Integrating Q Theory within the Prosodic Hierarchy: A case study from Nanti stress

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Abstract

Previous work has shown the predictive power of subsegmental representations on a monotonic scale ranging from 1 (q) to 4 (q q q q) subsegments for capturing the behavior of complex segments as well as patterns of segment strength. Here, we analyze an exceptional case from Nanti, where subsegmental representations alone are insufficient to capture the language's unique 12-point weight scale. Our analysis demonstrates that neither Q Theory nor Moraic Theory can capture this weight scale on its own; however, the Nanti data provide evidence for situating subsegments within the Prosodic Hierarchy, revealing that subsegmental representations interact hierarchically with moras to provide the level of granularity required to model the Nanti pattern. We explore how and why Q Theory can be effectively augmented by moraic structure, and we consider the broader implications of modeling phonological weight and segment strength as interrelated yet distinct dimensions of phonological representation.

Keywords: Q Theory, Moraic Theory, segment strength, syllable weight, Nanti

1 Introduction

This paper provides evidence for the integration of subsegments into the Prosodic Hierarchy, investigating the interaction between Q Theory and Moraic Theory in a case study of the Nanti stress system. Our proposal combines subsegmental and moraic representations to yield a more comprehensive model of phonological weight than either framework provides independently, each capturing different aspects of the language's weight-sensitive stress assignment pattern. Our key contribution is a principled mechanism for integrating subsegments into the lowest tier of the Prosodic Hierarchy, generating predictions about how segment strength interacts with moraic structure in computing phonological weight cross-linguistically.

Q Theory is a model of subsegmental representations, according to which, segments may be decomposed into a series of quantized and temporally-ordered subsegments (Garvin et al. 2018, Inkelas & Shih 2016a,b, Lapierre 2021, 2023, Schwarz et al. 2019, Shih & Inkelas 2014, 2018). A canonical segment is represented with three subsegments (q^1 q^2 q^3). This tripartite representation loosely draws on the three articulatory phases of a gesture within Articulatory

Phonology (Browman & Goldstein 1989): (i) movement towards the target, (ii) gestural plateau, and (iii) movement away from the target. Subsegmental representations have proved useful in modeling a range of complex segments and articulatory contours, including contour tones (Shih & Inkelas 2018), affricates (Garvin et al. 2018), complex nasal-oral segments (Garvin et al. 2018, Lapierre 2021, 2023, Lapierre & Russell ms.), and laryngealization in both consonants (Schwarz 2024) and vowels (Robertson Molinaro 2025). Throughout this paper, uppercase Q refers to the segmental tier, while lowercase q refers to the subsegmental tier.

More recently, an extension of Q Theory has been proposed to account for a rather different phonological phenomenon: segment strength (Garvin & Lapierre ms., Garvin et al. 2019, Schwarz et al. 2019). Segment strength is a constellation of phonological properties that make up a segment's propensity to resist or undergo certain phonological processes that reduce contrasts or eliminate structures. According to this proposal, vowels are represented along the monotonic, four-point strength scale presented in Table 1, where strong vowels are represented with a greater number of subsegments and weak vowels with fewer subsegments. A superlight segment with a single subsegment (v) is weaker than a light segment with two subsegments (v v), which is weaker than a full segment with three subsegments (v v v), which in turn is weaker than a strong segment with four subsegments (v v v v). Subsegmental representations interact directly with constraint violations such that altering the identity of a stronger vowel is more costly than altering a weaker one.

Table 1: Q-theoretic representations of vowel strength

	superlight	light	full	strong	
weakest	(v)	(v v)	(v v v)	(v v v v)	strongest

The Nanti case study focuses on the propensity of a segment to bear or attract stress—an important component of segment strength—where segment A is stronger than segment B if A is preferentially stressed over B. Stressability presents a particularly interesting case study, as the range of patterns it encompasses has often been modeled within Moraic Theory (Hayes 1989, 1995, Hyman 1985), which analyzes phonological weight by drawing on moraic representations. Moras—like subsegments—are abstract timing units to which a single segment may be multiply linked. In Moraic Theory, light vowels or syllables are represented with one mora (μ), heavy ones with two moras (μμ), and superheavy ones with three (μμμ) moras, while extrametrical segments—those that are invisible to stress assignment—are assigned no mora at all (e.g., Hayes 1995). Notably, the q-theoretic representations in Table 1 capture a similar spectrum of behavior, prompting the question: *Is the representation of both subsegments and moras necessary, or does one become redundant when the other is encoded?*

Crowhurst & Michael (2005)'s original analysis of Nanti stress similarly advocates for augmenting Moraic theory by appealing to vowel sonority. The q-theoretic representations proposed here share this central analytical insight: both approaches draw on sonority-based distinctions to model phonological weight. However, they differ in two crucial ways, yielding distinct theoretical predictions. First, the q-theoretic analysis provides explicit evidence for a hierarchical relationship between subsegments and moras, thereby allowing for the integration of subsegmental units within the Prosodic Hierarchy (Nespor & Vogel 1983, Selkirk 1981). This integration offers a principled architecture for the role of subsegments in computing phonological weight, rather than treating sonority as an external factor that directly modulates moraic representations.

Second, Q Theory unifies what Crowhurst & Michael (2005) treat as two independent subsegmental scales—vowel height and diphthong status—into a single representational dimension. By grounding the analysis in subsegmental strength, rather than in sonority or contour structure separately, the q-theoretic model generates broader predictions about patterns of stressability. Whereas a sonority-based model predicts that a segment's position on the sonority hierarchy directly determines its weight, a q-theoretic model predicts that stressability is conditioned by segment strength. Under this approach, segments can display a range of strength behaviors influenced not only by sonority but also by factors such as complexity and derivational status. Q Theory thus provides a unified account of both segmental complexity and vowel sonority within a single subsegmental framework.

Previous work on the use of Q Theory to model segment strength has shown that subsegmental representations not only account for a wide range of phonological behavior traditionally handled by moraic structure, but also offer distinct empirical coverage (Garvin & Lapierre ms., Schwarz et al. 2019). This suggests that subsegmental representations can serve as a viable—and, for some phonological phenomena, even superior—analytical alternative. The case study of Nanti stress assignment analyzed in this paper builds on this body of work, as its 12-point weight scale poses a challenge for both Q Theory and Moraic Theory when considered in isolation. We demonstrate that a hybrid approach—one that incorporates both subsegments and moras—captures the intricacies of Nanti's complex weight hierarchy. Our analysis thus provides an extension of Q Theory by illustrating how subsegments and moras can interact to yield a more fine-grained and empirically adequate model of weight-sensitive stress assignment in cases such as the one analyzed here. Furthermore, by integrating subsegments within the Prosodic Hierarchy, we situate the Nanti data within a broader typological and theoretical context, outlining the kinds of phonological phenomena each theory is best suited to capture, and arguing that their integration offers a unified framework capable of modeling both categorical and gradient patterns of phonological weight across languages.

This paper is organized as follows: §2 presents some background on patterns and models of phonological weight, as well as an overview of Nanti phonology; §3 presents the details of our analyses; §4 discusses the relevance and utility of combining Q Theory and Moraic Theory; and §5 concludes.

2 Background

2.1 Vowel strength and stress

Patterns of phonological strength are often modeled on a case-by-case basis, relying on a number of disparate phonological mechanisms. For instance, accounts of stress assignment generally draw on both a segment's derivational status—whether it has a correspondent in the input—and the phonological weight of the rhyme. In many languages, inserted vowels are invisible to stress assignment, resulting in noncanonical stress patterns in an otherwise regular metrical system (Alderete 2008, Elfner et al. 2016). Likewise, many languages exhibit a default stress pattern that is overridden by a syllable with a (super)heavy rhyme, where long vowels are heavier than short vowels, closed syllables are heavier than open syllables (when vowel length is held constant), and more sonorous codas are heavier than less sonorous codas (e.g., Gordon 2007, Hayes 1995, Kager 1995). Table 2 summarizes Moraic Theory's representations of syllable weight: light rhymes

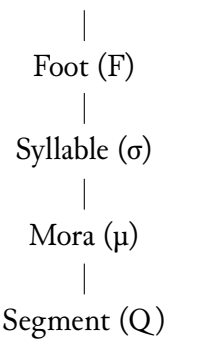
receive one mora, heavy rhymes two, superheavy rhymes three, and extrametrical rhymes receive no mora at all.

Table 2: Moraic representations of rhyme weight

	extrametrical	light	heavy	superheavy	
weakest	∅	μ	μμ	μμμ	strongest

To better understand the role of phonological weight in the grammar and situate its representational architecture, we begin by outlining the broader framework in which it is embedded. Moras are an integral part of the Prosodic Hierarchy (15), originally proposed by Selkirk (1980, 1978, 1981) and later expanded by (Nespor & Vogel 1982, 1983). Within this hierarchy, the mora—traditionally taken as the fundamental unit of phonological weight—is positioned between the syllable and the segment, dominating the latter. This lower portion of the hierarchy—specifically, the interface between moras and segments—forms the foundation of our analysis. Understanding how these units interact is crucial for modeling weight-sensitive stress systems, particularly in languages where segmental properties, vowel strength, or subsegmental structure influence the computation of weight. Our focus here is therefore on the representational component of the grammar, i.e., the units available for manipulation, rather than on the derivational component that constrains their behavior.

(1)



Moraic Theory has proved valuable in modeling a wide range of stress systems cross-linguistically. Palestinian Arabic (ISO: ajp, Semitic; Alxatib 2012, Cotter 2022, Watson 2011) illustrates its utility in modeling weight-sensitive systems. Stress falls on a final superheavy syllable (CV:C or CVCC) if present (2a-2c), otherwise on the penultimate syllable if heavy (CVC or CV:) (2d-2f). If neither of these conditions is met, default stress is assigned to the antepenult (or the initial in words with fewer than three syllables), regardless of weight (2g-2i). As is common in Arabic varieties, vowel epenthesis—[i] in most Levantine dialects—is used to resolve illicit (groups of) consonant clusters. Crucially, epenthetic vowels are invisible to stress, meaning that they don't count in the three-syllable window at the right edge of the word (Alxatib 2012), resulting in a seemingly opaque pattern of stress assignment (2j-2k, where epenthetic vowels are represented in parentheses). While the moraic scale in Table 2 neatly captures the data in (2), it crucially relies on a cyclic analysis in which stress is assigned before epenthesis occurs.

