.p^{j}e)(ʃi.**jém**).pa].ra
- *P$_{FT}$/Mon » *P/VC-μ (o.sà)(ráan.tai).ga.kse], not *(o.sà)(raan.tái).ga.kse]

Note that foot-level QualPk$_{FT}$ constraints correctly pick out the strongest syllable in each foot for stress but do nothing to determine which of these stressed syllables should bear word-level stress. This provides the motivation for adding the QualPk$_{PW}$ subhierarchy in 62 to the analysis. However, while forms like (*á.p^{j}e*)(*ʃi.jèm*).*pa*].*ra* supply the critical motivation for QualPk$_{PW}$, they do not establish QualPk$_{PW}$'s position in the broader metrical constraint hierarchy: precisely because CodaPk constraints cannot decide between the candidates in 63a, QualPk$_{PW}$ would successfully determine the location of word stress, whether it were ranked above or below the foot-level subhierarchy.

The forms that are crucial in showing that QualPk$_{PW}$ dominates CodaPk, and QualPk$_{FT}$ as well, are forms in which conflicts between foot- and word-stress requirements arise. Under an analysis that ranks QualPk$_{PW}$ above CodaPk, QualPk$_{PW}$ takes higher priority but only in word-level stress feet. An example is (*ná.ben*).*tem.pa*].*ro* (26), in which word-level requirements demand stress on the lower vowel, overriding CodaPk. Note that it is not possible to establish a critical ranking between *P$_{PW}$/Lo, *P$_{FT}$/Mon, and *P$_{FT}$/Hi, but it is critical for *P$_{PW}$/Mid to outrank *P$_{FT}$/Mon: otherwise, we would expect the unattested *(*na.bén*).*tem.pa*].*ro*. Finally, the tableau for (*o.tá*)(*sòŋ.ka*).*kse*].*ro* (27) in 64b shows that the analysis correctly accounts for the generalization that, when there is a choice so that QualPk$_{PW}$ is not at stake, word stress is assigned to a position that does not compel a violation of CodaPk (this, at the expense of a constraint, Rightmost-Main-Stress, to be defined in the next section).

(64) QUALPK$_{PW}$ > CODAPK: Conflicts between foot- and word-level requirements

a. CODAPK loses when only one site satisfies HEIGHTPK$_{PW}$

na.ben.tem.pa].ro	*P_{PW}/HI	*P_{PW}/MID	*P_{PW}/LO	*P_{FT}/HI *P_{FT}/MON	*P_{FT}/MID *P_{FT}/DIPH	*P_{FT}/LO	*P/VC-μ
i. ☞ (ná.ben).tem.pa].ro			*	* (MON)		*	
ii. *(na.bén).tem.pa].ro		*!			* (MID)		*

b. CODAPK is optimized when QUALPK$_{PW}$ is not at stake

o.ta.soŋ.ka.kse].ro	*P_{PW}/HI	*P_{PW}/MID	*P_{PW}/LO	*P_{FT}/HI *P_{FT}/MON	*P_{FT}/MID *P_{FT}/DIPH	*P_{FT}/LO	*P/VC-μ
i. ☞ (o.tá)(**sòŋ.ka**).kse].ro			*	* (MON)	* (MID)	*	*
ii. *(o.tà)(**soŋ.ká**).kse].ro			*	**! (MON)		**	

c. Ranking arguments:

- *P_{PW}/MID » *P_{PW}/LO NOT *P_{FT}/MON » *P_{PW}/MID } (ná.ben).tem.pa].ro, not *(na.bén).tem.pa].ro
- *P_{FT}/MON » *P_{FT}/MID (o.tá)(**sòŋ.ka**).kse].ro, not *(o.tà)(**soŋ.ká**).kse].ro

For the sake of thoroughness, arguments for several constraint rankings not illustrated in tableaux are summarized in 65. The constraints and rankings motivated in this section are summarized in the Hasse diagram in Figure 2.

(65) Additional ranking arguments

- *P_{PW}/HI » *P_{PW}/LO (pi.ká)(bi.rì).ti], not *(pi.kà)(bi.rí).ti]
  also: (sá.gɯi).te], not *(sa.gɯ́i).te]
  also: (i.tìŋ)(ka.ráa).ʃii.gʒi], not *(i.tìŋ)(ka.ràa)(ʃíi.gʒi)]
- *P_{PW}/HI » *P_{PW}/MID (ì.ri)(nó.ri).je], not *(ì.ri)(no.rí).je]
  also: (i.pó).kɯi.ti], not *(i.pò)(kɯ́i.ti)]
  also: (bʲé.tsi).kse].ro.me, not *(bʲe.tsí).kse].ro.me
- *P_{PW}/MID » *P_{PW}/LO (i.nò)(ʃi.já).gʲe.ti]; [o] patterns like [e]
- *P/σμ » QUALPK$_{PW}$ (nóo.ga).ka].ro, not *(noo.gá).ka].ro
  also: (nò.ti)(ma.ʃíi).ga.ka], not *(nò.ti)(má.ʃii).ga.ka]

6.3. WORD-LEVEL STRESS AND THE FOOT PARSE. In this section, we analyze the interaction between word-level stress conditions and the metrical foot parse, beginning with an account of the position of word-level stress. The two basic generalizations concerning the location of word stress are:

