Weight typology: An Optimality Theoretic approach

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Abstract

This paper reviews the descriptive generalizations regarding segment weight, and provides an Optimality Theory (OT) analysis that both confirms and challenges traditional typological expectations. Ultimately, the predictions of factorial ranking provide a means by which to examine the adequacy of individual OT analyses and a metric by which to re-examine our assumptions about linguistic patterns and the nature of phonological typology.

Descriptively, weight is shown to come in two flavors, coerced and distinctive. Each is relevant to both consonants and vowels, and each has its own generalizations – an implicational relationship between coerced weight and segment sonority, but no such relationship between distinctive weight and sonority.

Theoretically, the factorial ranking of a small set of constraints not only explains the descriptive generalizations, but also results in some unexpected predictions that are, in fact, empirically supported.

1. Introduction

The fact that Optimality Theory (OT) is intrinsically typological in nature has been discussed by a number of linguists, including Prince and Smolensky (1993), Bakovic (1998), Samek-Lodovici (1998), Fukazawa (1999), Morelli (1999), Morén (1999), and various papers in this volume. Since OT constraints are both universal and re-rankable, factorial ranking should yield every possible language type – no more and no less. One of the general claims regarding the advantage of OT over rule-based models lies in the fact that an OT grammar makes very specific and constrained typological predictions. This contrasts sharply with rule-based models, which do not produce a typology quite as straightforwardly. In fact, one of the major goals of any serious work within

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OT is to ensure that constraints needed for any one analysis cannot be re-ranked to yield "undesirable" typological results, i.e., phenomena that are unattested and unexpected given our present understanding of linguistic patterns.

This paper will provide a descriptive typology of phonological weight in which weight is unified across segment types, as well as across phenomena. Couched in Moraic Theory (McCawley 1968; Hyman 1985; Kager 1989), segment weight is shown to come in two flavors, coerced and distinctive. Each of these is relevant to both consonants and vowels, and each has its own generalizations. In addition, this paper will provide an OT mechanism for analyzing weight phenomena that uses a very limited number of tools. Specifically, coerced weight is shown to be the result of interactions among moraic markedness constraints, and distinctive weight is the result of interactions among markedness and faithfulness constraints. Finally, complex interactions between coerced and distinctive weight patterns (i.e., factorial rankings) are shown to result in the emergence of patterns that were previously unexpected under generally accepted assumptions but are actually found among the world's languages.

2. A basic descriptive weight typology

Cross-linguistically, weight can be quite complex, and there are many factors to take into account when describing and explaining it: segment type (consonant or vowel), sonority, weight distinctiveness, prosodic requirements, and phonological environment. According to Morén (1999), the interaction of these factors can sometimes obscure relationships among them, thus erroneously leading to several separate approaches to account for different pieces of the weight puzzle. For example, although distinctive vowel length and underived consonant geminates are often seen as different phenomena to be accounted for in different ways, careful examination of the data and their patterns suggests that a unified treatment is warranted.

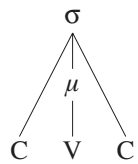
Within the framework of Moraic Theory, weight refers to relative moraic content. A segment or syllable is heavier than another by virtue of being associated with more morae. Moraic Theory is assumed in this paper, and the representations for a sample of syllables of differing weights found among the worlds languages are given in (1) through (3).[1] These are based on McCarthy and Prince (1986) and Hayes (1989), and are assumed in much of the current weight literature.

1. There is evidence that morae may also be shared among segments (Broselow et al. 1997). This has further implications for weight typology that are discussed in Morén (1999) and not addressed here.

(1) Light – monomoraic

a.

b.



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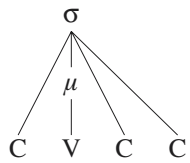
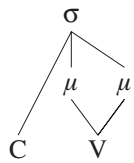


(2) Heavy – bimoraic

a.



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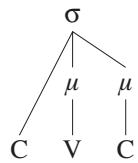

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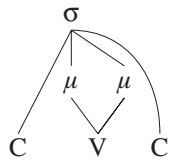

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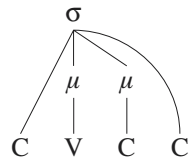
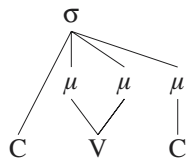
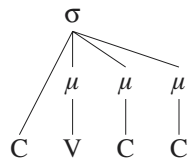


(3) Superheavy – trimoraic

a.



b.



The remainder of this paper will present a descriptive and factorial typology of weight systems, where weight is defined via moraicity.

2.1. Sources of weight[2]

In carefully reviewing the cross-linguistic weight data, it becomes clear that there are essentially two sources of weight, distinctive and coerced, each of which is relevant to both consonants and vowels (Morén 1999). Distinctive weight is underlying moraicity reflected in a surface contrast, and coerced weight is a restriction on minimal or maximal surface moraicity in some phonological context. Distinctive moraicity for consonants is traditionally thought of as underived geminates, and distinctive moraicity for vowels is typically thought of as underived vowel length. (4) and (5) illustrate this difference for consonants.

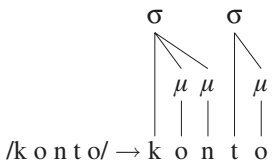
The diagram in (4) shows the standard analysis of intervocalic non-geminate versus intervocalic geminate consonants in a language like Hungarian[3]. In (4a), an underlyingly non-moraic intervocalic consonant surfaces as a non-moraic onset, as one might expect if we assume that prevocalic consonants normally syllabify as onsets. In (4b), an underlyingly moraic intervocalic consonant surfaces as moraic and ambisyllabic. The ambisyllabicity here is due to a combination of the need for moraic material to be in a syllable rime and the need for syllables to have onsets.