(2) Palestinian Arabic stress assignment (Alxatib 2012: 2)

a.	[ʃa.ba.ˈkaːt]	‘nets’	g.	[ˈʔa.la.mak]	‘your.SG pen’
b.	[bɑ.rɑː.ˈmiːl]	‘barrels’	h.	[ˈʃaː.fa.to]	‘she saw him’
c.	[wɑːs.ˈtˤɑːt]	‘connections’	i.	[ˈʔɑːr.me.to]	‘his sign’
d.	[dˤɑ.rɑ.ˈbɑt.kom]	‘she hit you.PL’	j.	[ˈʔa.k(ɪ)l.ha]	‘food.GEN.3SG.FEM’
e.	[mɑk.ˈtab.kom]	‘your.PL desk’	k.	[ˈʔa.k(ɪ)l.kom]	‘food.GEN.2PL’
f.	[tˤɑːl.ˈbɪt.na]	‘our student.FEM’			

However, work on languages such as Kanien’kéha shows that epenthetic vowels do not behave uniformly with respect to stress assignment, revealing a level of complexity that exceeds the simple binary of underlying versus epenthetic segments. In Kanien’kéha (ISO: moh, Iroquoian, US & Canada) (Michelson 1989, Michelson & Michelson 1988), for instance, stress generally falls on the penultimate syllable of the word (3a–b). However, epenthetic vowels in this position show divergent behavior: those inserted to resolve illicit CCC clusters can bear stress (3c), whereas those inserted between obstruent–sonorant sequences cannot (3d). These patterns reveal that epenthetic vowels vary in their ability to bear stress, suggesting that the underlying vs. epenthetic dichotomy is insufficient to account for Kanien’kéha’s stress system and motivating more granular phonological representations.

(3) Kanien’kéha vowels (Michelson & Michelson 1988: 141–142)

a.	/k-atirut-haʔ/	→ [ka.ti.ˈrut.haʔ]	‘we pull (habitually)’
b.	/k-haratat-s/	→ [kha.ˈraː.tats]	‘we lift (habitually)’
c.	/te-k-ahsutr-haʔ/	→ [te.kah.su.ˈter.haʔ]	‘we two splice (habitually)’
	DU-AGT-splice-HAB	te.kah.su.ˈt(e e)r.haʔ	
d.	/w-akra-s/	→ [ˈwa.ke.ras]	‘he/she smells (habitually)’
	N.AGT-smell-HAB	ˈwa.k(e).ras	

Q Theory provides a way to formalize this distinction without appealing to cyclicity (Adler & Zymet 2021), assigning segments to one of four strength categories (1) based on their phonological behavior, with derivational status contributing to—but not fully determining—strength. Garvin et al. (2019) and Schwarz et al. (2019) propose that in Kanien’kéha, stressable epenthetic vowels—those inserted to resolve CCC clusters—are represented with two subsegments (v v) (3c), whereas unstressable epenthetic vowels—those inserted between obstruent–sonorant sequences—are represented with only one subsegment (v) (3d). This distinction is formalized through a family of stringent stressability constraints (*Stress/v, *Stress/v, vv, *Stress/v, vv, vvv, and *Stress/v, vv, vvv, vvvv), each penalizing stress assignment to weaker segments relative to stronger ones. This analysis captures the tendency for stronger vowels to be preferred for stress without directly referencing derivational status, instead attributing variation in stressability to differences in segment strength.

Q Theory explicitly predicts that some languages will exhibit a four-way distinction in vowel strength—a prediction borne out in Panãra (ISO: kre, Jê, Brazil). Superlight copy vowels surface between onset consonants but do not serve as syllable heads (4a). The light vowel [i] surfaces to repair word-final oral codas but cannot bear stress despite Panãra’s otherwise stress-final pattern (4b). Phonemically short (4c) and long vowels (4d) contrast fully in vowel quality, differ in duration, and—unlike superlight and light vowels—can bear stress.

(4) Panãra vowel strength distinctions (Garvin et al. 2019: 3–4)

a.	/kɾɤ/	→ [kɤɾɤ]	(k k k) (ɤ) (ɾ ɾ) (ɤ ɤ ɤ)	‘thigh’
b.	/tɛp/	→ [ˈtɛ.pi]	(t t t) (ɛ ɛ ɛ) (p p p) (i i)	‘fish’
c.	/pa/	→ [pa]	(p p p) (a a a)	‘arm’
d.	/paː/	→ [paː]	(p p p) (a a a a)	‘foot’

While previous work has proposed that Q Theory may serve as an alternative to Moraic Theory, we argue that integrating subsegments into the Prosodic Hierarchy predicts that both subsegments and moras affect prosodic weight. Nanti’s 12-point weight scale, which we present in the next subsection, provides compelling evidence for this hybrid approach.

2.2 Nanti

2.2.1 Phonemic inventory

Nanti (Glottocode: nant1250, Arawak) is spoken by approximately 450 people in the Peruvian Amazon (Michael 2020). The language exhibits a phonemic inventory fairly typical of Western Amazonian languages, including five distinct vowel qualities /i, e, a, ɯi, o/, each of which exhibits a contrast for length /iː, eː, aː, ɯiː, oː/, as well as four contrastive diphthongs /ei[1], oi, ai, ae/. Note that /ɯi, ɯiː/ pattern phonemically as monophthongal mid vowels, rather than long diphthongs[2]. Michael (p.c., 2025) notes that Crowhurst & Michael (2005)’s original description of the metrical system glosses over “the difference between derived and underived diphthongs. In particular, intervocalic /h/ is generally deleted, except when doing so would result in a surface triphthong ([as well as] in certain speech styles, and in oral poetry), and this is the source of a lot of surface diphthongs. For the purposes of [weight], syllables with these surface diphthongs behave [like other phonemic diphthongs].” The full vowel inventory appears in Table 3.

Table 3: Nanti phonemic vowel inventory

	Short			Long			Diphthong		
	Front	Central	Back	Front	Central	Back	Front	Central	Back
High	i		ɯi	iː		ɯiː			
Mid	e		o	eː		oː	ei		oi
Low		a			aː			ai, ae	

In terms of its consonant inventory, the language exhibits a contrast between bilabial, coronal, and velar consonants, and each place of articulation contrasts a palatalized and a non-palatalized series. These consonants can further be categorized according to their manner of articulation, namely, voiced and voiceless stops and affricates, as well as fricatives, nasals, and approximants. The full consonant inventory appears in Table 4.

[1]Though the diphthong /ei/ does not appear in Crowhurst & Michael (2005)’s phonemic table, Michael (p.c., 2025) confirms that it patterns with other diphthongs, as mentioned in their prose.

[2]The distinction between ɯi, which patterns with other monophthongs, and all other diphthongs is predicted by ABC+Q, where two subsegments that are similar enough, i.e., both high vowels, can co-occur within the same segment, whereas subsegments of different heights can only pattern as diphthongs.

Table 4: Nanti phonemic consonant inventory

	Labial	Pal. labial	Coronal	Pal. coronal	Velar	Pal. velar	Glottal
Stops	p b	pʲ bʲ	t	tʲ	k g	kʲ gʲ	
Affricates			ts	tʃ	ks gz	kʃ gʒ	
Fricatives			s	ʃ			h
Nasals	m	mʲ	n	nʲ	ŋ		
Approximants	w		ɾ ɾʲ l	j			

2.2.2 Stress assignment

We now turn to an abridged description of stress assignment in Nanti following Crowhurst & Michael (2005), focusing on the assignment of primary stress. For reasons of space, this section omits certain details. We refer the reader to Crowhurst & Michael (2005)'s thorough exposition of the language's complex weight system for the comprehensive account, including iterative secondary stress assignment, its interaction with primary stress, and stress clash resolution.

Primary stress in Nanti is assigned to the heaviest syllable within the stress domain, which is not always coextensive with the morphological word. As Crowhurst & Michael (2005: 49) note, "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" . Additionally, the final syllable is extrametrical if it has the shape CV or CVN—the overwhelming majority of final syllable types in Nanti—meaning it cannot bear primary or secondary stress, as exemplified in (5a-5b).

Syllables in Nanti are of the type (C)V(:)(N). When multiple syllables are tied for heaviest, the rightmost receives primary stress (5). Secondary stress is assigned iambically from left to right, generally falling on alternating syllables (5c). The language avoids parsing feet to the right of the syllable receiving primary stress, though some exceptions are observed. Feet are marked in parentheses and the end of the phonological word by a right bracket.

(5) Iterative left-to-right iambs with final extrametricality (Crowhurst & Michael 2005: 51)

a.	['ta.ta]	('ta.ta)]	'what.INTERROG'
b.	['ʃi.gze]	('ʃi.gze)]	'run!'
c.	[i.ˌpi.ɾi.'ni.te]	(i.ˌpi).(ɾi.'ni)].te	'he sits'
d.	[o.'go.te.ɾo]	(o.'go).te].ɾo	'she will know it'
e.	[no.'ne.he.ɾo]	(no.'ne).he].ɾo	'I will see it'
f.	[o.ˌko.wo.'go.te.ɾo]	(o.ˌko).(wo.'go).te].ɾo	'she harvests it'
g.	[i.ˌɾi.pi.'ɾi.ni.te]	(i.ˌɾi).(pi.'ɾi).ni].te	'he will sit'

Syllable weight is determined on the basis of three independent weight scales: (i) vowel height, where low vowels are heavier than mid vowels, which are in turn heavier than high vowels (6); (ii) vowel length, where long vowels are heavier than short vowels (7); and (iii) coda presence, where closed syllables are heavier than open syllables (8).