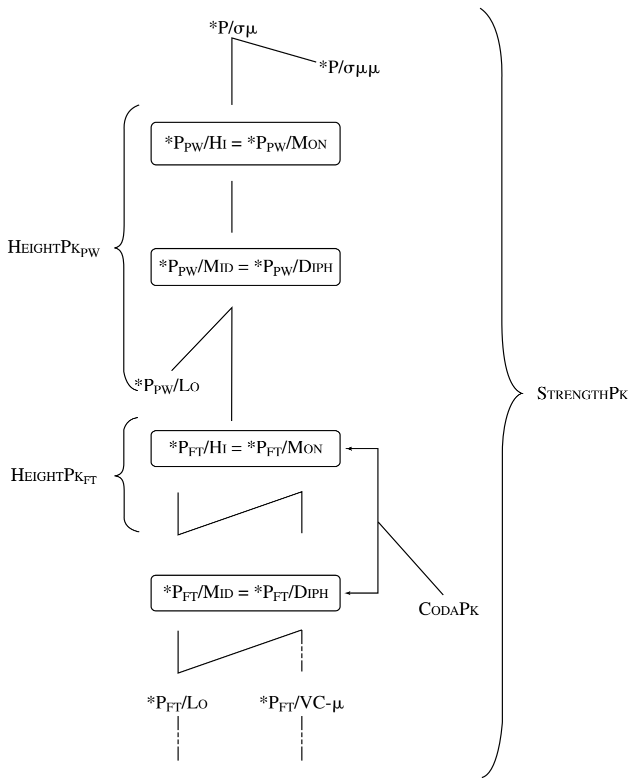


FIGURE 2. Word-level STRENGTHPK hierarchy and intersection with foot-level subhierarchies.

- Strongest peak: Word-level stress is assigned to the strongest syllable in the PrWd (e.g. (*ò.gui*)(*sá.kse*)] (23), (*ja.máa*)(*ta.kòi*)(*ga.nà*).*kse*]) (13b).
- Rightmost peak: When two or more syllables are tied for strongest status, word stress is assigned to the rightmost (e.g. (*pa.mà*)(*gze.tá*).*kse*].*na*) (21).

In the standard OT analysis of the Rightmost generalization, the constraint MAIN-STRESS-RIGHT in 66a is ranked above its mirror image counterpart MAIN-STRESS-LEFT in 66b (McCarthy & Prince 1993a).

(66) a. MAIN-STRESS-RIGHT: ALIGN-RIGHT(Head(PrWd), PrWd) (a.k.a. MSR)
The right edge of the main stress foot (Head(PrWd)) is aligned with the right edge of the PrWd. (one * per syllable intervening between $]_{\text{HEAD(PW)}}$ and $]_{\text{PW}}$)

b. MAIN-STRESS-LEFT: ALIGN-LEFT(Head(PrWd), PrWd) (a.k.a. MSL)
The left edge of the main stress foot (Head(PrWd)) is aligned with the left edge of the PrWd. (one * per syllable intervening between $_{\text{HEAD(PW)}}[$ and $_{\text{PW}}[$)

c. MAIN-STRESS-RIGHT » MAIN-STRESS-LEFT

Rightmostness gives way to the requirement that word stress should fall on the strongest syllable, showing that the word-level STRENGTHPK$_{\text{PW}}$ subhierarchy outranks MAIN-STRESS-RIGHT. Tableaux for (*pa.mà*)(*gze.tá*).*kse*].*na* and (*ja.máa*)(*ta.kòi*)(*ga.nà*).*kse*] appear in 67.

(67) STRENGTHPK$_{PW}$ » MAIN-STRESS-RIGHT

	STRENGTHPK$_{PW}$	MSR
pa.ma.gze.ta.kse].na		
a. ☞ (pa.mà)(gze.tá).kse].na		*
b. *(pa.má)(gze.tà).kse].na		**!*
ja.maa.ta.koi.ga.na.kse]		
c. ☞ (ja.máa)(ta.kòi)(ga.nà).kse]		*********
d. *(ja.màa)(ta.kòi)(ga.ná).kse]	*! (< maa)	*

Refinements are suggested by exceptions to both of the generalizations reviewed above. We find two exceptions to the Rightmost generalization:

- Word stress is not assigned to a position that requires a PrWd-final foot, if an equivalent syllable further to the left can be stressed instead (e.g. (*i.tò*)(*gá.be*)*.ta.ka*] (30)).
- If a bisyllabic PrWd-final foot is necessary to locate word stress on the strongest syllable, stress is not assigned to the ultima if the penult is equally strong (e.g. (*i.pò*)(*kái.gai*)] (31b)).

There is only one exception to the Strongest pattern:

- Light CV(N) ultimas are not stressed, even when strongest (e.g. (*no.tém*).*pa*].*ro* (20), (*i.rì*)(*pi.rí*).*ni.te*] (5)). (But a heavy CVV(N) ultima may be stressed; e.g. (*nà.wo*)(*wɯi.tái*)].*ro* (32a), and (*i.rò*)(*wà.ti*)(*káe*)].*ni*) (32b)).

That PrWd-final feet are avoided in forms like (*i.tò*)(*gá.be*).*ta.ka*] (30) is expressed as NOFINALFOOT in 68a (cf. NONFINALITY; Prince & Smolensky 1993, Hung 1994). And that stress is not assigned to ultimas, given a choice, suggests a ban on stressing syllables in PrWd-final position, stated as NOFINALSTRESS in 68b. Forms like (*i.pò*)(*kái.gai*)] (31b) support treating 68a,b as independent constraints: in this case, stress on the ultima is avoided even when conditions compel the presence of a word-final foot.

(68) a. NOFINALFOOT: No PrWd has a foot at its right edge. (one * per PrWd-final stressed foot)

b. NOFINALSTRESS: No PrWd has a stressed syllable at its right edge. (one * per PrWd-final stressed syllable)

An account of forms like (*i.tò*)(*gá.be*).*ta.ka*] requires both of the constraints in 68 to be ranked above MAIN-STRESS-RIGHT, as shown in 69.