(4)

In contrast, the standard analysis of Weight by Position (a type of coerced weight) in Modern Standard Italian is given in (5). An underlyingly non-moraic consonant surfaces as moraic when syllabified in coda position. Here the consonant mora is driven by a structural requirement, not the result of an underlying specification.

2. Since this is a phonological, not a phonetic, investigation, the terms "length" and "weight" are considered roughly equivalent since both are used here to indicate relative moraic content, not necessarily duration. Following tradition, "length" will be used to refer to vowel moraicity.
3. The question of the moraic status of vowels in the underlying representation is not addressed here due to space restrictions. See Morén (1999).

(5)



conto 'bill/check'

As will be seen below, each of these sources of weight (distinctive and coerced) is relevant to the classes of consonants and vowels, and each has its own generalizations. Since the typology of coerced weight is better studied, let us begin the discussion there.

2.1.1. Coerced weight. Zec (1988) carefully explored the relationship between syllabicity, moraicity and sonority. She found that the more sonorous a segment is, the more likely it will be moraic (in the syllable rhyme). In addition, she claimed that there is an implicational relationship between sonority and moraicity such that if a segment of one sonority is moraic in a given environment, then a segment of higher sonority will also be moraic in that environment.

Within the realm of consonants, the result of this implicational relationship is that there are only three major patterns of coerced consonant weight. No consonants are forced to be moraic in some environment, only more sonorous consonants are forced to be moraic in some environment, or all consonants are forced to be moraic in some environment. (6) illustrates this point by listing some languages and their corresponding sets of moraic segments.

(6)

	Sets of moraic segments	Languages[4]
a.	vowels	Khalkha Mongolian, Yidiŋ
b.	vowels + non-glottal sonorants	Kwakwala
c.	vowels + all sonorants	Lithuanian, Tiv
d.	vowels + all Cs but plain stops	NYE æ-tensing environment
e.	vowels + all Cs but aspirated stops	Icelandic
f.	all segments	Latin, Arabic dialects, Berber

For example, Kwakwala non-glottal sonorants are coerced to be moraic in coda position (Weight by Position), but glottal sonorants and all segments less sonorous are not. As Zec (1988) points out, evidence for this comes, in part, from the stress system. Kwakwala is a quantity-sensitive language, where stress

4. Sources: Arabic, Berber, Khalkha Mongolian, Kwakwala, Latin, Lithuanian, Tiv and Yidiŋ – Zec (1988, 1995). Metropolitan New York English – Morén (1999). Icelandic – Morén and Miglio (1998); Morén (1999).

is found on the final syllable if all syllables are light but is attracted to the leftmost heavy syllable. As can be seen in (7), syllables containing long vowels or non-glottalized sonorant codas must be heavy because they attract stress. Syllables containing glottalized sonorant or obstruent codas are not heavy because they do not attract stress, as shown in (8).

(7)	a.	[qáa.sa]	'to walk'
	b.	[x^{w}áa.k^{w}ə.na]	'canoe'
	c.	[gə́m.x̥a]	'carrying wood in arms'
	d.	[án.qa̰]	'to squeeze'
(8)	a.	[bə.xá]	'to cut'
	b.	[c'ə.xə.lá]	'to be sick'
	c.	[c'ət.xá]	'to squirt'
	d.	[max^{w}.c'á]	'to be ashamed'
	e.	[gə̰m'.x̥á]	'to use the left hand'
	f.	[a̰n'.qá]	'to put fire among'

Expanding on Zec's work, Morén (1999) showed that vowels are also susceptible to coerced weight, and that the same relationship between sonority and moraicity holds for this class of segments. Since syllable nuclei are minimally monomoraic due to prosodic restrictions, coerced vowel moraicity is manifested in augmentation of the vowel beyond monomoraic. Again, there are three major patterns: no vowels are forced to be moraic in some environment, only the more sonorous vowels are forced to be moraic in some environment, or all vowels are forced to be moraic in some environment. (9) illustrates this point by listing some languages and their corresponding sets of coerced bimoraic vowels.

(9)		Sets of coerced bimoraic vowels	Languages
	a.	none	Cayuvava, Chaha, Hua, Mazateco
	b.	low	English dialects, Russian dialects
	c.	low + mid	Russian dialects
	d.	all	Hawaiian, Icelandic, Italian

For example, there are many English dialects (e.g., Metropolitan New York) in which low back vowels obligatorily surface as long in stressed syllables.[5]

5. The distribution of the low front vowel is quite complex and beyond the scope of this paper. See Morén (1999) for a full analysis. Briefly described, this vowel behaves like the low back vowels in stress syllables that are either open or closed by a voiceless stop. In all other stressed syllables, the low front vowel has distinctive length and behaves like the non-low vowels. This pattern reinforces the claim that moraicity for lower sonority segments (e.g., plain stops) is dispreferred.

(10)

a.	[bɔːt] *[bɔt]	*bought*
b.	[pɔːɳč] *[pɔɳč]	*paunch*
c.	[ɹaːt] *[ɹat]	*rot*
d.	[faːnt] *[fant]	*font*

Morén (1999) analyses this, partially, as a response to the need for all stressed syllables to be minimally bimoraic (Stress to Weight Principle – Prince (1990)) and the preference to have moraic vowels over moraic consonants.

To summarize, coerced weight is relevant across segment classes, and there is an implicational relationship between sonority and coerced moraicity.

2.1.2. Distinctive weight. There is a wealth of literature discussing distinctive moraicity for vowels and consonants. However, vowel and consonant moraic patterns are generally thought of as different phenomena to be accounted for via different mechanisms. Close inspection, however, shows that there are parallels in the distribution of distinctiveness for vowel length and consonant weight that suggest a unified treatment is warranted.

