

# Codas are Universally Moraic

Jonathan Charles Paramore  
*University of California, Santa Cruz*  
jcparamo@ucsc.edu

## 1 Introduction

A fundamental notion underlying weight-sensitive processes involves the differentiation between heavy and light syllables. For example, about 40% - 45% of the world's languages utilize weight sensitivity as a component to determine stress placement (Gordon, 2006; Goedemans and van der Hulst, 2013), and in these languages, heavy syllables attract stress from light syllables that occur in a default position. The prevailing theory relied upon to account for this phenomenon assumes that overall mora count drives syllable weight determinations. In other words, in the most basic sense, languages treat syllables with more moras as heavier than syllables with less moras.<sup>1</sup> Heavy syllables for weight-sensitive stress, then, by nature of their moraic quantity, attract stress from light syllables. Nevertheless, a picture of weight sensitivity in which moraic quantity acts as the sole arbiter of syllable weight distinctions does not seem to capture the empirical realities that the typology of weight-sensitive systems presents. This is evinced by the fact that syllable weight is not uniform cross-linguistically for stress. Some languages, for instance, analyze all syllables containing a long vowel as heavy for stress, deeming all others light, as demonstrated by the stress criterion in (1i).<sup>2</sup> Examples of such languages include Murik (Abbott, 1985) and Lhasa Tibetan (Dawson, 1980; Gordon, 2006). Other languages, though, treat either the presence of a long vowel or the presence of a coda as grounds for attracting stress, as shown by the stress criterion in (1ii). Examples of languages that pattern in this way include Yana (Sapir and Swadesh, 1960; Hyde, 2006) and Arabic (Harrell, 1957, 1960; McCarthy, 1979a, 1979b; Gordon, 2006). Still other languages, like Kwakw'ala (Bach, 1975; Zec, 1994; Walker, 1996) or Quechua Inga (Levinsohn, 1976), employ the scale in (1iii), in which syllables with long vowels and syllables closed by a sonorant consonant are heavy, while open syllables with a short vowel and syllables closed by an obstruent are light.

(1) Common weight-sensitive stress criteria

- i.  $\{CV:\} > \{CVR, CVO\}$
- ii.  $\{CV:, CVR, CVO\} > \{CV\}$
- iii.  $\{CV:, CVR\} > \{CVO, CV\}$

---

<sup>1</sup>I set aside the distinction between trimoraic and less-than-trimoraic syllables (e.g.,  $\{CV:C, CVCC\} > \{CV:, CVC, CV\}$ ) in this paper. While the typological landscape of syllable weight requires theories of weight sensitivity to account for these distinctions, there is insufficient space to do so here.

<sup>2</sup>CVR represents a syllable closed by a sonorant coda, and CVO represents a syllable closed by an obstruent coda.

Notice that the hierarchical status of CVC syllables serves as the only divergence between the scales in (1). In (1i), both CVC syllable types pattern as light with CV, and in (1ii) they pattern as heavy with CV:. In (1iii), the weight status of CVC syllables is split, with syllables closed by a sonorant coda patterning as heavy and syllables closed by an obstruent coda patterning as light. Because of this variation, a unified analysis of the weight distinctions in (1) based solely on moraic quantity proves elusive. If we attempt to characterize codas as mora-bearing, thereby rendering CVC bimoraic, we account for the contrasts in the scale in (1ii) but not for the contrasts in (1i). On the other hand, if we characterize codas as weightless, thereby rendering CVC monomoraic, we account for the weight contrasts in (1i) but not for those in (1ii). Finally, regardless of whether we analyze codas as weight-bearing or not, the contrast between CVR and CVO in (1iii) cannot be captured by simple distinctions in moraic quantity. The disparity between these criteria for weight-sensitive stress, then, presents a problem that must be addressed by any theory attempting to account for the full range of stress criteria. Namely, how do we account for the cross-linguistic variation of CVC's weight?