(69) NOFINALSTRESS » NOFINALFOOT » MAIN-STRESS-RIGHT

i.to.ga.be.ta.ka]	NOFINALSTRESS	NOFINALFOOT	MSR
a. ☞ (i.tò)(gá.be).ta.ka]			**
b. *(i.tò)(gà.be)(tá.ka)]		*!	
c. *(i.tò)(gà.be)(ta.ká)]	*!		

When a PrWd contains a single strongest syllable, word stress is assigned to it unless it is a light ultima (e.g. (*i.rì*)(*pi.rí*).*ni.te*]), motivating the ranking NoFinalStress » HeightPk$_{PW}$. However, word stress is assigned to strongest light penults in forms like (*ò.gɯi*)(*sá.kse*)], (*ì.ri*)(*pó.kse*)] (from 22), showing that HeightPk$_{PW}$ » NoFinalFoot. The tableau for (*ì.ri*)(*pó.kse*)] is given in 70.[20]

(70) NoFinalStress » HeightPk$_{PW}$ » NoFinalFoot

i.ri.po.kse]	NoFinalStress	HeightPk$_{PW}$	NoFinalFoot
a. ☞ (ì.ri)(pó.kse)]			*
b. *(i.rí).po.kse]		*! (Hi < Mid)	
c. *(ì.ri)(po.ksé)]	*!		*

That a heavy ultima is stressed, when strongest, is possible if a word-level constraint sensitive to syllable quantity is ranked more highly than NoFinalStress. In our analysis, this is $^*P_{PW}/\sigma\mu$ in 71a. Tableaux for (*nà.wo*)(*wɯi.tái*)].*ro* and (*i.pò*)(*kài.gai*)] appear in 71b.

(71) a. $^*P_{PW}/\sigma\mu$: Avoid light syllables as word peaks. (one * per word peak with $\sigma\mu$)

b. $^*P_{PW}/\sigma\mu$ » NoFinalStress » HeightPk$_{PW}$ » NoFinalFoot

	$^*P_{PW}/\sigma\mu$	NoFinalStress	HeightPk$_{PW}$	NoFinalFoot
na.wo.wɯi.tai].ro				
i. ☞ (nà.wo)(wɯi.tái)].ro		*		*
ii. *(nà.wo)(wɯ́i.tai)].ro	*!		* (ɯi < a)	*
iii. *(ná.wo).wɯi.tai].ro	*!			
i.po.kai.gai]				
iv. ☞ (i.pò)(kái.gai)]				*
v. *(i.pò)(kai.gái)]		*		*
vi. *(i.pó).kai.gai]	*!		* (o < ai)	

We need both foot- and word-level versions of the constraint $^*P/\sigma\mu$: the first foot in (*nà.wo*)(*wɯi.tái*)].*ro* already violates some version of $^*P/\sigma\mu$, and making this foot the word-level stress foot creates no further violations if we have only a generic version of the constraint to serve both the foot and PrWd domains. Since the candidates (*nà .wo*)(*wɯi.tái*)].*ro* and *(*ná.wo*).*wɯi.tai*].*ro* would both violate generic $^*P/\sigma\mu$, adding the word-level stress foot (*wɯi.tái*) in the attested form would do nothing but gratuitously violate the lower-ranked constraint, $^*P/\sigma\mu\mu$; the predicted outcome should be

[20] We abbreviate in this section by representing HeightPk$_{PW}$ in a single column. A single violation of HeightPk$_{PW}$ occurs when a word peak is not the lowest vowel in the PrWd.

*(*ná.wo*).*wɯi.tai*].*ro*. A successful account must accept *nà* as the head of a foot since there is nothing better, but reject *nà* as the syllable with word stress since a heavy syllable is available. However, we may still assume that *P_{FT}/σμ and *P_{PW}/σμ occupy the same position in the hierarchy. (This issue is discussed further below.)

Finally, forms like (*i.rò*)(*wà.ti*)(*káe*)].*ni* show that a heavy ultima, when strongest, is stressed even if the result is a monosyllabic foot. This effect requires *P_{PW}/σμ to be ranked above FtMin(σ) in 74a. The tableau for (*i.rò*)(*wà.ti*)(*káe*)].*ni* is given in 72b.

(72) a. FtMin(σ): Feet are minimally binary at the syllable level. (one * per monosyllabic foot)

b. *P_{PW}/σμ » NoFinalStress, FtMin(σ)

i.ro.wa.ti.kae].ni	*P_{PW}/σμ	NoFinalStress	FtMin(σ)
i. ☞ (i.rò)(wà.ti)(káe)].ni		*	*
ii. *(i.rò)(wá.ti).kae].ni	*!		

The constraint rankings motivated in this section are shown in 73.

(73) Word-level StrengthPk hierarchy, completed
*P_{FT}/σμ, *P_{PW}/σμ » *P/σμμ, NoFinalStress, FtMin(σ)
NoFinalStress » {*P_{PW}/Hi, *P_{PW}/Mon} » {*P_{PW}/Mid, *P_{PW}/Diph} » *P_{PW}/Lo » NoFinalFoot

The remaining pattern to be accounted for is the metrical foot parse. We have seen that footing in Nanti is iterative from left to right—though not in general exhaustive, due to NoFinalFoot. When unfooted syllables are present, they cluster at the right edge of the PrWd. Degenerate feet are usually not permitted, but surface in the limited context discussed above. When degenerate feet are present, they occur at the same edge of the PrWd as unparsed syllables. An analysis that successfully accounts for Nanti's footing patterns adds the constraints Parse-σ (Hayes 1985 [1980], Prince & Smolensky 1993), All-Feet-Right and its mirror image counterpart All-Feet-Left (McCarthy & Prince 1993a), Initial-Ft (McCarthy & Prince 1993a), and Foot-Foot (Kager 1994) to the constraints defined earlier in this section.