(6) **Height scale**: /a(ː), ai, ae/ > /e(ː), o(ː), ɯi(ː), ei, oi/ > /i(ː)/ (Crowhurst & Michael 2005: 53–54)

a. **a > e**	[pi.ˌpo.ˈka.kse.na]	(pi.ˌpo)(ˈka.kse)].na	'you came to me'
b. **a > o**	[i.ˌne.ˈja.ko.te.ɾo]	(i.ˌne)(ˈja.ko).te].ɾo	'he knows about it'
c. **a > ɯi**	[ˈja.nɯi.ti]	(ˈja.nɯi)].ti	'he walked'
d. **e > i**	[ˌna.pʲe.ʃi.ˌgo.pi.ˌɾe.ˈja.kse]	(ˌna.pʲe).(ʃi.ˌgo).(pi.ˌɾe).(ˈja.kse)]	'I rested.PF'
e. **o > i**	[ˌo.ɾe.ˈwo.kʃi.ti.ɾo]	(ˌo.ɾe).(ˈwo.kʃi).ti].ɾo	'it is wetted by the rain'
f. **e = o**	[noŋ.ˈksen.te]	(noŋ.ˈksen).te]	'I will pierce (with an arrow)'
g. **o = ɯi**	[no.ˈtɯi.je.ɾo]	(no.ˈtɯi).je].ɾo	'I will knock it over'
h. **aː > iː**	[i.ˌtiŋ.ka.ˈɾaː.ʃiː.gʒi]	(i.ˌtiŋ).(ka.ˈɾaː).ʃiː.gʒi]	'they harvested thatch'
i. **aː > oi**	[ja.ˈmaː.ta.ˌkoi.ga.ˌna.kse]	(ja.ˈmaː).(ta.ˌkoi).(ga.ˌna).kse]	'they.MASC floated [it] away'
j. **ai > iː**	[jo.ˌbiː.ˈkai.ga.kse]	(jo.ˌbiː).(ˈkai.ga).kse]	'they.MASC drank'
k. **ai > oː**	[noː.ˈgai.ga.ɾo]	(noː.ˈgai).ga].ɾo	'we ate it'

(7) **Length scale**: /Vː/ > /V/ (Crowhurst & Michael 2005: 60)

a. **ai > a**	[i.ˌne.ˈhai.ga.kʃi.ɾi.ɾa]	(i.ˌne)(ˈhai.ga).kʃi].ɾi.ɾa	'he saw him over there'
b. **oi > a**	[mɯi.ˌta.ˈkoi.ga.kʃim.pi.ɾa]	(i.ˌta)(ˈkoi.ga).kʃim].pi.ɾa	'helped you with it'
c. **aː > a**	[i.ˌti.sa.ˈɾaː.kse.ɾo]	(i.ˌti)(sa.ˈɾaː).kse].ɾo	'he tore it'
d. **oː > a**	[no.ˌtsa.ˈɾoː.ga.kse]	(no.ˌtsa)(ˈɾoː.ga).kse]	'I was startled'

(8) **Coda scale**: /VC/ > /V/; /VːC/ > /Vː/ (Crowhurst & Michael 2005: 60)

a. **aN > a**	[i.ˌka.ˈman.ta.na.ɾa]	(i.ˌka).(ˈman.ta).na.ɾa]	'he tells me'
b. **oN > o**	[ˌoŋ.ko.wo.ˈgo.te.ɾo]	(ˌoŋ.ko).(wo.ˈgo).te].ɾo	'she will harvest it'
c. **oN > e**	[ˌkon.te.ja.ˈta.gze.ta]	(ˌkon.te).(ja.ˈta).gze.ta]	'departed separately'
d. **VːN > Vː**	[o.ˌsa.ˈɾaːn.tai.ga.kse]	(o.ˌsa).(ˈɾaːn.tai).ga.kse]	'they.MASC tore it with a purpose'

These three weight scales interact in complex ways, giving rise to the unique 12-point scale in Table 5. Phonemic vowel length plays a dominant role, followed by vowel height, and finally, presence of a coda. When controlling for height, a long vowel with a coda /V_iːN/ is heavier than a long vowel without /V_iː/ (8d), which in turn is heavier than a short vowel with a coda /V_iN/ (9a). However, when comparing across vowels of different height, a short mid vowel with a coda /eN/ is lighter than a short low vowel without a coda /a/ (9b-9c), and a short low vowel with a coda /aN/ [7] is lighter than a long high vowel /iː/ without a coda. These interactions are illustrated in (9). Although not every comparison in Table 5 is explicitly shown, the omitted rankings can be inferred by transitivity (see Crowhurst & Michael 2005).

(9) Interactions between weight scales (Crowhurst & Michael 2005: 61)

a.	**Vː > VN**	[iˈ.ɾoː.ga.ˌksem.pa.ɾo]	(i.ɾoː).(ga.ˌksem).pa].ɾo	'he will have consumed it'
b.	**a > eN**	['a.pʲe.ʃi.ˌjem.pa.ɾa]	('a.pʲe).(ʃi.ˌjem).pa].ɾa	'it (thatch) will decay'
c.	**a > oN**	[ˌom.pi.ˈta.kse]	(ˌom.pi).(ˈta.kse)]	'she will stay'
d.	**a > iN**	[ˌpiŋ.ki.ˈsa.kse.ɾa]	(ˌpiŋ.ki).(ˈsa.kse)].ɾa	'you will hit'

Crowhurst & Michael (2005) capture this weight hierarchy through an analysis appealing to both Moraic Theory and vowel sonority. The role of vowel length and coda consonants in the assignment of stress is modeled within a standard architecture of Moraic Theory. To account for the effect of vowel height, the authors draw on a family of PEAKPROMINENCE constraints (Kenstowicz 1997, Prince & Smolensky 1993), which penalize stress on syllables containing vowels of

Table 5: Nanti weight scale, where rhymes labeled with 1 are heaviest and rhymes labeled with 12 are lightest (Crowhurst & Michael 2005: 66)

	Long vowels						Short vowels					
Scale position	1	2	3	4	5	6	7	8	9	10	11	12
Rhyme shape			e:N	e:								
	a:N	a:	o:N	o:					eN	e		
	aiN	ai	eiN	ei	i:N	i:	aN	a	oN	o	iN	i
	aeN	ae	oiN	oi					ɯiN	ɯi		
			ɯi:N	ɯi:								

particular heights. This constraint family produces the expected implicational scale: stressed high vowels are less harmonic than stressed mid vowels, which are in turn less harmonic than stressed low vowels. A parallel set of PeakProminence constraints similarly captures the generalization that stressed monophthongs are less harmonic than stressed diphthongs.

3 Analysis

In this section, we present three analyses of the Nanti weight scale, each drawing on distinct phonological representations of the rhymes in Table 5. The first uses only moraic representations (§3.1), the second uses only subsegmental representations (§3.2), and the third combines both (§3.3). We show that neither the moras nor subsegments alone can capture the full pattern, but a combined moraic and subsegmental model succeeds in accounting for all aspects of the Nanti weight scale. Crucially, our analysis provides evidence for integrating subsegments within the Prosodic Hierarchy.

3.1 Moraic Theory

As will be shown in this section, Moraic Theory alone is insufficiently granular to capture the Nanti 12-point weight scale. This is because standard moraic representations predict a maximally 4-way distinction along the scale V:C » V: » VC » V (Morén 2000, Ryan 2020), and thus fails to capture any differences that are determined by vowel height, namely /a/ > /e, o/ > /i, ɯi/. Moraic Theory can, however, capture a subset of the patterns within this 12-point scale, namely weight differences that are determined by vowel length and presence of a coda, as well as their interaction.

3.1.1 Moraic representations and constraints

As noted in §1, the weight distinction between long and short vowels is conventionally represented by assigning two moras (μμ) to long vowels and a single mora (μ) to short vowels. Diphthongs typically pattern with long vowels and are likewise treated as bimoraic (Hayes 1995). We adopt these standard conventions for Nanti: short vowels are monomoraic, while long vowels and the diphthongs /ai, ae, ei, oi/ are bimoraic. However, Nanti displays an additional subtlety: although most diphthongs pattern with long vowels, the diphthong /ɯi/ occurs in both long and short forms. We analyze short /ɯi/ as monomoraic, since it patterns with short mid vowels

in weight, and long /ɯiː/ as bimoraic, as it patterns with long mid vowels. These moraic representations effectively capture the weight distinctions between short and long vowels in Nanti, as well as between monophthongs and diphthongs.

Moraic Theory also provides a straightforward mechanism to represent differences in weight between rhymes with and without codas. In many languages, coda consonants contribute a unit of weight to the rhyme that is absent in open syllables. Following Crowhurst & Michael (2005), we adopt a non-moraic representation of codas, and instead allow them to contribute an independent and uniform unit of weight. The justification for this is the following: If coda consonants are analyzed as bearing a mora (μ), the resulting system would only allow for a three-way weight scale (V:C » V:, VC » V), incorrectly treating both open syllables with a long vowel to closed syllables with a short vowel as equally bimoraic. By contrast, assigning codas a non-moraic but weight-bearing contribution yields the more fine-grained four-way distinction (V:C » V: » VC » V) proposed by Morén (2000) and Ryan (2020). This approach aligns more closely with the Nanti weight scale, where /V:/ is heavier than /VC/. The moraic representations for all possible Nanti rhymes are summarized in Table 6.