The standard approach to moraic structure – which I term the “Variable Weight” approach – contends that the culprit behind CVC's variation is a language-specific parameter governing coda moraicity (Hyman, 1985; Hayes, 1989; Zec, 2007; a.o). Within the Optimality Theory framework (Prince and Smolensky, 1993/2004), when CVC patterns as light with CV for stress, as in Lhasa Tibetan, the Variable Weight approach argues that this emanates from a high-ranked constraint precluding codas from projecting a mora. On the other hand, when CVC patterns as heavy with CV:, as in Yana, that same constraint must occupy a low position in the constraint rankings of the language. Finally, in a stress criterion like Kwakw'ala's, in which CVR syllables pattern as heavy with CV: and CVO syllables as light with CV, the Variable Weight approach posits that the distinction again falls out from differences in coda moraicity (Zec, 1995, 2007). A constraint dispreffering the moraicity of sonorant codas is low-ranked in Kwakw'ala, while a constraint dispreffering the moraicity of obstruent codas is high-ranked. In this way, the Variable Weight approach relies on variability in moraic structure to predict the typological variation of weight-sensitive stress criteria.

Nevertheless, as will be explicated in considerable depth in this paper, when other weight-sensitive processes in addition to stress are considered, the predictions of the Variable Weight approach stray from the observed facts concerning the cross-linguistic moraicity of codas. Specifically, weight-sensitive processes within a single language often diverge in how they treat codas in terms of weight (Gordon, 2006). In Lhasa Tibetan, for example, even though CVC syllables pattern as light for stress – thus, requiring codas to be non-moraic under the Variable Weight approach – compensatory lengthening in the language requires codas to be moraic. Similarly, Tibetan's tonal criterion permits CV: and CVR syllables to host a contour tone, but CVO syllables are unable to do so. Since moras are considered the tone-bearing unit in the language, the ability of CVR syllables to host contour tones indicates that at least sonorant codas must be moraic. In Lhasa Tibetan, then, a theory like the Variable Weight approach – which relies on a lack of coda moraicity to capture the language's weight-sensitive primary stress system – cannot account for the weight mismatches between these different processes and is thus untenable.

As an alternative to the Variable Weight approach, I propose a solution to CVC's variable weight status that maintains a uniform moraicity of codas, both cross-linguistically and within individual languages. That is, the difference in CVC's hierarchical status between the scales in

(1) has nothing to do with the relative moraicity of codas because the moraic structure of codas is universally fixed. Rather than relying on generic mora count to make weight distinctions, I propose a new syllable weight metric – **The Moraic Sonority Metric** – which constructs weight scales based on the number of moras *of a specified sonority* in a syllable rather than the sum total of moras in a syllable. By factoring sonority into weight computations, the Moraic Sonority Metric conflates the standard moraic quantity metric with prominence metrics like those discussed in Ryan (2019, 2020), thereby consolidating the two metrics into a single mechanism and obviating the need to call upon multiple disjointed constraint families to calculate weight. Additionally, the need for a theory of Coercion (Morén, 1999) – which relies on contextual within-language coda moraicity – to capture ternary stress scales also dissipates with the use of the Moraic Sonority Metric.

Under the approach outlined here, a language that wields the scale in (1ii) uses every mora type to compute syllable weight for stress. Thus, syllables that are bimoraic (CV:, CVR, and CVO) are heavy, while those that are monomoraic (CV) are light. A language that utilizes the stress scale in (1i), on the other hand, only includes vocalic moras in its weight computations for stress, resulting in syllables with two vocalic moras (CV:) behaving as heavy and syllables with less than two vocalic moras (CVR, CVO, and CV) behaving as light. Crucially, even though CVR and CVO are both bimoraic, they each contain only a single vocalic mora and thus are treated as identical to CV in such a system. Finally, a language with the stress scale in (1iii) considers only sonorant moras in its weight computations, thereby producing a scale in which syllables with two or more sonorant moras (CV: and CVR) attract stress, and syllables with less than two sonorant moras (CVO and CV) do not. Importantly, the theory relies on universal coda moraicity, which leads to one of the main arguments of the paper: Evidence from weight-sensitive phenomena other than stress demonstrates that codas consistently contribute weight to the syllable, even in languages in which CVC is treated as light for stress. Given the overwhelming percentage of languages that exhibit coda moraicity in at least one weight-sensitive process, I argue that coda moraicity should be consistently represented in moraic structure to reflect that fact.