(74) a. Initial-Ft: Align-Left(PrWd, Foot)
The left edge of every PrWd is aligned with the same edge of some foot. (one * per syllable intervening between $_F[$ and $_{PW}[$)

b. Parse-σ: Every syllable is included in a foot. (one * per unfooted syllable)

c. Foot-Foot: A syllable not included in foot structure does not occur adjacent to a foot. (one * for any edge of a syllable that is immediately adjacent to an edge of a foot that does not dominate it)

d. All-Feet-Right: Align-Right(Foot, PrWd) (a.k.a. AFR)
The right edge of every foot is aligned with the same edge of some PrWd. (one * per syllable intervening between $]_F$ and $]_{PW}$)

e. All-Feet-Left: Align-Left(Foot, PrWd) (a.k.a. AFL)
The left edge of every foot is aligned with the same edge of some PrWd. (one * per syllable intervening between $_F[$ and $_{PW}[$)

The particular pattern of iterative rightward parsing found in Nanti is best analyzed as an effect of the rankings Initial-Ft, FtMin(σ) » NoFinalFoot » Parse-σ, Foot-Foot, as illustrated in 75. (It is not necessary to posit critical rankings for the two top-most and two bottom-most constraints.)

(75) INITIAL-FT, FTMIN(σ) » NOFINALFOOT » PARSE-σ, FOOT-FOOT

a. Bisyllabic PrWds

ta.ta]	INITIAL-FT	FTMIN(σ)	NOFINALFT	PARSE-σ	FOOT-FOOT
i. ☞ (tá.ta)]			*		
ii. *(tá).ta]		*!		*	*
iii. *ta.ta]	*!			**	

b. Polysyllabic PrWds

i.to.ga.be.ta.ka]	INITIAL-FT	FTMIN(σ)	NOFINALFT	PARSE-σ	FOOT-FOOT
i. ☞ (i.tò)(gá.be).ta.ka]				**	*
ii. *(i.tò).ga.(be.tá).ka]				**	**!*
iii. *(i.tó).ga.be.ta.ka]				***!*	*
iv. *(i.tò)(gà.be)(tá.ka)]			*!		
v. *(i.tò)(gà.be)(tá).ka]		*!		*	*
vi. *i.to.(gà.be)(tá.ka)]	*!		*	**	*
vii. *i.(to.gà)(be.tá).ka]	*!			**	**

c. Ranking arguments:

- INITIAL-FT » NOFINALFOOT (tá.ta)], not *ta.ta]
- FTMIN(σ) » NOFINALFOOT (tá.ta)], not *(tá).ta]
- NOFINALFOOT » PARSE-σ (i.tò)(gá.be).ta.ka], not *(i.tò)(gà.be)(tá.ka)]
- NOFINALFOOT » FOOT-FOOT (i.tò)(gá.be).ta.ka], not *(i.tò)(gà.be)(tá.ka)]
- FTMIN(σ) » PARSE-σ (i.tò)(gá.be).ta.ka], not *(i.tò)(gà.be)(tá).ka]

Finally, both degenerate feet and sequences of unparsed syllables cluster at the right edge of the PrWd. These are both effects of ranking ALL-FEET-RIGHT above ALL-FEET-LEFT below FOOT-FOOT. Under this ranking, unparsed syllables (compelled by NOFINALFOOT and FTMIN(σ)) occur in sequences at the right edge because INITIAL-FT demands a foot at the left edge, and FOOT-FOOT optimizes unbroken chains of feet. Because ALL-FEET-RIGHT is ranked so low, it cannot compel a foot at the PrWd's right edge. This is the pattern we find in outputs with no degenerate feet. When FTMIN(σ) is outranked by $*P_{PW}/\sigma\mu$, we find a degenerate foot at the right edge of the PrWd, because placing the smallest foot to the right minimizes the number of syllables between the right edge of the PrWd and all feet further to the left. These effects are illustrated in 76.

(76) INITIAL-FT » FOOT-FOOT » AFR » AFL

		INITIAL-FT	FOOT-FOOT	AFR	AFL
a.	i.ro.wa.ti.kae].ni				
	i. ☞ (i.rò)(wà.ti)(káe)].ni			* ***	** ****
	ii. *(ì)(ro.wà)(ti.káe)].ni			** ***!*	* ***
	iii. *(i.rò).wa.(ti.káe)].ni		**!	***	***
	iv. *i.(ro.wà)(ti.káe)].ni	*!	*	**	* ***
b.	i.to.ga.be.ta.ka]				
	i. ☞ (i.tò)(gá.be).ta.ka]		*	** ****	**
	ii. *(i.tò).ga.(be.tá).ka]		**!*	* ****	***
	iii. *i.(to.gà)(be.tá).ka]	*!	**	* ***	* ***

c. Ranking arguments:
- AFR » AFL (i.rò)(wà.ti)(káe)].ni, not *(ì)(ro.wà)(ti.káe)].ni
- FOOT-FOOT » AFR (i.tò)(gá.be).ta.ka], not *(i.tò).ga.(be.tá).ka]
- INITIAL-FT » AFR (i.tò)(gá.be).ta.ka], not *i.(to.gà)(be.tá).ka]

Integrating the constraint rankings required for the foot parse with those in 73 produces the Nanti word stress constraint subhierarchy in Figure 3.