Table 6: Moraic representations of Nanti rhymes

	Long vowels						Short vowels					
Scale position	1	2	3	4	5	6	7	8	9	10	11	12
Segmental representation	a:N aiN aeN	a: ai ae	e:N o:N eiN oiN ɯi:N	e: o: ei oi ɯi:	i:N	i:	aN	a	eN oN ɯiN	e o ɯi	iN	i
Moraic representation	μμ a:N μμ aiN μμ aeN	μμ a: μμ ai μμ ae	μμ e:N μμ o:N μμ eiN μμ oiN μμ ɯi:N	μμ e: μμ o: μμ ei μμ oi μμ ɯi:	μμ i:N	μμ i:	μ aN	μ a	μ eN μ oN μ ɯiN	μ e μ o μ ɯi	μ iN	μ i

In Modeling Nanti's weight scale within Moraic Theory, we adopt two key constraints from Morén (2000): Weight-to-Stress, which refers to the moraic structure of vowels (10), and Coda-to-Stress, which captures the weight contribution of consonants (11).[3] In addition, to

[3]In Morén (2000)'s analysis, an additional constraint, PeakProminence, is needed to account for the fact that a rhyme containing a long vowel with a coda (V:C) patterns as heavier than a long vowel without a coda (V:). Because his analysis is implemented in a strictly ranked constraint system, PeakProminence is necessary to force this distinction. Here, we use a weighted constraint grammar, which eliminates the need for PeakProminence:

capture Nanti's default pattern of right-aligned stress, we include the standard Align-Stress-Right constraint (Kager 1999, McCarthy & Prince 1993), defined in (12).

(10) Weight-to-Stress (W-to-Str): Assign a violation for each unstressed bimoraic syllable

(11) Coda-to-Stress (C-to-Str): Assign a violation for each unstressed syllable with a coda

(12) Align-Stress-Right (Align-R): Assign a violation for each unstressed syllable at the right edge of the word

Given the representations in Table 6—which do not provide a formal means to encode weight distinctions based on vowel height—a model relying exclusively on moras and coda consonants cannot adequately capture the independent effect of vowel height on syllable weight in Nanti. The following subsection presents the moraic analysis in detail and highlights its limitations in accounting for height-driven weight distinctions.

3.1.2 Grammar

We used OT-Help (Staubs et al. 2010) to generate a grammar of the Nanti weight scale, implementing Optimality Theory (Prince & Smolensky 1993) within a Harmonic Grammar framework (Legendre 1990), where constraints are assigned numerical weights. In a first iteration, the model failed to converge when attempting to generate a grammar accounting for all three weight scales—vowel length, vowel height, and coda presence—together with their interactions. As discussed above, this follows from the fact that the mora-only model can successfully account for the weight scales of vowel length and coda presence, as well as their interactions, but it can neither account for the vowel height scale, nor its interactions with the other two scales.

In a second iteration, we restricted the input data to the components of the system that the mora-only model can in principle capture: default right-aligned stress, vowel length, coda presence, and their interactions. This model converged, and we report on its input and results below. We first exemplify the components of the Nanti stress system that the mora-only model successfully models; we then turn to exemplifying the components of the system it cannot account for, namely the effects of vowel height and their interactions with vowel length and coda presence.

Table 7 illustrates the basic pattern of right-aligned stress in Nanti for an input sequence containing vowels of equal weight, here the mid short vowel /e/ followed by the mid short vowel /o/. Both of these rhymes are monomoraic and codaless, and thus equivalent in weight, allowing us to observe the default pattern of right-aligned stress. In this tableau and all others in this chapter, the stressed syllable is preceded by a stress mark ['] and appears in bold font. In winning candidate (a), stress is assigned to the right-most vowel [o], thus incurring no violations of any of the constraints. In losing candidate (b), stress falls on the left-most vowel [e], incurring a fatal violation of Align-Stress-Right.

Table 8 exemplifies the effect of phonemic vowel length for an input sequence containing long /i:/ followed by short /i/. This configuration illustrates how long vowels attract stress over short vowels. Candidate (a) avoids violations of both Coda-to-Stress and Align-Stress-Right, but fatally violates Weight-to-Stress. In comparison, winning candidate (b) only incurs a violation

distinct weights on Weight-to-Stress and Weight-by-Position—the latter replaced by Ryan's Coda-to-Stress (Ryan 2014)—produce the required hierarchy.

Table 7: Moraic analysis of default right-aligned stress given an input sequence /e ... o/

/e ... o/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
👉 a. μ μ | | [e ... 'o]				0
b. μ μ | | ['e ... o]			1	-1

of Align-Stress-Right and avoids violations of the more highly weighted Coda-to-Stress and Weight-to-Stress.

Table 8: Moraic analysis of weight to stress given an input sequence /i: ... i/

/i: ... i/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
a. μμ μ ∨ | [i: ... 'i]	1			-4
👉 b. μμ μ ∨ | ['i: ... i]			1	-1

Table 9 illustrates the effect of a coda on syllable weight for an input sequence containing the codaful rhyme /aN/ followed by the codaless rhyme /a/. Losing candidate (a) avoids violations of both Weight-to-Stress and Align-Stress-Right, but incurs a fatal violation of Coda-to-Stress. Winning candidate (b) avoids violations of both Weight-to-Stress and Coda-to-Stress, but incurs a violation of Align-Stress-Right. Because the weight of Coda-to-Stress exceeds that of Align-Stress-Right, candidate (b) wins.

Table 9: Moraic analysis of Coda-to-Stress given an input sequence /aN ... a/

/aN ... a/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
a. μ μ | | [aN ... 'a]		1		-2
👉 b. μ μ | | ['aN ... a]			1	-1

Table 10 illustrates the interaction between the effects of phonemic vowel length and coda presence for an input containing the codaless long vowel /e:/ followed by the coda-bearing short vowel /eN/. Candidate (a) avoids violations of both Coda-to-Stress and Align-Stress-Right, but incurs a fatal violation of the most highly-weighted constraint, Weight-to-Stress. Winning candidate (b), by contrast, incurs one violation each of Coda-to-Stress and Align-Stress-Right, but their combined weight does not exceed that of Weight-to-Stress.

Table 10: Moraic analysis of Coda-to-Stress given an input sequence /eː ... eN/

/eː ... eN/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
a. μμ μ ∨ | [eː ... ˈeN]	1			-4
👉 b. μμ μ ∨ | [ˈeː ... eN]		1	1	-3

We now turn to those aspects of the Nanti weight scale that the mora-only model fails to capture, namely the effect of vowel height and its interaction with the other weight scales. To demonstrate this, we use the weights obtained from the second iteration of the model generated by OT-Help—recall that the tableaux in the rest of this subsection were not included in the model's training data.

Table 11 shows the model's inability to account for height-based weight distinctions for the input sequence /e ... i/. As summarized in Table 5, /e/ holds a position of 10 on the Nanti weight scale, whereas /i/ holds a position of 12, meaning that the former patterns as heavier than the latter. Candidate (a) is therefore expected to win, but actually loses out to candidate (b). This is because both vowels are phonemically short and thus equally monomoraic; and in the absence of a mechanism to encode the greater weight of /e/ over /i/, stress is assigned to /i/ by default right-alignment. Candidate (a) does not incur any constraint violations, whereas candidate (b) incurs a violation of Align-Stress-Right. As a result, the model incorrectly selects candidate (a) as the winner.

Table 11: Moraic analysis of height given an input sequence /e ... i/

/e ... i/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
💣 a. μ μ | | [e ... ˈi]				0
b. μ μ | | [ˈe ... i]			1	-1

Finally, Table 12 illustrates the model's failure to account for the interaction between vowel height and presence of a coda, given an input sequence /a ... eN/. /a/ occupies weight level 8 on the scale (Table 5), while /eN/ occupies level 9, making /a/ the heavier rhyme. Candidate (b) should therefore emerge as optimal, but it instead loses to candidate (a). Because both vowels are monomoraic in the mora-only representation, they are treated as equal in weight; in the absence of a mechanism to encode height-based weight, stress defaults to the syllable with the coda. Winning candidate (a) does not incur any constraint violations, whereas losing candidate (b) incurs violations of both Coda-to-Stress and Align-Stress-Right. This outcome fails to account for the greater contribution of vowel height to phonological weight in Nanti relative to that of codas.

Table 12: Moraic analysis of height given an input sequence /a ... eN/

/a ... eN/	Weight-to-Stress	Coda-to-Stress	Align-Stress-Right	$\mathscr{H}$
weights	4	2	1	
💣 a. μ μ | | [a ... ˈeN]				
b. μ μ | | [ˈa ... eN]		1	1	-3

In the next subsection, we turn to a discussion of the subsegment only-model of Nanti weight.

3.2 Q theory

This section demonstrates that a purely q-theoretic analysis is likewise insufficient to capture the 12-point weight scale observed in Nanti. While Q Theory successfully models the default right-aligned stress pattern as well as each of the independent weight scales—vowel height, vowel length, and coda presence—it fails to account for how each of these dimensions of weight interact. This is because Q Theory predicts a strictly monotonic weight scale, but as was shown in §2.2.2, the three independent weight scales do not contribute equally to syllable weight.

3.2.1 Subsegmental representations and constraints

To determine the q-theoretic representations for vowels of different height—/a/ » /e, o, ɯi/ » /i/—we begin with the crucial observation that the diphthong /ɯi/ patterns with the mid vowels on the three-way vowel height scale. This implies that mid vowels must contain minimally 2 subsegments: representing a diphthong—a complex segment—with only 1 subsegment is simply not possible. Given that mid vowels pattern as stronger than high vowels, and low vowels pattern as stronger than mid vowels, we model high vowels with one subsegment, mid vowels with two, and low vowels with three. These representations are in agreement with a basic assumption of Q Theory, namely that canonical short segments may contain up to three subsegments (Shih & Inkelas 2019). Phonemic vowel length—contrastive for all vowel qualities—is represented with one additional vowel subsegment (Garvin & Lapierre ms., Garvin et al. 2019, Schwarz et al. 2019).