It is important to note that despite the fact that coerced moraicity seems dependent on sonority, a careful review of the cross-linguistic data leads directly to the conclusion that distinctive moraicity does not follow sonority (Jaeger 1978; Taylor 1995; Morén 1999). For example, there are languages with no distinctive consonant weight, distinctive weight for more sonorous consonants only, distinctive weight for less sonorous consonants only, and distinctive weight for all consonants. This is illustrated in table (11), which compares weight distinctiveness for the broad classes of obstruent and sonorant consonants. The shaded cells are those in which less sonorous segments have distinctive weight but more sonorous segments do not. These are quite surprising given the robust relationship between coerced weight and sonority seen above.

(11) Languages, consonant classes and distinctive weight

Obstruent	Son	Language[6]
Yes	Yes	Balochi, Brahui, Gujarati, Hungarian, Modern Standard Italian
No	Yes	Hausa
Yes	No	Chechen, Lak
No	No	Burushaski, Chaha, Hawaiian, Khalkha Mongolian

6. Sources: Balochi, Brahui – Elfenbein 1997. Burushaski, Lak – Anderson 1997. Chaha – Leslau 1997. Chechen – Nichols 1997. Gujurati – Mistry 1997. Hausa – Newman 1997. Hawaiian – Elbert and Pukui 1979; Morén 1999. Hungarian – Nádasdy 1985; Morén 1999. Khalkha Mongolian – Svantesson 1994. Modern Standard Italian – Vogel 1982; Morén 1999.

An example of the expected case is that of Hausa, which allows underived geminates to be sonorants but not obstruents (Newman 1997).[7] This is expected because more sonorous segments are moraic, but less sonorous segments are not.

(12) a. [dà.gà] 'from'
b. [ha.nuu] 'frankincense tree'
c. *[dàg.gà]
d. [han.nuu] 'hand'

However, other languages allow less sonorous consonants to be geminates, but not more sonorous consonants. For example, Japanese allows voiceless stops but not voiced stops to be underived geminates in the Yamato (native) vocabulary (Itô et al. 1995; Fukazawa 1999).

(13) a. [juk.ku.ri] 'slowly'
b. [mot.to] 'more'
c. *[jug.guri]
d. *[mod.do]

Finally, a careful examination of the cross-linguistic vowel moraicity data leads to the conclusion that distinctive vowel length is not constrained by sonority either. There are languages with no distinctive vowel length, distinctive length for more sonorous vowels only, distinctive length for less sonorous vowels only, and distinctive length for all vowels. This is illustrated in (14), which shows weight distinctiveness for high and low vowels in a sample of languages.

(14) Languages, vowel classes and distinctive weight

High	Low	Language[8]
Yes	Yes	Balochi, Brahui Hawaiian, Hungarian, Khalkha Mongolian
No	Yes	Persian, Khasi
Yes	No	Atayal, Metro. NY English, Stand. Am. English
No	No	Chechen, Gujarati, Icelandic, Modern Standard Italian, Spanish

7. Geminates of all sonorities are commonly found in morphologically derived forms, and there is an extremely small set of underived obstruent geminates that are not addressed here.
8. Sources: Atayal – Crothers 1978. Balochi, Brahui – Elfenbein 1997. Chechen – Nichols 1997. Gujurati – Mistry 1997. Hawaiian – Elbert and Pukui 1979; Morén 1999. Hungarian – Nádasdy 1985; Morén 1999. Icelandic – Einarsson 1945; Morén 1999. Khalkha Mongolian – Svantesson 1994. Khasi – Maddieson 1984. Metropolitan New York English – Morén 1999. Modern Standard Italian – Vogel 1982; Morén 1999. Persian – Windfuhr 1997. Spanish –

2.2. Summary of the basic descriptive weight typology

Coerced and distinctive weight are relevant to both vowels and consonants. However, coerced weight follows sonority – moraic less-sonorous segments imply moraic more-sonorous segments, but distinctive weight does not – moraic less-sonorous segments do not imply moraic more-sonorous segments.

3. An OT analysis of weight (moraicity)

The following sections review the OT analysis of weight argued for in Morén (1999). They show that this particular analysis captures the above patterns in a straightforward and economical way. Further, this analysis makes predictions regarding complex interactions between coerced and distinctive weight, which are borne out in the cross-linguistic data.

3.1. Coerced weight

To account for the coerced weight patterns outlined above, Morén (1999) claims that two types of constraints are needed – general moraic markedness constraints and coercive moraic markedness constraints. The former is a family of constraints of the type given in (15). These are relative to different sonority classes, and are ranked in a universal moraic markedness hierarchy based on sonority, as shown in (16).

(15) *MORA[SEGMENT] – Do not associate a mora with a particular type of segment.[9]

(16) Simplified universal markedness hierarchy[10]
*MORA[ASPIRATEDSTOP] ≫ *MORA[PLAINSTOP]
≫ *MORA[VOICEDSTOP] ≫ *MORA[CONTINUANT]
≫ *MORA[NASAL] ≫ *MORA[LIQUID]
≫ *MORA[HIGHVOWEL] ≫ *MORA[MIDVOWEL]
≫ *MORA[LOWVOWEL]

Harris 1983. Standard American English – Moulton 1990.

9. Throughout this paper, the moraic constraints will refer to different natural classes of segments. This is only a convenient shorthand for groupings of constraints relative to all universally determined sonority classes. For example, *MORA[CONSONANT] represents the full sub-hierarchy of *MORA[ASPSTOP] ≫ *MORA[PLAINSTOP] ≫*MORA[VOICEDSTOP]≫ etc. The class constraints are used when further divisions in the hierarchy are not relevant to the discussion.

10. This hierarchy roughly follows the sonority scale of Selkirk (1984), and is shown to be minimally necessary in Morén (1999).