7. DERIVATIONAL MODELS ARE LESS EFFECTIVE TOOLS FOR ANALYZING NANTI. The formal analysis of the Nanti stress data developed in this section has employed the framework of optimality theory (Prince & Smolensky 1993, McCarthy & Prince 1993a,b 1994, 1995) because several of the characteristics of OT are particularly well suited for analyzing data with the properties found in Nanti.

One of the most Nanti-friendly properties of the OT framework is the parallel evaluation of all aspects of a candidate for output. This type of analysis accommodates top-down influences on phonological structure that bottom-up derivational analyses are not well equipped to handle. A persuasive argument against analyses relying on bottom-up constructionism is advanced by Prince and Smolensky (1993; see especially §3.2) based on evidence from stress and syllable structure in Fijian. The evidence from Nanti supports the findings of these authors. As we have shown, Nanti foot-level stress is subject to the top-down influence of requirements on word stress. An example occurs in the form (*im.pó*).*kse*] 'he will come' (25). The optimal site for foot-level stress is the syllable *im*, but this choice is overridden by word-level constraints that optimize stress on the stronger vowel in *po*. Under parallel evaluation in OT, multiple candidates representing different metrical possibilities are considered for output, including the best foot- and word-stress choices, *(*ím.po*).*kse*] and (*im.pó*).*kse*]. The OT grammar selects (*im.pó*).*kse*] as the optimal choice, because this candidate minimizes the costliness of violations over the entire constraint hierarchy.

In bottom-up derivational analyses, by contrast, word stress is not assigned until all foot-level rules have applied to the string of syllables *im.po.kse*, yielding the

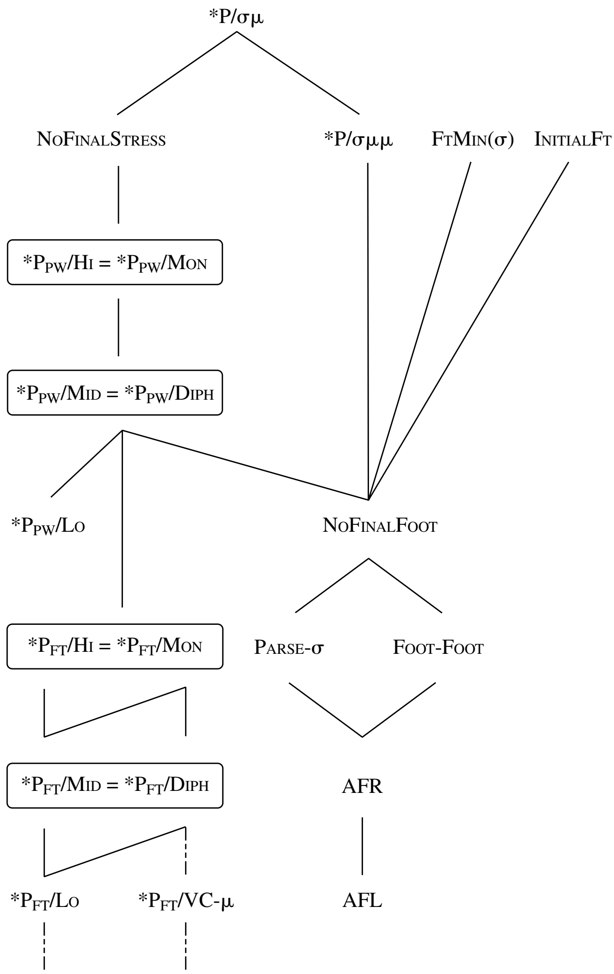


FIGURE 3. The integrated Nanti STRENGTHPK hierarchy and intersection with parsing constraints.

representation in 77a. When word-stress rules apply to the output of the foot-level rules, a repair rule would need to reassign the head of the foot to derive the correct output structure (77b).

(77) A derivational analysis for (*im.pó*).*kse*]

a. Output of foot-level rules	b. Word-level: stress reassignment
x .	. x .
(ím.po).kse	(. x .)
	(im.pó).kse

A second example involves repairs required after word-level processes have assigned stresses that clash with stresses assigned at the foot-level, in forms such as (*ò.ko*)(*rì.kʃi*)(*tá.ka*)] 'she wore a nose-disc'. In this case, foot-level rules derive the representation in 78a, while word-stress rules yield 78b. Next, a rule of TROCHAIC SHIFT must apply to repair the stress clash introduced by word-stress assignment (78c), followed by a second application of trochaic shift to repair the stress clash derived by the initial repair, deriving the final outcome (78d).

(78) A derivational analysis for (*ò.ko*)(*rì.kʃi*)(*tá.ka*)]

```
a. Output of foot-level rules        b. Word level: stress assignment
    .   x    .   x                        .    .    .    .    x  .
   (o.kò) (ri.kʃì) .ta.ka                (.   x    .    x    x  .)
                                         (o.kò) (ri.kʃì) (tá.ka)
c. Word level: trochaic shift (1)    d. Word level: trochaic shift (2)
    .    .    .    .    x  .              .    .    .    .    x  .
   (.   x    x    .    x  .)             (x   .    x    .    x  .)
   (o.kò) (rì.kʃi) (tá.ka)               (ò.ko) (rì.kʃi) (tá.ka)
```