We represent coda nasals with two subsegments (NN), based on the following reasoning: A canonical segment is represented with three subsegments (Shih & Inkelas 2018), where q^1, q^2, and q^3 reflect the tripartite temporal structure of segments—analogous, but not necessarily identical, to gestural phases such as movement towards closure, hold, and release. As Michael (p.c., 2018) observes, "[n]asal codas in Nanti appear before voiceless stops only, to which they place assimilate, and there is no release of the nasal stop. There are no word-final nasal codas." This motivates a subsegmental representation for nasal codas with only two subsegments, as the movement away from the closure—q^3—is not realized. The q-theoretic representations for all possible Nanti rhymes are summarized in Table 13.

Modeling Nanti's weight scale using Q Theory further requires us to define constraints that crucially refer to subsegments. To operationalize segment strength, we need constraints that favor stress on vowels with more subsegments over those with fewer. There are several formally

Table 13: Subsegmental (Q-theoretic) representations of Nanti rhymes

	Long vowels						Short vowels					
Scale position	1	2	3	4	5	6	7	8	9	10	11	12
Segmental representation	a:N aiN aeN	a: ai ae	e:N o:N eiN oiN ɯi:N	e: o: ei oi ɯi:	i:N	i:	aN	a	eN oN ɯiN	e o ɯi	iN	i
Subsegmental representation	aaa-a-NN aai-i-NN aae-e-NN	aaa-a aai-i aae-e	ee-e-NN oo-o-NN ei-i-NN oi-i-NN ɯi-i-NN	ee-e oo-o ei-i oi-i ɯi-i	i-i-NN	i-i	aaa-NN	aaa	ee-NN oo-NN ɯi-NN	ee oo ɯi	i-NN	i

equivalent ways to encode this pattern (see e.g. the PeakProminence family of Kager (1995) and Prince & Smolensky (1993); here, we adopt stringent constraints (De Lacy 2004) to capture the implicational pattern whereby vowels of lower strength are dispreferred for stress relative to vowels of greater strength (13). We also make use of Align-Stress-Right (12), defined in §3.1.1.

(13) a. *Stress/q (*Str-1q): Assign a violation for every 1 subsegment rhyme that bears stress

b. *Stress/q, qq (*Str-2q): Assign a violation for every 1 or 2 subsegment rhyme that bears stress

c. *Stress/q, qq, qqq (*Str-3q): Assign a violation for every 1, 2 or 3 subsegment rhyme that bears stress

d. *Stress/q, qq, qqq, qqqq (*Str-4q): Assign a violation for every 1, 2, 3 or 4 subsegment rhyme that bears stress

e. *Stress/q, qq, qqq, qqqq, qqqqq (*Str-5q): Assign a violation for every 1, 2, 3, 4 or 5 subsegment rhyme that bears stress

f. *Stress/q, qq, qqq, qqqq, qqqqq, qqqqqq (*Str-6q): Assign a violation for every 1, 2, 3, 4, 5 or 6 subsegment rhyme that bears stress

Given the representations in Table 13, Q Theory predicts a maximally 6-way distinction in rhyme strength: up to three subsegments for vowel height, one additional subsegment for phonemic length, and two additional subsegments for codas. This architecture encodes the assumption that within each weight scale (i.e., vowel height, vowel length, coda presence), greater weight corresponds to a greater number of subsegments. The 12-point weight scale in Table 5 shows, however, that Nanti exhibits complex interactions among vowel height, vowel length, and coda structure. Crucially, the contribution of phonemic vowel length to weight is greater than that of coda consonants, yet Q Theory assigns only one subsegment to vowel length, compared to two for codas. This misalignment reveals a core limitation: although Q Theory offers fine-grained representations within each dimension, it cannot capture the relative contributions across scales. Nanti's weight distinctions are not simply additive across independent parameters; rather, they arise from weighted interactions that Q Theory, in its current form, is not equipped to handle.

The following subsection returns to this issue in more detail, identifying the specific points where Q Theory fails to account for the interaction among vowel height, vowel length, and coda-based weight.

Before turning to the implementation of the grammar, it is worth considering why a raw subsegmental analysis—one that represents all weight distinctions exclusively through subsegmental counts—is incompatible with q-theoretic principles, despite being technically possible for the Nanti data. Any adequate q-theoretic analysis should, to the extent possible, follow established conventions to represent each factor contributing to weight, e.g., vowel height, vowel length, and coda presence in the Nanti case. In our proposed representations, differences in height are encoded through the number of subsegments, length uniformly adds one subsegment to this base representation, and codas contribute two subsegments—all principled decisions that follow directly from previous work on subsegmental structure.

A brute-force subsegment-only analysis would require abandoning these established principles. To generate the correct weight distinctions, codas would need to contribute only one subsegment—the only configuration that yields the Nanti pattern—yet this contradicts all prior proposals for consonantal representation in Q Theory (Garvin et al. 2018, Inkelas & Shih 2016a). Similarly, to distinguish all six vowel categories (short/long × low/mid/high) through subsegmental count alone, the representations would need to be as follows: low long vowels = 11 subsegments, mid long = 9, high long = 7, and so on, with length contributing six subsegments rather than one. Such representations depart radically from the canonical three-subsegment architecture of segments within Q Theory (Shih & Inkelas 2019). This alternative model would be overfitted to Nanti, discarding the principled rationale for subsegmental representations developed on the basis of data from multiple languages and phenomena, and sacrificing cross-linguistic generalizability for descriptive coverage of a single phenomenon. In addition, beyond the problem of overfitting, an analysis that distinguishes rhymes containing 1 to 12 subsegments requires the phonological grammar to count subsegments—potentially up to 12. This is theoretically problematic, as phonological systems have long been argued not to count beyond three units.[4]. We therefore prioritize an analysis that maintains consistency with the established architecture of q-theoretic.

3.2.2 Grammar

We again used OT-Help (Staubs et al. 2010) to generate a Harmonic Grammar model of the Nanti weight scale. In a first iteration, the model did not converge when tasked with generating a grammar simultaneously accounting for each of the three weight scales as well as their interactions. This failure is expected: while the subsegment-only model can successfully capture each individual scale—vowel height, vowel length, and coda presence—it cannot model the interactions among them.

In a second iteration, we therefore restricted the input to the independent effects of default right-aligned stress and the three scales, omitting the interaction patterns. The model successfully optimized and converged, and we discuss its output below. We begin by exemplifying the components of the Nanti stress system that the subsegment-only model can account for;

[4]We note, however, that this restriction has been debated, particularly for tonal phenomena, nevertheless, a system that counts to 12 is unprecedented (Paster 2019, Rolle & Lionnet 2019).

we then show where this model fails, namely in capturing the interactions between phonemic length, presence of a coda, and vowel height.

Table 14 exemplifies the basic pattern of right-aligned stress in Nanti for an input containing the mid short vowel /e/ followed by the mid short vowel /o/. Because these rhymes are equal in weight, they reveal the default pattern of right-alignment. In winning candidate (a), stress falls on the right-most vowel [o], avoiding a violation of ALIGN-STRESS-RIGHT. In losing candidate (b), stress is assigned to the left-most candidate [e], incurring a fatal violation of this constraint. Both candidates incur the same violations of the stringent constraints *STR-2q, *STR-3q, *STR-4q, *STR-5q, and *STR-6q, since in both cases, the stressed vowel consists of two subsegments.

Table 14: Subsegmental analysis of default right-aligned stress given an input sequence /e ... o/

/e ... o/	*STR-1q	*STR-2q	*STR-3q	*STR-4q	*STR-5q	*STR-6q	ALIGN-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
☛ a. [e ... **'o**] (ee) ... **(oo)**		1	1	1	1	1		-7
b. [**'e** ... o] **(ee)** ... (oo)		1	1	1	1	1	1	-8

Table 15 illustrates the effect of phonemic vowel length for an input sequence containing the long vowel /i:/ followed by short /i/. This example shows that long vowels attract stress relative to short vowels. Candidate (a) avoids a violation of ALIGN-STRESS-RIGHT, but incurs a violation of each of the stringent constraints because the stressed short high vowel [i] contains only one subsegment. Candidate (b), with stress on the long vowel, violates ALIGN-STRESS-RIGHT and all stringent constraints except *STR-1q. Since *STR-1q is assigned a higher weight than ALIGN-STRESS-RIGHT, candidate (b) wins.

Table 15: Subsegmental analysis of weight to stress given an input sequence /i:... i/

/i: ... i/	*STR-1q	*STR-2q	*STR-3q	*STR-4q	*STR-5q	*STR-6q	ALIGN-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. [i: ... **'i**] (i-i) ... **(i)**	1	1	1	1	1	1		-9
☛ b. [**'i:** ... i] **(i-i)** ... (i)		1	1	1	1	1	1	-8

Table 16 illustrates the effect of a coda for an input containing the codaful rhyme /aN/ followed by codaless /a/. Losing candidate (a) avoids a violation of ALIGN-STRESS-RIGHT, but incurs violations of *STR-3q, *STR-4q, *STR-5q, and *STR-6q, since the stressed short low vowel /a/ contains three subsegments. Winning candidate (b), which stresses the coda-bearing syllable, incurs violations of ALIGN-STRESS-RIGHT, as well as *STR-5q, and *STR-6q, since /aN/ is represented with a total of five subsegments. Because the combined violations of *STR-3q and *STR-4q outweigh a single violation of ALIGN-STRESS-RIGHT, candidate (b) emerges as optimal.