There are a variety of coercive moraic markedness constraints found in the literature that are used to explain various weight phenomena. This type of constraint seems to fall into two classes – those that are relative to a particular class of segments and those that do not specify segment type.[11] (17) is an example of the former because it refers specifically to consonants, and (18) and (19) are examples of the latter.

(17) WEIGHTBYPOSITION (WBYP) – Coda *consonants* must surface as moraic (based on Hayes 1989)

(18) FOOTBINARITY (FTBIN) – Prosodic feet must be binary under syllabic or moraic analysis (McCarthy and Prince 1995)

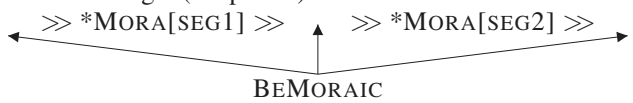
(19) STRESSTOWEIGHT (STOW) – Prominent syllables must be heavy – i.e., "stressed syllables must be heavy" (based on Prince 1990)

To abstract away from the specific constraints needed for specific analyses, the constraint in (20) will be used below to illustrate the predicted typology of factorial constraint ranking. Note that it is not meant to be a universal constraint, but represents any coercive moraic markedness constraint.

(20) "BEMORAIC" – shorthand for any constraint or set of constraints that force moraicity in some environment.

Within the realm of coerced weight, ranking a coercive moraic markedness constraint with respect to the universal moraic markedness hierarchy yields the three patterns discussed in Section 2.1.1. This relationship can be schematized as in (21), where BEMORAIC may be ranked above both of the constraints in the universal hierarchy, within the hierarchy, or below the hierarchy on a language by language basis.

(21) Coerced weight (simplified)



Note that in this simplified scenario where SEG1 is less-sonorous than SEG2, there are only three (3!/2!) possible permutations of the two general moraic markedness constraints and the coercive moraic markedness constraint. (22) provides the constraint rankings needed to explain the treatment of coda obstruents and sonorants in three different languages types.

11. The dichotomy between coercive moraic markedness constraints based on target segment specification will not be addressed here due to lack of space. See Morén (1999) for a discussion of the relevance of this dichotomy to explaining cross-linguistic weight patterns.

(22) a. *MORA[OBSTRUENT] ≫ *MORA[SONORANT] ≫ WBYP
(e.g., Khalkha Mongolian)
b. *MORA[OBSTRUENT] ≫ WBYP ≫ *MORA[SONORANT]
(e.g., Lithuanian)
c. WBYP ≫ *MORA[OBSTRUENT] ≫ *MORA[SONORANT]
(e.g., Cairene Arabic)

In Khalkha Mongolian, coda consonants do not contribute to syllable weight. This is apparent by examining the stress system in which long vowels attract stress, but closed syllables containing short vowels do not. The constraint ranking in (22a) gets this result because it states that it is worse to have either a moraic obstruent or a moraic sonorant than to have a non-moraic coda consonant. This is illustrated in (23) and (24).

(23) Khalkha Mongolian non-moraic obstruent coda

/baeguulagdax/ ‘to be organized’	*MORA [OBS]	*MORA [SON]	“BEMORAIC” (WBYP)
a. ☞ σ μ bae.gúu. l a g .dax			*
b. σ́ μ μ bae.guu. l a g .dax	*!		

(24) Khalkha Mongolian non-moraic sonorant coda

/uitgartae/ ‘sad’	*MORA [OBS]	*MORA [SON]	“BEMORAIC” (WBYP)
a. ☞ σ μ úit. g a r .tae			*
b. σ́ μ μ uit. g a r .tae		*!	

In contrast, Lithuanian coda sonorants are moraic, but coda obstruents are not. Zec (1988) bases this claim, partially, on syllable shape restrictions. Only obstruents are found in coda positions following long vowels. Sonorant codas are licit only following short vowels. These facts may be interpreted such that coda obstruents are non-moraic, sonorants are moraic, and there is a bimoraic

upper limit on the number of moraic elements per syllable (not evaluated below). The constraint ranking in (22b) gets this result because the constraint requiring codas to be moraic is ranked above the constraint against moraic sonorants, but below the constraint against moraic obstruents.

(25) Lithuanian non-moraic obstruent coda

/tuupti/ 'to perch'	*MORA [OBS]	"BEMORAIC" (WBYP)	*MORA [SON]
a. ☞ σ μ μ t u p.ti		*	
b. σ μ μ t u p .ti	*!		

(26) Lithuanian moraic sonorant coda

/kaarti/[12] 'to hang'	*MORA [OBS]	"BEMORAIC" (WBYP)	*MORA [SON]
a. σ μ μ k a r.ti		*!	
b. ☞ σ μ μ k a r .ti			*

Finally, there are many languages (including Cairene Arabic) in which all coda consonants may be moraic. In this type of language, the coercive moraic markedness constraint is ranked above all the constraints against moraic consonants, as seen in (22c). In Cairene Arabic, if either the penult or antepenult is heavy, then stress is on the penult. If all syllables are light, then stress is on the antepenult. As (27) and (28) show, penultimate stress results from antepenults closed by both obstruents and sonorants. Thus, these syllables must be bimoraic.

12. The long vowel in the input is to satisfy Richness of the Base (Prince and Smolensky 1993).

(27) Cairene Arabic moraic obstruent coda

/maktaba/ ‘library’	“BeMoraic” (WbyP)	*Mora [obs]	*Mora [son]
a. σ́ (μ) m a k .ta.ba	*!		
b. ☞ σ (μ μ) m a k .tá.ba		*	

(28) Cairene Arabic moraic sonorant coda

/falsafa/ ‘philosophy’	“BeMoraic” (WbyP)	*Mora [obs]	*Mora [son]
a. σ́ (μ) f a l .sa.fa	*!		
b. ☞ σ (μ μ) f a l .sá.fa			*

Coerced vowel length can be explained in a similar fashion. If SEG1 is a less-sonorous vowel and SEG2 is a more-sonorous vowel, then there are also three (3!/2!) possible permutations of this hierarchy with a constraint forcing bimoraicity in some environment. The rankings that result in these three patterns are given in (29).