Note that trochaic shift must be a SMART rule, with access to nonlocal information. In order to apply to the foot (*ri.kʃì*), trochaic shift must KNOW that a second application is possible in the preceding foot (*o.kò*). In forms such as (*no.kà*)(*mo.sò*)(*wá.ti*)], in which a shifted first foot is not possible, shift in the middle foot is blocked as well. Rules are generally not permitted this degree of power in derivational frameworks. A purely mechanical alternative would be to apply trochaic shift to (*no.kà*)(*mo.sò*)(*wá.ti*)], yielding (*no.kà*)(*mò.so*)(*wá.ti*)]. Then, the shifted foot (*mò.so*) would have to be bumped back to (*mo.sò*). The reverse bump would need to be triggered as a response to a statement in the derivational grammar that iambic feet are preferred to trochaic feet in Nanti—in other words, a constraint. Although our database contains no examples of the required length and structure, it is easy to imagine a hypothetical four-foot form such as (*no.sà*)(*me.rè*)(*po.rè*)(*há.ka*)]. To correctly derive this pattern, a derivational analysis has the options of (i) double-bumping to the left, then double-bumping to the right again; or (ii) employing a rule of trochaic shift with the ability to look ahead nonlocally, two feet to the left, in determining whether or not to apply. The selection mechanism employed by the OT grammar does not face these problems, because whole candidates are evaluated in parallel in selecting optimal outputs.[21]

Another property of OT that suits it especially well for analyzing Nanti is its interactive and hierarchical nature. Nanti's stress system is based on stress scales and the evaluation of a syllable's fitness to serve as a metrical head based on its ranking in the scale and on whether any competing syllable has a higher ranking. It is impossible for even a derivational account to provide an adequate treatment of Nanti stress without some built-in mechanism for capturing interactions between components of the analysis, whether or not this interactivity is acknowledged. Derivational models can produce the effect of a scale by implementing a series of sequentially ordered rules (e.g. Stress-Lo, Stress-Mid, Stress-Hi, and so on; see, for example, Dell and Elmedlaoui's (1985) derivational analysis of sonority-based syllabification in Imdlawn Tashlhiyt Berber and Prince and Smolensky's (1993) influential reanalysis and discussion). This can be done without acknowledging the system's scale-like behavior, in which case the fact that the rule sequence produces a prominence-based scale whose effects are seen repeatedly across languages is treated as an accident. Another possibility is the inclusion of a statement that the rule sequence responds to a scale (possibly expressed as a meta-constraint on metrical structure), in which case the scale is reproduced in two components of the analysis. It is possible to demonstrate that such an approach is not even mechanically successful for Nanti—at least, not without contortions unlikely to meet

[21] We are grateful to Bruce Hayes for pointing out the implications of nonlocality for derivational analyses in cases like these.

publishable standards.[22] However, even if these problems could be successfully addressed, we see no point in pursuing an approach so handicapped by the loss of generality and/or inescapable redundancies when a tool that more directly and straightforwardly captures the generalizations discussed here is available in the form of an OT analysis.

Properly construed, a scale is a set of conditions accompanied by statements indicating that one condition, A, takes precedence over another, B, when A and B impose conflicting requirements in some context. In derivational rule-based analyses, statements of this kind were often expressed as DO B, EXCEPT WHEN A IS POSSIBLE or DO B, BUT WHEN A IS NOT POSSIBLE. The OT grammar captures such statements formally by representing A and B as constraints that are then ranked, A » B, to capture the interaction between them. (For a detailed discussion, see Prince & Smolensky 1993, especially §§3 and 4.) The OT grammar captures the optimal or BEST status of outputs that satisfy higher-ranked requirements (here, A) relative to lower-ranked ones (B) by placing a higher premium on satisfying higher-ranked constraints, providing a more direct way of capturing the nature of the scale.

8. DISCUSSION AND CONCLUSION. In this concluding section, we comment on some of the implications of the Nanti data, focusing on two specific areas. The first concerns gaps in the typology of attested metrical patterns filled by Nanti. Second, we outline the aspects of Nanti's stress harmony system we take to be universal and which might be subject to language-specific variation and sketch an abbreviated typology of patterns predicted under our account.

Nanti contributes two additions to the typology of attested metrical patterns. First, the Nanti scale CVVN > CVV > CVN > CV provides a solid example of a multigrade weight system based on syllable structure alone. In the few attested examples of metrical systems providing evidence for more than two weight grades,

[22] A derivational approach such as that described here can work well in forms such as (*piŋ.ka*)(*mo.soi*).*ga.kse*], whose feet contain syllables of different strength. In this case, a rule sequence in which four rules, STRESS-LONG-MID, STRESS-CIN, STRESS-SHORT-LO, and STRESS-SHORT-MID, apply in the order stated can generate the attested foot (and word) stress patterns. To capture the stress scale, the grammar must state that once a stress-assigning rule has applied, no other stress-assigning rules may take effect. This is necessary to prevent foot stress in (*piŋ.ka*), for example, from being redone as (*piŋ.kà*) when Stress-Short-Lo applies after Stress-CiN. However, this restriction would have to hold only on some rules. Others, such as rules resolving stress clash, would have to be allowed to apply later when head-assigning rules produce a stress clash, for example, (*nò.ko*)(*gá.ko*).*ta*].*ro* 'I request it' in 6. This form exemplifies a second problem for a rule-based analysis—namely, that of determining the position of the stressed syllable in a foot containing syllables of equivalent strength. If iambic stress is assigned early in the derivation (either as part of the foot initially parsed or by a later head-assigning rule), then all subsequent head-assigning rules must apply as repair strategies. These repair strategies would have to apply in response to a meta-constraint on metrical structure taking the form of a scale, and the position of both syllables in the foot would have to be located on the scale and compared. Thus, if a foot such as (*ga.kò*) is initially constructed, then the rule Stress-Short-Lo must be allowed to apply, but a later rule Stress-Short-Hi would have to be blocked. A body of derivational work (e.g. Hammond 1989, Crowhurst 1992, Hewitt 1992, Crowhurst & Hewitt 1995) argued that head rules applied independently of foot-parsing rules, and this assumption is reflected in the standard OT practice of employing independent constraints for foot parsing on the one hand, and for the presence and position of heads within feet on the other (e.g. McCarthy & Prince 1993a, Kager 1999; see especially Crowhurst 1996 in which this issue is directly tackled). Assuming that foot parsing and head assignment occur independently, then, a mechanically successful account for feet such as (*no.ko*), whose syllables are equivalent, would be to have foot-parsing rules apply from left to right. Subsequent head-assigning rules would scan from right to left. Thus, *no.ko.ga.ko.ta*].*ro* would be initially footed as (*no.ko*)(*ga.ko*).*ta*].*ro*. The head-assigning Stress-Short-Lo would produce (*no.ko*)(*gàko*).*ta*].*ro*. Later, Stress-Short-Mid scanning from right to left should assign stress to *ko* as the first syllable to be encountered in the foot (*no.ko*), yielding (*no.kò*)(*gàko*).*ta*].*ro*. This change in directionality would be unprecedented in a derivational analysis.