A twofold purpose underlies the arguments made throughout the rest of the paper. First, I seek to justify the above assertion that cross-linguistic variations in weight criteria for all weight-sensitive processes are best captured with a syllable weight metric that incorporates and intertwines moraic sonority in tandem with moraic quantity into its weight computations. Second, I aim to defend the claim that codas are universally moraic, which is, in its strongest form, a theory of Uniform Moraic Quantity (UMQ). The remainder of the paper progresses as follows. Section 2 critically assesses the standard Variable Weight approach – which advocates for cross-linguistic variation in coda moraicity to account for the typological inconsistency of stress scales – and highlights the shortcomings of the theory in relation to its predictions of language-specific coda moraicity. The bulk of the theoretical machinery introduced in this paper, including the Theory of Uniform Moraic Quantity (UMQ) and the Moraic Sonority Metric, is delineated in section 3. Section 4 argues for a method in which the Moraic Sonority Metric could be formalized into a set of OT constraints to account for cross-linguistic variation in weight-sensitive stress criteria and explores the factorial typology of the proposed Moraic Sonority constraints. Section 5 offers a discussion, and section 6 gives concluding remarks.

## 2 The Variable Weight Approach to Weight Sensitivity

### 2.1 Traditional assumptions of moraic structure

The traditional approach to the variation in CVC's hierarchical position on weight-sensitive stress scales has been to maintain that distinctions in weight are equivalent to distinctions in moraic quantity. This approach to determining syllable weight is accomplished by allowing the moraicity of codas to vary from language to language alongside CVC's hierarchical variation across stress criteria (Hyman, 1985; McCarthy and Prince, 1986, 1995; Hayes, 1989; Zec, 2003). That is, assuming an Optimality Theoretic approach (Prince and Smolensky, 1993/2004), it is claimed that moraic structure is stipulated on a language-specific basis, with the Weight by Position constraint in (2i) – which penalizes non-moraic codas – ranked above  $*\mu_C$  in (2ii) in languages that analyze CVC as bimoraic for stress but below  $*\mu_C$  in languages that analyze CVC as monomoraic for stress.

#### (2) Variable Weight constraints

##### i. Weight by Position (WxP) (Hayes, 1989; Sherer, 1994)

Assign a violation for every coda consonant not linked to its own mora.

##### ii. $*\mu_C$ (Morén, 1999)

Assign a violation for every moraic coda consonant.

A representation of the syllable structure, taken from Zec (2007), for the scales in (1i) and (1ii) under the Variable Weight approach is depicted in (3). Notice that CV syllables consistently contribute a single mora to the syllable, and CV: syllables consistently contribute two moras. CVC syllables under this theory, on the other hand, contribute a single mora when they pattern with CV in (3i) and two moras when they pattern with CV: in (3ii). To attain the scale in (1iii), in which coda weight seems to be distinguished by the relative sonority of consonants, proponents of the Variable Weight approach must engineer a more restrictive WxP constraint that penalizes non-moraic sonorant codas only, resulting in a language where CVO syllables surface with the moraic structure of the CVC syllable in (3i) and CVR syllables with the moraic structure of the CVC syllable in (3ii). Something akin to this analysis takes shape in Zec (2007, pp. 183–187).