(29) a. *Mora[high]≫*Mora[low]≫“BeMoraic”
(e.g., Gujarati)
b. *Mora[high]≫“BeMoraic”≫*Mora[low]
(e.g., Russian dialects)
c. “BeMoraic”≫*Mora[high]≫*Mora[low]
(e.g., Standard Italian)

The result of (29a) is the complete lack of coerced vowel bimoraicity. Since Gujarati has no long vowels, it must have this ranking. (29b) results in coerced bimoraic low vowels, but no coerced bimoraic high vowels. There are Russian dialects in which stressed low vowels are bimoraic, but both unstressed low vowels and stressed non-low vowels are monomoraic. (29c) forces coerced bimoraicity for all vowels. In Standard Italian, all vowels are bimoraic in open stressed penults, as seen in (30).

(30)	a.	[víi.le]	*[ví.le]	*vile*	'mean'
	b.	[káa.sa]	*[ká.sa]	*casa*	'house'

To summarize the OT analysis of coerced weight patterns, the implicational relationship between coerced weight and sonority is the result of the interaction of a universal moraic markedness hierarchy with markedness constraints ensuring that some minimal or maximal[13] prosodic requirement is met.

3.2. Distinctive weight

Distinctiveness is captured in OT via the ranking of faithfulness constraints on some structure above markedness constraints against that structure. This allows both marked and unmarked structures to surface faithful to underlying specifications. The opposite ranking allows only unmarked structures to surface.

There are two types of faithfulness constraints needed to account for distinctive weight. Both are from Morén (1999).[14] (31) says that a particular segment affiliated with a mora underlyingly should remain affiliated a mora on the surface. Conversely, (32) says that a segment that did not have a mora underlyingly should not have a mora on the surface.[15]

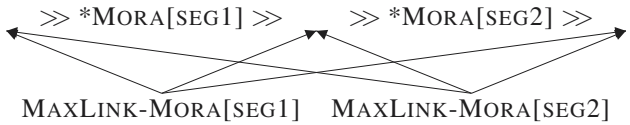
(31) MAXIMALITYLINK-MORA[SEGMENT] (MAXLINK-MORA[SEG]) –
let ζ_j be segments, S_k phonological representations,
S_1 *R* S_2,
ζ_1 is an element of S_1,
ζ_2 is an element of S_2,
ζ_1 R ζ_2, and
ζ_2 belongs to a specific sonority class of segments,
if ζ_1 is associated with a mora,
then ζ_2 is associated with a mora.

13. Although these constraints are not discussed here, an example might be *TRIMORAICSYLLABLE – trimoraic syllables are prohibited. This could force the loss of a mora.
14. The moraic faithfulness constraints are formalized here to capture the lack of an implicational relationship between sonority and distinctive weight. Note that if the faithfulness constraints were either unary (not relative to different segments) or ranked in a universal hierarchy mirroring the universal moraic markedness hierarchy, an (incorrect) implicational relationship between sonority and distinctiveness would result. See Morén (1999) for a detailed discussion.
15. Due to space considerations, and the fact that DEPLINK-MORA[SEG] constraints are only relevant when there is an interaction between coercive and distinctive weight, only the MAXLINK-MORA[SEG] constraint family and its interaction with the general moraic markedness constraints will be addressed in this section.

(32) DEPENDENCELINK-MORA[SEGMENT] (DEPLINK-MORA[SEG]) –
let ζ_j be segments, S_k phonological representations,
S_1 *R* S_2,
ζ_1 is an element of S_1,
ζ_2 is an element of S_2,
ζ_1 R ζ_2, and
ζ_1 belongs to a specific sonority class of segments,
if ζ_2 is associated with a mora,
then ζ_1 is associated with a mora.

Ranking the set of moraic faithfulness constraints with respect to the universal moraic markedness hierarchy yields the distinctive weight patterns described in Section 2.1.2. Since the faithfulness constraints are relative to the same sonority classes as the markedness constraints, and they are not in a universal hierarchy, there is no implicational relationship between moraicity and sonority. This is schematized in (33), where the faithfulness constraints may be ranked independently above both of the constraints in the universal hierarchy, within the hierarchy, or below the hierarchy.

(33) Distinctive weight (simplified)



Although there are twelve (4!/2!) possible permutations of the two general moraic markedness constraints and the two moraic faithfulness constraints, only four distinct patterns emerge. (34) through (37) illustrate this with distinctive obstruent and sonorant weight and provides example languages corresponding to each pattern.

(34) No distinctive weight (e.g., Khalkha Mongolian)
a. *MORA[OBS] ≫ MAXLINK-MORA[OBS]
b. *MORA[SON] ≫ MAXLINK-MORA[SON]

(35) Distinctive weight for obstruents and sonorants (e.g., Standard Italian)
a. MAXLINK-MORA[OBS] ≫ *MORA[OBS]
b. MAXLINK-MORA[SON] ≫ *MORA[SON]

(36) Distinctive weight for obstruents, but not sonorants (e.g., Chechen)
a. MAXLINK-MORA[OBS] ≫ *MORA[OBS]
b. *MORA[SON] ≫ MAXLINK-MORA[SON]

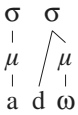
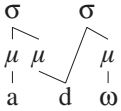
(37) Distinctive weight for sonorants, but not obstruents (e.g. Hausa)

a. *MORA[OBS] ≫ MAXLINK-MORA[OBS]

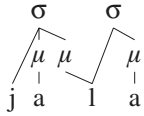
b. MAXLINK-MORA[SON] ≫ *MORA[SON]

Tableaux (38) and (39) illustrate the interaction of moraic markedness and faithfulness constraints in Khalkha Mongolian – a language with no underived geminates. Since markedness outranks faithfulness, the output will have a non-moraic intervocalic consonant regardless of underlying moraicity. Note that superscript morae are associated with the segment on the left in the following underlying representations.[16]

(38) Khalkha Mongolian non-distinctive obstruent weight

/ad$^{\mu}$ω/ 'horse'	*MORA[OBS]	MAXLINK-MORA[OBS]
a. ☞ 		*
b. 	*!	