it has been possible to exploit differences in the moraic structure of syllables in accounting for the behavior. For example, a variety of Hindi described by Kelkar (1968) exploits the three weight grades in 79a. CVC and CVV syllables pattern as equivalent in this stress system, in that the first (or only) consonant in a Hindi coda contributes as much weight as a vowel mora. Thus, it is possible to analyze CVC and CVV syllables as bimoraic. Super-heavy syllables, CVVC and CVCC, are analyzed as trimoraic—a marked option crosslinguistically, but possibly necessary in this case. According to descriptions of Kashmiri stress (Bhatt 1989, cited in Kenstowicz 1994; Munshi & Crowhurst 2005), in contrast, closed CVC syllables pattern as heavier than CV syllables but lighter than CVV. Morén (2000) reduces this apparent three-way weight distinction to only two weight grades by analyzing CVC as bimoraic in some cases and monomoraic in others (79b). Whether a coda consonant is mora-bearing in Morén's analysis depends on the metrical context.

(79) Multigrade weight systems
  a. Kelkar's Hindi (Kelkar 1968, Hayes 1995)
     CVVC, CVCC > CVV, CVC > CV
     σμμμ > σμμ > σμ
  b. Kashmiri (Morén 2000, Munshi & Crowhurst 2005)
     Apparent three-way weight scale: CVV > CVC > CV
     Morén's proposal:
     CVV, CVC > CV or CVV > CVC, CV
     σμμ > σμ σμμ > σμ

However, a moraic analysis of the scale CVVC > CVV > CVC > CV in Nanti is not available—unless quadri-moraic syllables, σμμμμ, are accepted as a typological option. If such a possibility is rejected, then it becomes necessary to seek an analysis that separates the quantitative contribution of nonmoraic syllable codas from the contribution of moraic elements in the syllable. The analysis developed in this article does exactly this.

The Nanti strength scale is much more finely articulated than CVVC > CVV > CVC > CV, due to the influences of vowel height and diphthongs on stress. Such a finely articulated scale demands more machinery than the standard light vs. heavy—and sometimes heavy vs. super-heavy—options allowed by moraic analyses. We have accounted for these by proposing a web of interactions among constraints forming a series of peak-prominence subhierarchies, QUANT, CODA, HEIGHT, and DIPH, in addition to the basic constraints governing rhythm. The second typological contribution of the Nanti data is to show that such a language is possible.

Now that we understand that a stress system combining the influences at work in Nanti can in fact exist, it becomes necessary to determine which elements of Nanti's strength scale are universal and which can be expected to vary. Quite simply, we expect each of the scales Quant, Coda, Height, and Diph to have universal validity. Thus, the statements in 80 should be true with no exceptions.

(80) Predicted universals
  a. Quant: If a prominent position (e.g. a metrical head position) is sensitive to differences in the moraic quantity of syllables:
     - The preference will be for heavier syllables to coincide with the prominent position.
     - No language will preferentially distribute lighter syllables to prominent positions, other factors being equal.

b. Coda: If a prominent position is sensitive to the open vs. closed status of syllables:
   - The preference will be for closed syllables to coincide with the prominent position.
   - No language will preferentially distribute open syllables to prominent positions, other factors being equal.

c. Height: If a prominent position is sensitive to vowel height:
   - The preference will be for lower vowels to coincide with the prominent position.
   - No language will preferentially distribute higher vowels to prominent positions, other factors being equal.

d. Diph: If a prominent position is sensitive to the distinction between monomoraic monophthongs and diphthongs:
   - The preference will be for the diphthong to coincide with the prominent position.
   - No language will preferentially distribute short monophthongs to prominent positions.

The scales Quant, Coda, Height, and Diph are expected to be invariant across languages because they are grounded in physical properties of syllables that correlate with differences in their relative prominence or salience. In our analysis, these scales (as grammaticalized by Nanti) are formally captured by subhierarchies of constraints, QUANTPK, CODAPK, HEIGHTPK, and DIPHPK, whose internal rankings we expect to be fixed by universal grammar. These subhierarchies therefore have the status of meta-constraints in the universal constraint pool.