#### (3) Moraic Structure under the Variable Weight approach

##### i. WxP lowly ranked: $\{CV:\} > \{CVC, CV\}$



##### ii. WxP highly ranked: $\{CV:, CVC\} > \{CV\}$



## 2.2 The Variable Weight approach and Lhasa Tibetan

While the Variable Weight approach offers an ostensibly appealing solution to the cross-linguistic behavior of CVC for primary stress, it incorrectly predicts the moraicity of codas for a host of other weight-sensitive phenomena. To illustrate, consider the mismatches in weight criteria outlined below for primary stress, tone, and compensatory lengthening in Lhasa Tibetan. As demonstrated in (4i), primary stress in Tibetan falls on the initial syllable when no heavy (CV:) is present, but when one or more heavy exists, stress falls on the leftmost CV:, as in (4ii).

(4) Tibetan Stress Criterion:  $\{CV:\} > \{CVR, CVO, CV\}$  (Dawson, 1980)

i. initial stress

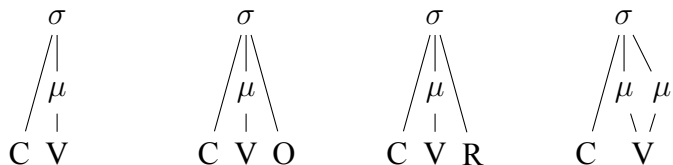
'lap.ta “school”      'wo.ma “milk”      'ju.qu “pen”

ii. leftmost heavy

am.'tɔ: “person from Amdo”      'qe:.la: “teacher”  
lap.'tɛ: “of the school”      kʰa.'pa: “telephone”

Because both CVR and CVO pattern as light alongside CV in the Lhasa Tibetan stress system, the Variable Weight approach requires  $*\mu_C$  to be high ranked, thereby rendering all codas non-moraic in the language to allow CV: to attract stress from CVC in words like *am.'tɔ:* and *lap.'tɛ:*. Consequently, the Variable Weight approach predicts that syllables in Lhasa Tibetan will manifest weight behaviors consistent with the moraic structures in (5), in which both CVO and CVR are monomoraic and light.

(5) Moraic Structure of Tibetan Syllables under the Variable Weight Approach



Nevertheless, while the moraic structures in (5) make the correct predictions for the *primary stress* criterion in Tibetan, issues arise when considering the *tonal* and *compensatory lengthening* weight criteria, which both deviate (in different ways) from the stress criterion in how they treat syllables closed by a coda.<sup>3</sup> Consider, for instance, the tonal pattern of the Tibetan words in (6).<sup>4</sup> Only CV: and CVR may host a contour tone (as in *qhâm* or *mâ:*), whereas neither CVO nor CV has been found to do so.

(6) Tibetan Tonal Criterion:  $\{CV:, CVR\} > \{CVO, CV\}$  (Dawson, 1980)

qʰâm “Kham”      mâ: “war”      kâ: “to be stuck”  
tɕk.pá “nomad”      kúk.pé “dumb”      ɲín.pé “old”

According to autosegmental tonal representation, every tone must anchor itself to a tone-bearing unit (TBU) (Goldsmith, 1976a, 1976b; Hyman and Leben, 2020). Contour tones, which are often considered to be made up of a sequence of two distinct level tones, can either link to a single TBU or require every discrete tonal level in the contour to anchor to a separate TBU. In a language

<sup>3</sup>One may wonder if approaches like Zec’s (1995, 2003) Sonority Threshold constraints or the theory of Coercion can account for mismatches like those found in Tibetan, but see sections 4.1.5 and 5.1 for discussions on why the two approaches cannot be relied upon to resolve the matter.