Table 16: Subsegmental analysis of coda-to-stress given an input sequence /aN ... a/

/aN ... a/	*Str-1q	*Str-2q	*Str-3q	*Str-4q	*Str-5q	*Str-6q	Align-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. [aN ... **'a**] (aaa-NN) ... **(aaa)**			1	1	1	1		-5
☛ b. [**'aN** ... a] **(aaa-NN)** ... (aaa)					1	1	1	-3

Tables (17) and (18) exemplify the effects of vowel height, where Table 17 presents an input sequence with a long mid vowel /e:/ followed by a long high vowel /i:/, and Table 18 presents an input sequence with a long low vowel /a:/ followed by a long mid vowel /e:/. In Table 17, losing candidate (a) satisfies Align-Stress-Right but violates *Str-2q, *Str-3q, *Str-4q, *Str-5q, and *Str-6q, since the stressed long high vowel /i:/ has only two subsegments. Winning candidate (b) incurs violations of Align-Stress-Right, and of the stringent constraints *Str-3q through *Str-6q, but crucially avoids violating *Str-2q, since the long vowel /e:/ is represented with three subsegments. Because violating *Str-2q is more costly than violating Align-Stress-Right, candidate (b) wins.

Table 18 follows the same logic. Candidate (a) avoids violating Align-Stress-Right, but incurs a violation of each of *Str-3q, *Str-4q, *Str-5q, and *Str-6q because the long stressed vowel /e:/ has three subsegments. Candidate (b) violates Align-Stress-Right, as well as *Str-4q through *Str-6q, but avoids a violation of *Str-3q, since the long vowel /a:/ has four subsegments. Because a violation of *Str-3q is more costly than a violation of Align-Stress-Right, candidate (b) wins.

Table 17: Subsegmental analysis of height given a mid and high vowel input sequence /e:... i:/

/e: ... i:/	*Str-1q	*Str-2q	*Str-3q	*Str-4q	*Str-5q	*Str-6q	Align-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. ['**e:** ... i:] (ee-e) ... **(i-i)**		1	1	1	1	1		-7
☛ b. [e: ... '**i:**] **(ee-e)** ... (i-i)			1	1	1	1	1	-6

Table 18: Subsegmental analysis of height given a low and mid vowel input sequence /a: ... e:/

/a: ... e:/	*Str-1q	*Str-2q	*Str-3q	*Str-4q	*Str-5q	*Str-6q	Align-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. [a: ... '**e:**] (aaa-a)...**(ee-e)**			1	1	1	1		-5
☛ b. ['**a:** ... e:] **(aaa-a)** ... (ee-e)				1	1	1	1	-4

We now turn to the parts of the Nanti weight scale that the subsegment-only model fails to capture—specifically, the cross-over points among the three independent weight scales. To illustrate this, we use the weights generated in the model's second iteration, which excluded all of the tableaux presented in the rest of this subsection.

Table 19 demonstrates the model's inability to account for the greater weight contribution of vowel length relative to coda presence. The input sequence /eː ... eN/ includes the long mid vowel /eː/, which holds position 4 on the Nanti weight scale, and the short mid vowel with a coda /eN/, which holds position 9. Because /eː/ patterns as heavier than /eN/, candidate (a) is expected to win, but it actually loses out to candidate (b). Losing candidate (a) avoids a violation of ALIGN-STRESS-RIGHT, but incurs violations of *STR-3q through *STR-6q, since the long vowel /eː/ is represented with three subsegments: two for the mid-vowel, and an additional subsegment added to represent phonemic vowel length. Winning candidate (b), in comparison, incurs violations of ALIGN-STRESS-RIGHT, as well as *STR-4q, through *STR-6q, since /eN/ contains four subsegments: two for the short mid vowel, and two for the coda consonant. Because candidate (a) incurs a strict superset of the violations incurred by candidate (b), candidate (b) wins—an undesired outcome.

Table 19: Subsegmental analysis of interaction between coda and length given an input sequence /eː ... eN/

/eː ... eN/	*STR-1q	*STR-2q	*STR-3q	*STR-4q	*STR-5q	*STR-6q	ALIGN-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. ['eː ... eN] **(ee-e)** ... (ee-NN)			1	1	1	1	1	-6
💣 b. [eː ... 'eN] (ee-e) ... **(ee-NN)**				1	1	1		-3

Finally, Table 20 presents the model's failure to capture the greater weight of a codaless long high vowel compared to that of a short low vowel with a coda, given an input sequence /iː ... aN/. /iː/ holds position 6 on the Nanti weight scale, and /aN/ holds position 7, meaning that the former patterns as heavier than the latter. Candidate (a) is therefore expected to win, but it instead loses to candidate (b).Candidate (a) avoids a violation of ALIGN-STRESS-RIGHT but violates *STR-2q, through *STR-6q, since the long vowel /iː/ is represented with two subsegments: one for its high vowel quality, and an additional subsegment to represent phonemic length. Candidate (b), in comparison, incurs violations of ALIGN-STRESS-RIGHT, as well as *STR-5q, and *STR-6q, since the rhyme /aN/ is represented with a total of five subsegments: three for the short low vowel, and two for the coda consonant. Because the combined violations of *STR-2q, *STR-3q and *STR-4q are weighted more heavily than a single violation of ALIGN-STRESS-RIGHT, candidate (b)incorrectly emerges as the winner.

We now turn to a model of Nanti weight that combines subsegmental moraic representations.

3.3 Integrating Q theory within the Prosodic Hierarchy

In the previous subsections, we showed that neither subsegmental nor moraic representations alone provide the granularity needed to model the full Nanti weight scale. A combined approach

Table 20: Subsegmental analysis of interaction between coda, length, and height given an input sequence /aN … i:/

/aN … i:/	*Str-1q	*Str-2q	*Str-3q	*Str-4q	*Str-5q	*Str-6q	Align-R	$\mathscr{H}$
weights	2	2	2	1	1	1	1	
a. ['aN … i:] **(aaa-nn) … (i-i)**		1	1	1	1	1		-7
💣* b. [aN … **'i:**] (aaa-nn) … **(i-i)**					1	1	1	-3

that integrates the mechanisms of both Moraic Theory and Q Theory (μ+Q), however, successfully captures all required distinctions. More broadly, the Nanti pattern offers empirical support for an architecture in which subsegments are incorporated into the Prosodic Hierarchy as units subordinate to moras.

Our proposed representational model (Table 21) draws on both the moraic representations introduced in §3.1, which encode vowel length and coda presence, as well as the subsegmental representations introduced in §3.2, which encode vowel height. High vowels are represented with one vowel subsegment (v), mid vowels with two (v v), and low vowels with three (v v v). Coda consonants are represented with two nasal consonant subsegments (n n). Short vowels and the short diphthong /ɯi/ are monomoraic (μ), while long vowels and the diphthongs /ai, ae, oi, ei, ɯi:/ are bimoraic (μμ)[5]. This integrated μ+Q model not only captures the three independent weight scales attested in Nanti, but also successfully accounts for their complex interactions and the specific cross-over points between scales.

We adopt the three constraints introduced in §3.1—Weight-to-Stress, Coda-to-Stress and Align-Stress-Right—without modification. We introduce minimal modifications to the constraints referring to subsegments introduced in §3.2 (14). Notably, the number of stringent subsegmental constraints is reduced by half, and these constraints now refer to vowel subsegments specifically, rather than all subsegments within the rhyme. This refinement reflects the fact that the independent weight contribution of coda consonants is already captured by Coda-to-Stress.

(14) a. *Stress/v (*Str-1v): Assign a violation for every 1 subsegment vowel that bears stress
b. *Stress/v, vv (*Str-2v): Assign a violation for every 1 or 2 subsegment vowel that bears stress
c. *Stress/v, vv, vvv (*Str-3v): Assign a violation for every 1, 2 or 3 subsegment vowel that bears stress

[5]Although vowel length could in principle be encoded subsegmentally—by adding an additional subsegment to long vowels, consistent with prior Q-theoretic representations of vowel length (Garvin & Lapierre ms., Garvin et al. 2019, Schwarz et al. 2019)—such representations are insufficient for modeling the contribution of vowel length to phonological weight in Nanti. As shown in §3.2, they cannot replace the role of moras in capturing the full Nanti pattern. We therefore encode length exclusively via moraic structure to avoid redundancy.

Table 21: μ+Q representations of Nanti rhymes

	Long vowels						Short vowels					
Scale position	1	2	3	4	5	6	7	8	9	10	11	12
Segmental representation	a:N aiN aeN	a: ai ae	e:N o:N eiN oiN ɯi:N	e: o: ei oi ɯi:	i:N	i:	aN	a	ɛN oN ɯiN	e o ɯi	iN	i
μ+Q representation	μμ a:N (aaa-NN) μμ aiN (aaa-NN) μμ aeN (aaa-NN)	μμ a: (aaa) μμ ai (aaa) μμ ae (aaa)	μμ e:N (ee-NN) μμ o:N (ee-NN) μμ eiN (ee-NN) μμ oiN (ee-NN) μμ ɯi:N (ee-NN)	μμ e: (ee) μμ o: (ee) μμ ei (ee) μμ oi (ee) μμ ɯi: (ee)	μμ i:N (i-NN)	μμ i: (i)	μ aN (aaa-NN)	μ a (aaa)	μ ɛN (ee-NN) μ oN (ee-NN) μ ɯiN (ee-NN)	μ e (ee) μ o (ee) μ ɯi (ee)	μ iN (i-NN)	μ i (i)

3.3.1 Grammar

As in the previous subsections, we used OT-Help (Staubs et al. 2010) to generate a Harmonic Grammar analysis of the Nanti weight scale. In contrast to the mora-only and subsegment-only models, the integrated moraic–subsegmental model (μ+Q) successfully converged on the first iteration, including data relevant to all patterns—the default right-aligned stress pattern, the independent effects of each of the three weight scales of vowel height, vowel length, and coda presence, as well as all of their interactions—as input to the model. In what follows, we illustrate how the μ+Q model captures each component of the 12-point Nanti weight scale.

Table 22 presents the basic pattern of right-aligned stress in Nanti for the input /e … o/. Because both rhymes are equivalent in weight, they incur identical violations of *Str-2v and *Str-3v. In winning candidate (a), stress is assigned to the right-most vowel [o], thereby avoiding a violation of Align-Stress-Right. Losing candidate (b) assigns stress to the leftmost vowel [e], incurring a fatal violation of Align-Stress-Right.