(39) Khalkha Mongolian non-distinctive sonorant weight

/jal$^{\mu}$a/ 'fly'	*MORA[SON]	MAXLINK-MORA[SON]
a. ☞		*
b. 	*!	

In contrast, Tableaux (40) and (41) show the ranking of faithfulness above markedness in Italian to yield geminate intervocalic consonants if they are underlyingly moraic.

16. The inputs here could be either moraic or nonmoraic and the result would be the same – nonmoraic. The moraic input is illustrated here simply to show the effect of the Richness-of-the-Base hypothesis of Prince and Smolensky (1993).

(40) Italian distinctive obstruent weight

	/gat$^{\mu}$o/ 'cat'	MAXLINK-MORA[OBS]	*MORA[OBS]
a.	σ σ μ μ g a t o	*!	
b. ☞	σ σ μ μ μ g a t o		*

(41) Italian distinctive sonorant weight

	/non$^{\mu}$o/ 'grandfa-ther'	MAXLINK-MORA[SON]	*MORA[SON]
a.	σ σ μ μ n o n o	*!	
b. ☞	σ σ μ μ μ n o n o		*

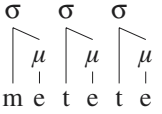
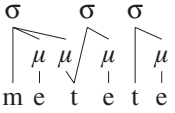
Recall from (14) that distinctive vowel patterns parallel that of consonants. Therefore, they can be explained if SEG1 and SEG2 in (33) were vowels of different sonorities. Due to space limitations, these rankings are not listed or evaluated here.

An interesting case to note is that of Modern Standard Italian, which has distinctive moraicity for consonants (less-sonorous) but not for vowels (more-sonorous). Note that [C] represents the class consonants and [V] represents the class of vowels.

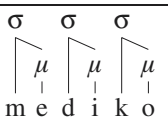
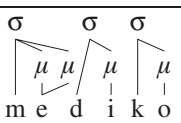
(42) Constraint ranking for Italian distinctive moraicity
MAXLINK-MORA[C]≫*MORA[C]≫*MORA[V]
≫MAXLINK-MORA[V]

As (43) and (44) demonstrate, a single faithfulness constraint against losing underlying morae falsely predicts that distinctive consonant length implies distinctive vowel length. This clearly demonstrates that distinctive moraicity is not constrained by sonority.

(43) Correct Italian distinctive consonant weight with single faithfulness

/met$^{\mu}$ere/ 'to put'	MAXLINK-MORA	*MORA[C]	*MORA[V]
a. 	*!		***
b. ☞ 		*	***

(44) Incorrect Italian distinctive vowel length with single faithfulness

/me$^{\mu\mu}$diko/ 'doctor'	MAXLINK-MORA	*MORA[C]	*MORA[V]
a. ☜ 	*!		***
b. ☹ 			****

(45) compares a sample of languages based on whether or not they have distinctive weight for consonants or vowels. Again, the shaded cells are of particular interest because they show that there is no implicational relationship between sonority and distinctive weight.

(45) Languages, segment classes and distinctive weight

Consonant	Vowel	Language[17]
Yes	Yes	Balochi, Brahui, Hungarian, Oromo
No	Yes	Burushaski, Khalkha Mongolian, Hawaiian
Yes	No	Icelandic, Ilokano, Modern Standard Italian
No	No	Chaha

To summarize the OT analysis of distinctive weight patterns provided by Morén (1999), the lack of an implicational relationship between distinctive

17. Sources: Balochi, Brahui – Elfenbein 1997. Burushaski – Anderson 1997. Chaha – Leslau 1997. Hawaiian – Elbert and Pukui 1979; Morén 1999. Hungarian – Nádasdy 1985; Morén 1999. Icelandic – Einarsson 1945; Morén 1999. Ilokano – Morén m.s. Khalkha Mongolian – Svantesson 1994. Modern Standard Italian – Vogel 1982; Morén 1999. Oromo – Lloret 1997.

weight and sonority is the result of the interaction of a universal moraic markedness hierarchy with freely re-rankable faithfulness constraints ensuring that underlying moraicity is maintained on the surface.

4. Interactions between coerced and distinctive weight

There are several predictions that the factorial ranking of the constraints above makes regarding the interaction of coerced and distinctive weight. This section presents one such prediction and shows that the implicational relationship between coerced moraicity and sonority can be contravened under influence of distinctive weight constraints.

Educated Colloquial Hungarian (ECH) is a language where lower-sonority segments are forced to be moraic in particular environments, but higher-sonority segments are not. This poses a problem for the traditional generalization that if a less-sonorous segment is lengthened in some environment, then all more-sonorous segments should lengthen in that environment. As summarized in (46), all vowels in this language have distinctive length in non-final syllables, but non-low final vowels neutralize to either long or short (shaded cells) depending on the prosodic structure of the word. In contrast, low vowels always have distinctive length in open syllables, regardless of position.