<sup>4</sup>Ŷ (high falling) represents a contour tone. All other tones exemplified here are monotonic.

with weight-sensitive tone like Tibetan, the mora functions as the TBU, and syllables must consist of the requisite number of moras to host a contour tone. In other words, for a syllable to host a contour tone made up of two level tones, it must contain at least two moras. Thus, since both CV: and CVR syllables can host a contour tone (either high falling or low falling) in Tibetan, they must both be bimoraic in the language. As we saw above, however, the Variable Weight approach requires CVR syllables to be monomoraic to yield primary stress to CV:. The resulting monomoraic structure predicted by the Variable Weight approach cannot explain the ability of CVR syllables to host contour tones. As demonstrated in (7), CV: syllables have no issue hosting a contour tone in Tibetan under the analysis of the Variable Weight approach since they are predicted to project two moras. For CVR, on the other hand, its monomoraic structure prevents the second tone of the contour from finding a docking site, as shown by the autosegmental representation of the word *qhâm* in (7). The high tone in the high falling contour links to the vocalic mora projected by [a], but the low tone in the contour cannot find a mora on which to dock since [m] is non-moraic. Under the proposed moraic structure, then, CVR syllables in Tibetan should not be able to host a contour tone. The issue at hand for the Variable Weight approach is that the stress criterion and the tonal criterion of Lhasa Tibetan seemingly require conflicting moraic structures to account for the empirical evidence, and the Variable Weight approach cannot resolve the discrepancy; CVR must be simultaneously monomoraic for stress and bimoraic for tone.

(7) The Variable Weight Approach's prediction of TBUs in Tibetan

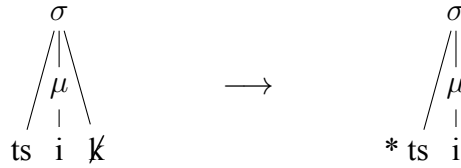


Turning now to compensatory lengthening (henceforth CL), the situation in Tibetan is even further complicated for the Variable Weight approach. Standard CL involves the deletion of a moraic consonant and the subsequent lengthening of the preceding vowel. Under moraic theory, the impetus for this process is that when the consonant deletes, it strands its mora, which relinks to the preceding vowel and results in lengthening. Whereas the stress criterion requires all CVC syllables to be monomoraic, and the tonal criterion requires CVR to be bimoraic and CVO monomoraic, CL effects in Lhasa Tibetan attest to the moraicity of both sonorant and obstruent codas. As demonstrated by words like *tsi*: “one” and *kə:ki* “do, make” in (8), when an obstruent coda is deleted, the mora stranded by the deleted coda relinks to the preceding vowel, resulting in surface vowel lengthening.

- (8) Tibetan CL Criterion: {CV:, CVR, CVO} > {CV} (Dawson, 1980)
- |                                |       |                  |            |
|--------------------------------|-------|------------------|------------|
| /tsik/ → tsi:                  | “one” | /kəp.ki/ → kə:ki | “do, make” |
| /tʃur.ku/ → tʃu:.ku “nineteen” |       |                  |            |

Due to the monomoraic structure of CVO syllables under the Variable Weight approach, however, the deletion of obstruent codas should not result in vowel lengthening. Instead, because obstruent codas are non-moraic, the Variable Weight approach predicts that obstruent coda deletion should result in the surface form in (9), in which coda deletion does not result in the preceding vowel lengthening because no mora is stranded.

(9) The Variable Weight Approach and Compensatory Lengthening in Tibetan



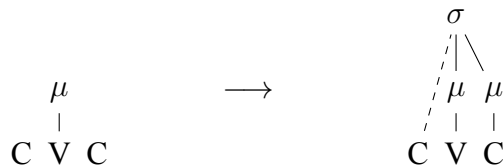
In sum, the data from Lhasa Tibetan illustrates that the Variable Weight approach to weight sensitivity is ill-equipped to handle language-internal variations in syllable-weight criteria like that of Tibetan. The reason for this lack of success, as mentioned above, is that the language-specific parameterization of moraic structure is a foundational element of the theory. In other words, the Variable Weight approach assumes that syllable weight is language-specific and not process-specific. Nevertheless, as Lhasa Tibetan demonstrates, the facts confound such an assumption. With this in mind, it is clear that we need a theory of moraic structure that effectively captures the variant behavior of coda weight while simultaneously maintaining their cross-linguistic moraicity. Only then will the process-specific nature of syllable weight criteria be attainable.