Table 23 exemplifies the effect of phonemic vowel length for an input sequence /i: … i/. Both candidates violate *Str-1v, *Str-2v and *Str-3v. Losing candidate (a) avoids a violation of Align-Stress-Right, but fatally violates the most highly weighted constraint, Weight-to-Stress. In contrast, winning candidate (b) satisfies Weight-to-Stress and instead incurs a violation of the lowest weighted constraint, Align-Stress-Right.

Table 22: μ+Q analysis of default right-aligned stress given an input sequence /e … o/

	/e … o/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathscr{H}$
	weights	12	4	4	2	1	1	
👉 a.	μ μ | | [e … **'o**] (ee) **(oo)**			1		1		-5
b.	**μ** μ | | **['e** … o] **(ee)** (oo)			1		1	1	-6

Table 23: μ+Q analysis of weight to stress given an input sequence /i:… i/

	/i: … i/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathscr{H}$
	weights	12	4	4	2	1	1	
a.	μμ **μ** \/ | [i: … **'i**] (i) **(i)**	1	1	1		1		-21
👉 b.	**μμ** μ \/ | **['i:** … i] **(i)** (i)		1	1		1	1	-10

Table 24 illustrates the effect of a coda on syllable weight for an input /aN … a/. Both candidates violate *Str-3v. Losing candidate (a) additionally incurs a fatal violation of Coda-to-Stress, whereas winning candidate (b) avoids violating this constraint and instead incurs a violation of Align-Stress-Right. Because Coda-to-Stress carries a higher penalty than Align-Stress-Right, candidate (b) wins.

Table 24: μ+Q analysis of coda-to-stress given an input sequence /aN … a/

	/aN … a/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathscr{H}$
	weights	12	4	4	2	1	1	
a.	μ **μ** | | [aN … **'a**] (aaa-nn) **(aaa)**				1	1		-3
👉 b.	**μ** μ | | **['aN** … a] **(aaa-nn)** (aaa)					1	1	-2

Tables 25 and 26 exemplify the effects of vowel height. Table 25 presents an input with a long mid vowel /e:/ followed by a long high vowel /i:/. Table 26 presents an input with a long

low vowel /a:/ followed by a long mid vowel /e:/. In Table 25, both candidates violate *Str-2v and *Str-3v. Candidate (a) additionally incurs a fatal violation of *Str-1v. Candidate (b) avoids violating *Str-1v and instead incurs a less costly violation of Align-Stress-Right.

In Table 26, both candidates incur a violation of *Str-3v. Candidate (a) also incurs a fatal violation of *Str-2v, while candidate (b) avoids this violation and instead incurs a violation of Align-Stress-Right. Because *Str-2v is weighted more highly than Align-Stress-Right, candidate (b) emerges as the winner.

Table 25: μ+Q analysis of height given a mid and high vowel input sequence /e … i/

	/e … i/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathcal{H}$
	weights	12	4	4	2	1	1	
	a. μ μ | | [e … 'i] (ee) **(i)**		1	1		1		-9
☛	b. μ μ | | ['e … i] **(ee)** (i)			1		1	1	-6

Table 26: μ+Q analysis of height given a low and mid vowel input sequence /a … e/

	/a … e/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathcal{H}$
	weights	12	4	4	2	1	1	
	a. μ μ | | [a … 'e] (aaa) **(ee)**			1		1		-5
☛	b. μ μ | | ['a … e] **(aaa)** (ee)					1	1	-2

Table 27 illustrates how vowel length interacts with the presence of a coda when vowel height is held constant, using the input sequence /e: … eN/. Both candidates incur one violation each of *Str-2v and *Str-3v. In addition, losing candidate (a) fatally violates the most highly weighted constraint, Weight-to-Stress. Winning candidate (b) avoids a violation of this constraint, but instead incurs violations of both Coda-to-Stress and Align-Stress-Right. Because the weight of Weight-to-Stress exceeds the combined weight of Coda-to-Stress and Align-Stress-Right, candidate (b) is optimal.

Finally, Table 28 exemplifies the interaction between all four independent contributors to phonological weight in Nanti, given an input sequence /aN … i:/: vowel length, vowel height, presence of a coda, and default right-alignment. Both candidates incur a violation of *Str-3v. In addition, losing candidate (b) violates both the lowest-weighted constraint, Align-Stress-Right, and the highest-weighted constraint, Weight-to-Stress. Winning candidate (a) avoids

Table 27: μ+Q analysis of interaction between coda and length given an input sequence /eː … eN/

	/eː … eN/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathscr{H}$
	weights	12	4	4	2	1	1	
	a. μμ μ ∨ | [eː … ˈeN] (ee) **(ee-nn)**	1		1		1		-17
👉	b. **μμ** μ ∨ | [**ˈe**ː … eN] **(ee)** (ee-nn)			1	1	1	1	-8

violating these two constraints, but instead incurs a violation of each of *Str-1v, *Str-2v and Coda-to-Stress. Because the combined weight of Weight-to-Stress and Aling-Stress-Right is greater than the combined weight of *Str-1v, *Str-2v and Coda-to-Stress, candidate (a) wins.

Table 28: μ+Q analysis of interaction between coda, length, and height given an input sequence /aN … iː/

	/aN … iː/	W-to-Str	*Str-1v	*Str-2v	C-to-Str	*Str-3v	Align-R	$\mathscr{H}$
	weights	12	4	4	2	1	1	
👉	a. μ **μμ** | ∨ [aN … **ˈiː**] (aaa-nn) **(i)**		1	1	1	1		-11
	b. **μ** μμ | ∨ [**ˈa**N … iː] **(aaa-nn)** (i)	1				1	1	-14

A key aspect of this analysis is that the constraint referring to moraic structure—specifically Weight-To-Stress—receives a substantially higher weight (12) than any constraint targeting segmental or subsegmental structure, including the stringent constraints referencing subsegments, as well as the constraint Coda-To-Stress referencing a coda segment, whose weights range between 1 and 4. This asymmetry is theoretically significant: it not only supports the integrated μ+Q model for Nanti, but also provides principled evidence for situating subsegments within the Prosodic Hierarchy. In particular, the weighting pattern motivates a hierarchical structure in which moras dominate segments, which in turn dominate subsegments: μ » Q » q.

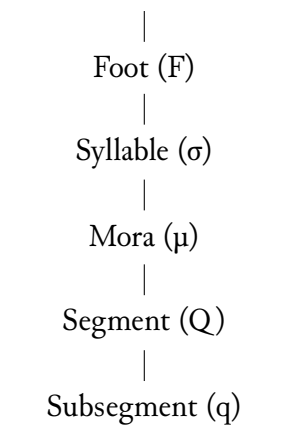
4 Discussion

The previous section presented three distinct analyses of the Nanti weight scale in Table 5: a mora-only analysis, a subsegment-only analysis, and a combined mora+subsegment analysis. Neither the mora-only nor the subsegment-only models were able to capture fully capture the Nanti weight scale. The mora-only model failed to account for distinctions in vowel height and their

interactions with other weight scales, while the subsegment-only analysis failed to capture the interaction between vowel height, vowel length, and coda presence. The integrated μ+Q analysis, by contrast, successfully modeled all components of the 12-point weight scale observed in Nanti, namely each independent weight scale—vowel height (a » e,o » i), vowel length (V: » V), and coda presence (VC » V)—as well as their interactions.

This uniquely complex 12-point weight hierarchy provides strong motivation for treating segment strength and syllable weight as separate yet hierarchically organized components of stressability. Both moras and subsegments can independently contribute to stress assignment: vowel length is represented moraically, while vowel height and segment complexity are represented subsegmentally. Each weight scale contributes monotonically to the overall hierarchy, but not equally. Vowel length exerts a markedly stronger effect on stress placement than either vowel height or coda presence, demonstrating the dominant role of moras. This asymmetry is reflected in the constraint weights for the μ+Q analysis of Nanti: the mora-based constraint WEIGHT-TO-STRESS receives a substantially higher weight than constraints referring to the presence of a segment (CODA-TO-STRESS) or segment quality (stringent subsegmental constraints), demonstrating that moras play a more significant role than subsegments in stress assignment. These findings support the revised Prosodic Hierarchy in 4, in which subsegments are subordinate to segments, which are in turn subordinate to moras.

(15)



Moraic Theory was partially developed to model aspects of phonological weight, including vowel length and rhyme structure. It is therefore not surprising that Moraic Theory can straightforwardly account for the effects of vowel length and coda presence in the Nanti weight scale. However, effects of segment strength—specifically the sonority scale tied to vowel height—are not as easily captured in a moraic analysis. Here, we propose that Q Theory a more direct account of this dimension of the Nanti pattern. Moreover, segmental complexity interacts with segment strength in Nanti: the language exhibits four contrastive diphthongs /ei, ai, ae, oi/ that pattern as phonemically long, as well as one diphthong which may be either long /ɯi:/ or short /ɯi/. Because Q Theory encodes subsegmental structure, it naturally captures how segmental complexity contributes to phonological weight in Nanti.

While Crowhurst & Michael (2005)'s analysis also captures the intricacies of the 12-point Nanti weight scale, we argue that the q-theoretic analysis captures the Nanti pattern more directly and offers broader typological applicability. Although the sonority-based scale accounts for a

significant component of the pattern, it does not readily explain why the high diphthong /ɯi/ patterns with mid vowels. To account for this, Crowhurst & Michael (2005) invoke a set of PeakProminence constraints specifically targeting monophthongs vs. diphthongs. Under Q Theory, however, this follows without additional machinery: high vowels are represented with one subsegment, whereas diphthongs necessarily require at least two. The minimal q-theoretic representation of the high diphthong thus contains two subsegments, correctly predicting that its alignment with mid vowels rather than with high vowels. Q Theory therefore provides a unified account of segmental complexity and vowel sonority.