While we ascribe universal status to the scales Quant, Coda, Height, and Diph, and the subhierarchies we have used to implement them formally, we assume that interactions among these fixed components of the grammar, and with possible RHYTHMPK subhierarchies, should vary crosslinguistically. It should be possible for any two subhierarchies to intersect at some point, or for the constraints of one or more of these subhierarchies to be interspersed with the constraints of others. (This is how the Qual scale we have used is constructed: the constraints of DIPHPK were interleaved with those of HEIGHTPK to account for the metrical equivalence of the light diphthong [ɯi] and the mid vowels [e, o].) Even though subhierarchy-internal constraint rankings for QUANTPK, CODAPK, HEIGHTPK, and DIPHPK are, by hypothesis, universally fixed, the set of possibilities for interaction among the constraints within these subhierarchies and with rhythmic constraints is immense.[23] We imagine that the full set of possibilities for interaction among constraints in the subhierarchies we have employed would predict a typology of stress patterns too extensive to be plausible. Possibly, rankings among some of the peak-prominence SUBHIERARCHIES are also universally fixed. For example, ranking CODAPK above QUANTPK predicts a system in which light CVC syllables attract stress while heavy CVV syllables do not. It may well be that such a language is impossible, in which case, the ranking QUANTPK » CODAPK should be considered universally fixed as well. We leave this interesting issue as a topic for future research.

[23] Thus, it is not possible to present a complete factorial typology of all of the patterns predicted under our account. Any finer-grained ranking of the individual constraints in any given hierarchy must depend on the evidence of the specific language under analysis.

By way of concluding, we comment on some implications of two aspects of the theoretical approach we have adopted in accounting for Nanti stress. First, referees have wondered why we have employed peak-prominence subhierarchies, such as *P/σμ » *P/σμμ, instead of standard single constraints penalizing unwanted structures, such as the WEIGHT-TO-STRESS PRINCIPLE (WSP: 'Heavy syllables are stressed', Prince 1990, Kager 1999). There are several reasons for this choice. First, although the WSP states that heavy syllables are stressed, it does not directly capture the generalization that light syllables are dispreferred as stress peaks relative to heavy syllables. The peak-prominence subhierarchy *P/σμ » *P/σμμ does capture this generalization. Second, employing a peak-prominence subhierarchy makes it possible to provide a unified account of several distinct but intuitively related phonological behaviors as following from a single generalization. In addition to the WSP, for example, earlier work in metrical theory employed a second constraint, the STRESS-TO-WEIGHT PRINCIPLE or SWP (Prince 1990), which requires stressed syllables to be heavy. The requirements expressed by the WSP and the SWP are very similar; stating them in terms of different constraints to some extent is to miss the underlying generalization that in general, heavy syllables make better stress peaks than light syllables. In our account, both WSP and SWP effects follow from *P/σμ » *P/σμμ, depending on how other constraints are ranked in relation to *P/σμ and *P/σμμ. For example, if the constraint $\text{DEP}_{\text{IO}}(\mu)$ ('Don't epenthesize moras', McCarthy & Prince 1995) is ranked above *P/σμ, then heavy syllables may be sought out for stress, but when no heavy syllable is available to be stressed, vowels will not be lengthened to avoid stress on light syllables (e.g. Tübatulabal, Voegelin 1935; Fijian, Dixon 1988). If $\text{DEP}_{\text{IO}}(\mu)$ is ranked below *P/σμ, however, then lengthening under stress should be possible (e.g. Tiriyó, Meira 1998). Another reason for using peak-prominence hierarchies and not single constraints is the existence of demonstrable consequences that follow from the rankings of two or more constraints in the subhierarchy. For example, in this article we have shown that the metrical equivalence of light diphthongs and mid vowels is due to a special ranking relation between BOTH of the constraints in DIPHPK and other constraints in HEIGHTPK.

A final aspect of our analysis worth commenting on is the apparent duplication of peak-prominence constraints and many rankings among them to account for similarities in the way stress is assigned at the foot and word levels. This duplication, however achieved, is necessary: foot- and word-level requirements on stress are implemented in distinct phonological domains, and in Nanti these requirements, though similar, are not the same. Once we accept that duplication is necessary, then a number of interesting questions arise in connection with the approach. The first is why the degree of similarity between foot- and word-level requirements on stress in Nanti is so high. A second issue that should be addressed is that of how constraint duplication should be handled in an OT analysis. Are foot- and word-level versions of stress constraints (or indeed, any constraints on phonological structure) readily encoded in the universal constraint set, CON? Or are they generated as needed, and if so, how?

One intriguing possibility is that the striking similarity between foot- and word-level stress requirements in Nanti is the result of generalizing a prosodic pattern at one level of structure to another level of structure—a cognitive strategy that should not be at all surprising. Suppose that a Nanti learner were to work out foot-level stress patterns first.[24] As an economical first hypothesis, the learner might assume that what works

[24] We are not seriously suggesting that foot-level patterns are necessarily learned first. We are using this assumption for the point of the example.

for foot stress also works for word stress. Under this assumption, relevant portions of the foot-stress hierarchy might be BUMPED UP to the word level in the learner's phonological grammar. If in the process of building grammars learners begin with the hypothesis 'if pattern P at level X, then P at level Y', the task of working out language-specific constraint rankings at the new level must be much easier than it might otherwise be: if Nanti learners generalize the foot-level stress hierarchy to the word level, they need only work out, based on conflicting evidence, that HEIGHTPK and CODAPK are ranked differently at the word level, but they should not need to reconstruct the full word-stress hierarchy.

The mirroring of metrical requirements at the foot and word levels has been noted before, in stress systems much simpler than Nanti's. For example, there is an overwhelming tendency for word stress in left-to-right footing systems to be located at the left edge of the PrWd, while the mirror image pattern is observed in right-to-left footing systems (Michael Hammond, p.c., 1990). The mirroring effect between foot- and word-level requirements is especially striking in Nanti because the stress pattern itself is unusual. It is precisely for this reason, however, that Nanti provides an incentive for us to adopt a view of grammar building that includes processes of hierarchy generalization. On this view, the proliferation of constraints at the foot and word levels is not an undesirable feature of the analysis of Nanti presented in this work, but it rather represents a parsimonious view of constraint interaction and projection that takes advantage of well-established human cognitive strategies.

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