### 3 A solution to weight mismatches

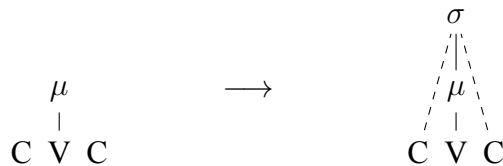
#### 3.1 Uniform Moraic Quantity Theory

A theory of Uniform Moraic Quantity (UMQ), contra the Variable Weight approach, requires a universally rigid adherence to the moraicity of codas. Within the OT framework, this is accomplished by promoting the Weight by Position constraint from (2i) to a constraint on GEN (cf. Steriade, 1991). As a consequence, any candidate manifesting a moraic structure in which a coda attaches directly to the syllable without contributing a mora cannot be considered as a viable output, as demonstrated in (10). This means that, for every coda consonant that is present, it must contribute its own mora to the syllable, regardless of how any individual process may treat codas in relation to weight.

- (10) UNIFORM MORAIC QUANTITY (UMQ)  
 Coda consonants must link to their own mora.
- i. Permissible moraic structure of CVC



- ii. Violates UMQ constraint on GEN



The UMQ achieves two key advantages over the standard Variable Weight analysis, which will be outlined in sections 3.2 and 3.3 respectively. First, the UMQ makes more accurate predictions concerning the moraicity of coda consonants. As will be demonstrated in what follows, even when CVC is treated as light for stress, evidence for the inherent moraicity of codas emerges for most languages if we look at the behavior of codas for other phonological processes. Since the UMQ establishes that codas are universally moraic, we expect such processes that reveal the moraicity of codas to occur. This, however, is not the case for the Variable Weight approach, which predicts that codas ought to function monomoraically in all domains for languages in which CVC patterns as light with CV for primary stress.

The second advantage of the UMQ lies in its provision of a simple universal schema for moraic structure, eliminating the need to make language- and context-specific stipulations about the moraic structure of syllables. The Variable Weight approach, as demonstrated by its handling of the different weight-sensitive scales above, requires the moraic status of codas to be specified on a language-by-language basis. One may wonder whether the UMQ simplifies moraic theory or simply shifts the burden of stipulation from moraic structure to a new portion of the grammar to explain weight variations. As will be demonstrated in section 3.3, however, the metric used to make syllable weight distinctions under the approach outlined here capitalizes on stipulations that are already implicitly invoked for other means in current moraic theory. In other words, the UMQ enables us to rid the grammar of restrictions on moraicity without adding new restrictions, thereby lowering the overall number of ad hoc stipulations that must be imposed.

### **3.2 A cross-linguistic examination of coda moraicity**

In section 2, we explored the general proposal of the Variable Weight approach to weight sensitivity, testing its predictions on data from Lhasa Tibetan to demonstrate how weight criteria mismatches provide evidence against treating weight as a language-specific property. As a solution, I proposed a theory of Uniform Moraic Quantity, which requires every coda consonant to link to its own mora cross-linguistically. Since this assertion so straightforwardly contradicts the foundational assumptions of the Variable Weight approach, determining which approach stands on firmer empirical ground concerning the cross-linguistic moraicity of codas is a rather simple matter. To test which approach makes the correct predictions, we need only analyze the behavior of CVC in languages in which the Variable Weight approach predicts that codas should be non-moraic to determine whether it is consistent with bimoraicity or monomoraicity in these languages. In languages in which CVC patterns as light for stress, the Variable Weight approach predicts that codas should be non-moraic, but the UMQ predicts the opposite. If we find that codas exhibit weight-bearing characteristics in these languages, this provides strong evidence in favor of the UMQ. If, on the other hand, we find that codas exhibit weightless characteristics for other weight-sensitive phenomena for most “CVC light” for stress languages, this would indicate that perhaps Lhasa Tibetan is an exception to an otherwise sound proposal made by the Variable Weight approach. As portrayed in the 2x2 contingency table in (11), however, Lhasa Tibetan is far from the only language that belies the Variable Weight approach. The table classifies 107 languages from Gordon’s (2006) survey of weight-sensitive processes that both permit coda consonants and exhibit weight-sensitive stress. Each language is classified according to two categorical variables: coda weight for stress and coda weight for other weight-sensitive processes. The goal is to highlight the cross-linguistic frequency with which co-