(46) Open syllable vowel length in Educated Colloquial Hungarian

	Height	Tensing differ.	Non-final	Final	
				Monosyllable	Polysyllable
[ii/i,uu/u,üü/ü]	high	no	distinctive	long	short
[öö/œ,oo/ɔ]	mid	yes	distinctive	long	long
[ee/ɛ,aa/ɒ]	low[18]	yes	distinctive	distinctive	distinctive

For example, all high vowels are long in open stressed monosyllables, but low vowel length is distinctive in this environment. This is shown in (47).

(47)
a. [buː] *bú* 'melancholy' *[bu]
b. [fiː] *fí* 'phi' *[fi]
c. [faː] *fá* 'FA in music' [fɒ] *fa* 'tree'

The neutralization of non-low vowel length is a typical minimal word phenomenon and can be explained by ranking a constraint requiring foot binarity above a constraint against moraic high vowels, as shown in (49).

18. The somewhat unconventional classification of [eː] and [ɛ] as low vowels is argued for by Nádasdy (1985). Note that this is not a necessary conclusion and that the present analysis can be easily modified to treat these vowels as mid.

(48) FOOTBINARITY (FTBIN) – Prosodic feet must be binary at the syllabic or moraic level.

(49) Coerced bimoraicity of high vowels

/bu/ 'meloncholy'	FTBIN	*MORA[HIGH]
a. σ μ b u	*!	*
b. ☞ σ μ μ b u		**

The problem is that the ranking of FTBIN over *MORA[HIGH] implies that low vowels will also lengthen in this environment because *MORA[HIGH] universally ranks above *MORA[LOW].

(50) FTBIN ≫ *MORA[HIGH] ≫*MORA[LOW]

(51) Incorrect coerced bimoraicity of low vowels

/fa/ 'tree'	FTBIN	*MORA[HIGH]	*MORA[LOW]
a. ☞ σ μ f ɒ	*!		*
b. ☹ σ μ μ f ɒ			**

Although this is a desirable result under traditional expectations, it is an incorrect result given the empirical fact that low vowels have distinctive length in this environment in this language, as shown in (47).

However, we can make use of the fact that vowel length is distinctive and that distinctiveness is mediated via freely re-rankable faithfulness constraints to explain this unexpected result. If we rank the constraint against adding a mora to a high vowel below FTBIN, but the constraint against adding a mora to a low vowel above FTBIN, then the correct result is obtained for both high and low vowels, as shown in tableaux (52) and (53).

(52) Coerced bimoraicity of high vowels

/bu/ 'melon-choly'	DEPLINK-MORA [LOW]	FTBIN	DEPLINK-MORA [HIGH]	*MORA [HIGH]	*MORA [LOW]
a. σ μ b u		*!	*	*	
b. ☞ σ μ μ b u			**	**	

(53) Correct lack of coerced bimoraicity of low vowels

/fa/ 'tree	DEPLINK-MORA [LOW]	FTBIN	DEPLINK-MORA [HIGH]	*MORA [HIGH]	*MORA [LOW]
a. ☞ σ μ f a	*	*			*
b. σ μ μ f a	**!				**

To summarize, the factorial ranking of the constraints proposed in Morén (1999) makes predictions that are at odds with traditional assumptions about weight typology – a strict implication between sonority and coerced weight. However, upon closer examination of the empirical facts, those predictions are borne out and assumptions regarding weight typology must be revised.

5. Conclusion

This paper discusses weight typology from both a descriptive and theoretical perspective. Descriptively, moraicity comes in two flavors, coerced and distinctive – each of which is applicable to both vowels and consonants, and each of which comes with its own generalizations. Theoretically, weight typology is the logical result of a relationship between sonority and moraicity and the factorial ranking of constraints within the OT framework. It is important to note that the descriptive observations and the proposed representations are important in their own right and not dependent on the OT. However, Optimality Theory provides a very straightforward account of both the core generalizations

regarding coerced and distinctive weight systems and their complex interactions.

The specific results are as follows. Following Morén (1999), weight is the result of the interactions of three general constraint families: general moraic markedness constraints, coercive moraic markedness constraints, and moraic faithfulness constraints. The general moraic markedness constraints are co-occurrence constraints that penalize moraic segments. They are relative to both vowels and consonants, and they are universally ranked following sonority. Ranking the universal moraic markedness hierarchy with respect to coercive moraic markedness constraints, e.g., Weight by Position or Foot Binarity, yields an implicational relationship between coerced moraicity and sonority. If segments of one sonority are forced to be moraic in some environment, then segments of higher sonority will also be moraic in that environment. However, there are two complications. First, distinctive moraicity is not subject to sonority. Languages often allow an underlying consonant or vowel length distinction for less-sonorous segments but not more-sonorous segments. This fact is captured here by interleaving freely re-rankable moraic faithfulness constraints with the universal moraic markedness hierarchy.

Second, the distribution of vowel length in Educated Colloquial Hungarian illustrates the fact that the interaction between coerced and distinctive weight (mitigated through factorial constraint ranking) can yield violations of the coerced weight implicational relationship with sonority. This is unexpected given traditional views of weight, but is fully supported by the proposed OT typology.

Finally, the predictions of factorial constraint ranking in OT not only provide an internal means by which to examine the adequacy of individual constraints and analyses proposed in the OT literature, but they also provide a metric by which to re-examine our assumptions about linguistic patterns and the true nature of typology.

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References

Anderson, Gregory (1997). Lak phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 973–1000. Winona Lake: Eisenbrauns.

Anderson, Gregory (1997). Burushaski phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 1021–1041. Winona Lake: Eisenbrauns.

Bakovic, Eric (1998). Unbounded stress and factorial typology. Unpublished ms., Rutgers University. [ROA-244-0298].

Broselow, Ellen, Su-I Chen and Marie Huffman (1997). Syllable weight: convergence of phonology and phonetics. *Phonology* 14: 47–82.

Crothers, J. (1978). Typology and universals of vowel systems. In *Universals of Human Language: Phonology*, Vol. 2, Joseph H. Greenberg (ed.), 93–152. California: Stanford University Press.