Beyond the Nanti case study, a strength-based account of stressability offers broader empirical coverage of the factors that impact stressability than sonority alone. For instance, although all epenthetic vowels in Kanien'kéha surface as /ə/, only some epenthetic vowels may bear stress. Schwarz et al. (2019) attribute this pattern to subsegmental structure: super-light vowels (v) cannot be stressed, whereas light vowels (v v) can. On this view, it is segment strength—not vowel quality per se—that determines stressability. Although further research is needed, the q-theoretic architecture predicts exactly this type of the asymmetry: strong segments—those that resist phonological alternations—are more likely to be stressable than weak ones.

The proposal that moras and subsegments can each independently contribute to weight raises the question: *Which weight-related phenomena are subsumed under Moraic Theory vs. Q theory?* Both frameworks can be leveraged to account for a range of phonological phenomena, with some overlap. Moraic Theory has proved particularly effective for modeling syllable weight, stress assignment, vowel and consonant length, compensatory lengthening, reduplication, templatic morphology, prosodic minimality and maximality, tone association, and syllable typology (e.g., Gordon 2007, Hayes 1989, 1995, Hyman 1985, Itô 1990, Kager 1999, Kavitskaya 2014, McCarthy & Prince 1986, Mellesmoen 2025). These phenomena generally involve supra-segmental properties such as rhythm and timing and are therefore most naturally handled by Moraic Theory. Q Theory, on the other hand, is particularly useful in modeling segmental phenomena, including complex consonants and vowels, segment typology, vowel and consonant length, tone association, vowel shortening and lengthening, stressability of epenthetic vs. underlying vowels, segment strength, harmony, subsegmental alternations (e.g. nasality, laryngeality), and subphonemic morphological alternations (Dąbkowski 2025, Garvin & Lapierre ms., Garvin et al. 2018, Inkelas & Shih 2016a,b, Lapierre 2021, 2023, Lapierre & Russell 2023, ms., Lapierre et al. 2019, Robertson Molinaro 2025, Schwarz et al. 2019, Schwarz 2024, Shih & Inkelas 2018). Figure 1 schematizes these phenomena in a Venn diagram, illustrating areas of overlap and distinction. Some phenomena can be analyzing using either theory, though they may lend themselves more naturally to one framework. For example, compensatory lengthening is more straightforwardly captured in Moraic Theory, while segment complexity is more naturally modeled using Q Theory.

This returns us to the question posed in §1: *Is it necessary to represent both subsegments and moras, or does one become redundant once the other is encoded?* The present analysis suggests that both moras and subsegments make independent contributions to weight, and their combined use allows for a more fine-grained characterization of prosodic patterns. For instance, integrating Q Theory with Moraic Theory may offer a productive way of modeling the nuanced contributions of onsets to weight Ryan (2014), Topintzi (2010). At the same time, the contributions of moras and subsegments may overlap, and in any given language, a single representational layer may suffice. Indeed, as discussed in §2.1, the patterns from Palestinian Arabic can be analyzed with

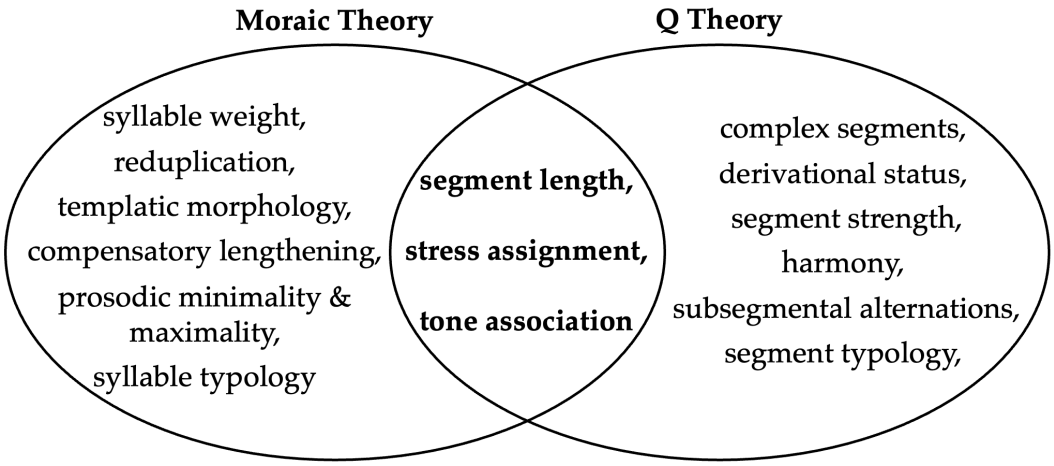


Figure 1: The phenomena that Moraic Theory and Q Theory are best suited to model

a purely moraic account, and likewise, Kanien'kéha, and Panãra can be analyzed within a purely subsegmental framework.

The Nanti case study is particularly striking in terms of typological complexity. On the one hand, the 12-point weight scale observed in Nanti is—to the best of our knowledge—unattested elsewhere. On the other hand, many additional factors are known to influence weight, including differences among (i) classes of consonants (e.g., sonorant vs. obstruent) (Gordon 2007, 2002), (ii) onset consonants (Gordon 2005, Topintzi 2010); (iii) simple vs. complex codas/onsets Kelly (2004), Ryan (2014); and (iv) segment strength (Garvin & Lapierre ms., Schwarz et al. 2019). Both Moraic Theory and Q Theory independently predict that these factors should affect stress assignment cross-linguistically. However, it is unlikely for any single language to develop a categorical weight scale incorporating all of these distinct elements. Instead, we predict that their contributions are more likely to emerge gradiently in many languages.

Testing the hypothesis that other languages exhibit low-level subpatterns consistent with these predictions requires a corpora large enough to uncover probabilistic effects while controlling for each independent variable (e.g. the SPADE Consortium). Quantitative work on English (Moore-Cantwell 2020) and German (Tomaschek et al. 2023) provides preliminary support for this hypothesis. We propose that the present μ+Q model can be extended to capture the independent effects of, and interactions among, all of these factors—thus offering a novel architecture capable of accounting for a wide-range of phonological weight behavior across languages.

5 Conclusion

This paper analyzed Nanti's uniquely complex 12-point weight scale, which reflects the interaction of three independently monotonic but non-proportional weight scales: (i) vowel height, where low vowels are heavier than mid vowels, which are heavier than high vowels; (ii) vowel length, where long vowels are heavier than short vowels; and (iii) coda presence, where closed syllables are heavier than open ones (Crowhurst & Michael 2005). Although each scale operates monotonically, their combined effects are not proportional: vowel length plays a greater role than vowel height, which in turn plays a greater role than coda presence.

We evaluated three models of the Nanti data: (i) one based on moraic representations alone, (ii) one based on subsegmental representations alone, and (iii) a hybrid model incorporating both moras and subsegments. Our findings show that neither the mora-only nor the subsegment-only model can fully account for the Nanti pattern. The mora-only model captures the independent effects of vowel length and coda presence, as well as their interaction, but fails to capture vowel height effects, as well as its interaction with the other two scales. The subsegment-only model accounts for the individual contributions of all three scales, but fails to model their interactions. The combined μ+Q model, by contrast, correctly predicts both the independent effects of, and the complex interactions among, all three scales, allowing for a comprehensive analysis of Nanti's stress system.

Although our analysis of the Nanti data aligns in many respects with Crowhurst & Michael (2005)'s original account, it provides a representational architecture that extends to a wider range of phenomena involving segment strength and phonological weight effects across languages, including gradient patterns. Our central claim is that in any system where phonological strength conditions stress assignment, weaker segments will consistently be disfavored as stress-bearing units relative to stronger ones.

These findings have broader theoretical implications. Moraic Theory and Q Theory offer distinct insights into phonological weight, with complementary empirical coverage. Whereas Moraic Theory is best suited for modeling rhythm, timing, and syllable structure, Q Theory is better equipped to capture patterns grounded in segmental properties such as sonority, natural class membership, and contours. While many phenomena can be adequately modeled within either framework, our analysis demonstrates that where segmental quality and syllable structure interact—as in Nanti's weight-sensitive stress system—a unified approach drawing on both representational tools is not only advantageous, but necessary.

Crucially, this study provides evidence for situating subsegments within the Prosodic Hierarchy. The constraint weighting pattern reveals that moras dominate subsegments hierarchically: the mora-based constraint receives substantially higher weight than constraints targeting segments or subsegments. This hierarchical relationship predicts that moras play a more categorical role in determining weight, while subsegments contribute more gradiently, resulting in fine-grained weight scales like Nanti's 12-point system. Future work testing subsegmental models of onset weight, for example, may further illuminate the gradient role of subsegments within the Prosodic Hierarchy and their contribution to probabilistic patterns of stress assignment cross-linguistically.

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Sharon has a truly unique ability to handle any problem with calm and thoughtful clarity. Strategic, composed, and generous, she turns even the most difficult situations into solutions that benefit everyone. She thinks broadly, acts decisively, and always leads with care—qualities we

aspire to. We wouldn't be the phonologists we are today without her. Sharon taught us not only about phonology, but about the field's structural dynamics, and when "good enough" is better than perfect. She has exceptional talent for strategy—whether navigating interpersonal dynamics or positioning research ideas—and we often find ourselves asking, "What would Sharon do?"

We were incredibly fortunate to have Sharon as an advisor, even while she served in upper administration. She always made time for us, even when she had none to give, and consistently treated us as colleagues rather than students. Much of the confidence we have built comes from her unwavering message of trust and empowerment. Sharon, thank you for your vision, wisdom, calm, and steadfast support. We are deeply grateful to have learned from such an extraordinary role model and hope to pass forward the guidance you have given us to our own students.

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Abbreviations

C	consonant	FEM	feminine	N.AGT	non-agent
V	vowel	GEN	genitive	PF	phrase-final
N	nasal consonant	HAB	habitual	PL	plural
AGT	agent	INTERROG	interrogative	SG	singular
DU	dual	MASC	masculine	STAT	stative

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