das exhibit moraicity for at least one weight-sensitive process. The **columns** in the table sort all languages in the survey into two subcategories based on the weight behavior of codas in *the stress system*: (1) codas contribute to weight ( $C_\mu$ ) and (2) codas do not contribute to weight ( $C$ ). The **rows**, on the other hand, sort all languages in the survey into the same two subcategories based on the weight behavior of codas for *all other weight-sensitive processes* (e.g., tone, compensatory lengthening, etc.). If codas contribute to weight for at least one weight-sensitive process other than stress, codas are treated as contributors to weight in that language and sorted into the appropriate row accordingly.

(11) 2x2 contingency table demonstrating cross-linguistic coda moraicity

Other Processes	Stress		
	$C_\mu$	$C$	Total
	$C_\mu$	$C$	Total
$C_\mu$	36	32*	68
$C$	34	5	39
Total	70	37	107

\*Gordon provides evidence of coda weight from other processes for 27 languages in this cell. I found evidence for an additional 5 languages in the survey.

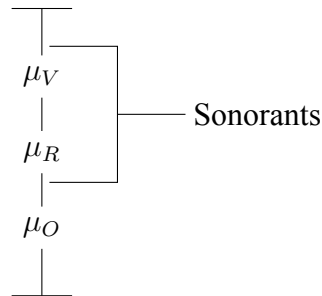
As is evident from the top left cell, 36 languages in the survey treat codas as weight-bearing both for the stress system and for at least one other weight-sensitive process. An additional 34 languages treat codas as contributors to weight for the stress system but not for any other process considered in the survey. In total, then, 70 languages (65%) are shown by Gordon to exhibit coda moraicity in their stress system. For the remaining 37 languages in the survey in which CVC is light for stress (column  $C$ ), Gordon provides evidence that 27 definitively contain at least one other weight-sensitive process requiring moraic codas. In total, then, Gordon indicates that 97 of the 107 relevant languages (91%) in his survey display coda moraicity for at least some phonological process examined in the survey. Of the ten languages that Gordon (2006) does not indicate contain another process validating the moraicity of codas, I have found evidence in five of those languages suggesting the presence of moraic codas (See the appendix for examples). This means that at least 102 of 107 relevant languages (95%) in Gordon's survey display at least one weight-sensitive process that treats codas as weight-bearing. This is evidenced in (11) by the fact that 102 languages (36+34+32) are categorized into a cell that requires coda moraicity for at least one phonological process. The remaining five languages in which no evidence has been supplied to demonstrate coda moraicity either do not have adequate and accessible phonological descriptions or require further exploration.<sup>5</sup> Further scrutiny could lead to either the discovery of different processes that indicate coda moraicity in these languages or the finding that they represent languages in which codas are treated as light for all weight-based processes despite their moraicity. In any case, either finding is consistent with the present proposal. I leave it to future research to settle this matter. The upshot of this discussion is that coda consonants overwhelmingly exhibit moraicity cross-linguistically, so our theory of weight should reflect this fact in its foundational assumptions.