Einarsson, Stefán (1945). *Icelandic*. Baltimore: The Johns Hopkins Press.

Elbert, Samuel and Mary Kawena Pukui (1979). *Hawaiian Grammar*. Honolulu: University Press of Hawaii.

Elfenbein, Josef (1997). Balochi phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 761–776. Winona Lake: Eisenbrauns.

Elfenbein, J. (1997). Brahui phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 797–814. Winona Lake: Eisenbrauns.

Fukazawa, Haruka (1999). Theoretical implications of OCP effects on features in Optimality Theory. Unpublished Ph.D. dissertation, University of Maryland at College Park. [ROA-307-0399].

Harris, James (1983). *Syllable Structure and Stress in Spanish: A Nonlinear Analysis*. Cambridge: MIT Press.

Hayes, Bruce (1989). Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20: 253–306.

Hyman, Larry (1985). *A Theory of Phonological Weight*. Publications in Languages Sciences 19, Dordrecht: Foris.

Itô, Junko, Armin Mester, and Jaye Padgett (1995). Licensing and underspecification in Optimality Theory. *Linguistic Inquiry* 26: 571–613.

Jaeger, Jeri (1978). Speech aerodynamics and phonological universals. BLS 4.

Kager, René (1989). *A Metrical Theory of Stress and Destressing in English and Dutch.* Dordrecht: Foris.

Leslau, Wolf (1997). Chaha (Gurage) phonology. In *Phonologies of Asia and Africa*, Vol. 1, Alan S. Kaye (ed.), 373–398. Winona Lake: Eisenbrauns.

Lloret, Maria-Rosa (1997). Oromo phonology. In *Phonologies of Asia and Africa*, Vol. 1, Alan S. Kaye (ed.), 493–520. Winona Lake: Eisenbrauns.

Maddieson, Ian (1984). *Patterns of Sounds*. Cambridge: Cambridge University Press.

McCarthy, John and Alan Prince (1986). Prosodic morphology. Unpublished ms., University of Massachusetts, Amherst and Brandeis University.

McCarthy, John and Alan Prince (1995). Faithfulness and reduplicative identity. In *University of Massachusetts Occasional Papers 18: Papers in Optimality Theory*, Jill Beckman, Laura Walsh Dickey, and Suzanne Urbanczyk (eds.), 249–384. Amherst: GLSA.

McCawley, James (1968). *The Phonological Component of a Grammar of Japanese.* The Hague: Mouton.

Mistry, P.J. (1997). Gujarati phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 653–674. Winona Lake: Eisenbrauns.

Morelli, Frida (1999). The phonotactics and phonology of obstruent clusters in Optimality Theory. Unpublished Ph.D. dissertation, University of Maryland at College Park.

Morén, Bruce (2001). Ilokano stress: Implications for Moraic Theory and phonetics. Unpublished ms., Georgetown University.

— (1999). Distinctiveness, coercion, and sonority: A unified theory of weight. Ph.D. dissertation, University of Maryland at College Park. Published in 2001. New York: Routledge.

Morén, Bruce and Viola Miglio (1999). Issues in Icelandic phonology: a unified approach. In *Proceedings of the Xth Conference of Nordic and General Linguistics*, Gudrún Thórhallsdóttir (ed.), 155–168. Reykjavík, Iceland: Institute of Linguistics, University of Iceland.

Moulton, William (1990). Some vowel systems in American English. In *Studies in the Pronunciation of English*, Susan Ramsaran (ed.). New York: Routledge.

Nádasdy, Ádám (1985). Segmental phonology and morphology. In *Approaches to Hungarian*, Vol. 1. Szedged: JATE.

Newman, Paul (1997). Hausa phonology. In *Phonologies of Asia and Africa*, Vol. 1, Alan S. Kaye (ed.), 537–552. Winona Lake: Eisenbrauns.

Nichols, Johanna (1997). Chechen phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 941–972. Winona Lake: Eisenbrauns.

Prince, Alan (1990). Quantitative consequences of rhythmic organization. In *Parasession on the Syllable in Phonetics and Phonology*, 355–398. Chicago: Chicago Linguistic Society.

Prince, Alan and Paul Smolensky (1993). Optimality Theory: Constraint interaction in generative grammar. To appear, MIT Press. TR-2, Rutgers University Cognitive Center.

Samek-Lodovici, Vieri (1998). OT-interactions between focus and canonical word order: deriving the cross-linguistic typology of structural contrastive focus. Unpublished ms. Germany: Konstanz University. [ROA-257-0498].

Selkirk, Elizabeth O. (1984). On major class features and syllable theory. In *Language Sound and Structure*, Mark Aronoff, Richard Oehrle, France Kelley and Bonnie Wilken Stephens (eds.), 107–136. Cambridge: MIT Press.

Svantesson, Jan-Olof (1994) Mongolian syllable structure. In *Lund University Department of Linguistics Working Papers 42*, M. Aronoff & R. Oehrle (eds), 225–239. Lund University, Sweden.

Taylor, Martha (1995). Some patterns of geminate consonants. In *The University of Chicago Working Papers in Linguistics,* Vol. 1, 120–129.

Vogel, Irene (1982). *La Sillaba come Unità Fonologica.* Bologna: Zanichelli.

Windfuhr, Gernot (1997). Persian phonology. In *Phonologies of Asia and Africa*, Vol. 2, Alan S. Kaye (ed.), 675–690. Winona Lake: Eisenbrauns.

Zec, Draga (1988). *Sonority Constraints on Prosodic Structure*. Ph.D. dissertation, Stanford University. Published in 1994, New York: Garland.

— (1995). Sonority constraints on syllable structure. *Phonology* 12: 85–129.