<sup>5</sup>These languages include Comanche (Charney, 1993; Robinson, 1990), Mojave (Langdon, 1977; Munro, 1976; Munro et al., 1992), Nganasan (Wagner-Nagy, 2019), Winnebago (Gordon, 2006; Hale, 1985; Hale and White Eagle, 1980; Morrison, 1994), and Ojibwa (Piggot and Grafstein, 1983)

### 3.3 The Moraic Sonority Metric

An immediate question arises from the proposed UMQ theory in (10), which obligates coda consonants to link to their own mora. That is, if the variant behavior of CVC is not connected to a widespread diversity in its moraic structure, then what provokes its hierarchical instability across different processes and languages? I take it that the rampant variation in CVC's weight status stems from a **Moraic Sonority Metric** that determines syllable weight based on the number of moras *of a specified sonority* in a syllable rather than the sum total of moras in a syllable. Whereas the standard "Moraic Quantity" metric evaluates syllable weight by comparing mora count without regard to the sonority values of those moras, the Moraic Sonority Metric assumes moras are inherently encoded with the sonority of the segment that they dominate and uses this information in its weight computations in conjunction with moraic quantity. Crucially, the Moraic Sonority Metric is restricted in the distinctions it can make by the moraic sonority hierarchy in (12), which contains three sonority levels. Vocalic moras ( $\mu_V$ ) are the most sonorant mora type and are positioned at the top of the hierarchy. Sonorant consonant moras ( $\mu_R$ ) make up the middle tier on the hierarchy. While  $\mu_R$  are less sonorant and lighter than  $\mu_V$ , they are more sonorant and heavier than obstruent consonant moras ( $\mu_O$ ), which reside at the bottom of the sonority hierarchy and are lighter than both  $\mu_V$  and  $\mu_R$ .

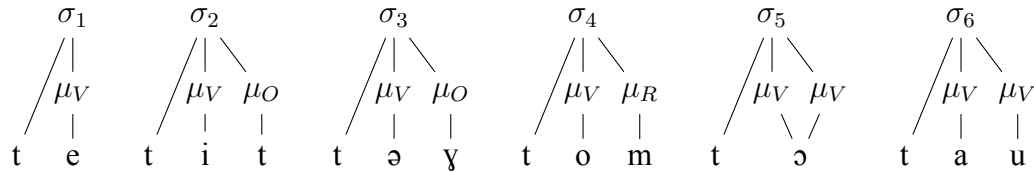
(12) The Moraic Sonority Hierarchy (cf. Zec, 2007)



A weight-sensitive process constructs its criterion with the aid of the Moraic Sonority Hierarchy by choosing a point on the hierarchy and making a bifurcation. Every mora type above the bifurcation is used in weight computations by that process, and every mora type below the bifurcation is excluded from weight computations by that process. Some processes make a bifurcation below all sonority levels, thus including every mora type in their syllable weight measurements. The result is a criterion that treats all bimoraic syllables in the hypothetical examples in (13) as heavy regardless of the sonority values and all monomoraic syllables as light. If, however, a process makes a bifurcation between  $\mu_R$  and  $\mu_O$  on the Moraic Sonority Hierarchy, only syllables with at least two sonorant moras (either  $\mu_V$  or  $\mu_R$ ) will be treated as heavy because non-sonorant moras ( $\mu_O$ ) fall below the bifurcation and are ignored in the weight computations. Consequently, [tɔ:] and [tau] in (13) would be treated as heavy because they contain two vocalic moras, and [tom] would also be heavy because it contains one vocalic mora and one sonorant consonant mora, adding up to two sonorant moras. Even though [tit] and [təɣ] are bimoraic, they each contain only a single sonorant mora and would therefore be treated as light alongside CV for a weight-sensitive process that makes a bifurcation between  $\mu_R$  and  $\mu_O$ . If a process establishes its bifurcation point between  $\mu_V$  and  $\mu_R$  on the scale, only vocalic moras will be included in weight computations. The result is that only syllables with two vocalic moras (tɔ: and tau in (13)) will be treated as heavy, and all

others will be treated as light. Finally, if a weight-sensitive process makes a bifurcation above all sonority levels on the hierarchy, the result is a quantity-insensitive process. In other words, because all mora types are ignored in weight computations when a bifurcation is positioned above every sonority level, all syllables will be treated equivalently.

(13) Moraic structure explicitly annotated with sonority



Based on the dual assumptions that the UMQ universally compels every coda consonant to link to its own mora and that all moras are inherently encoded with the sonority of their associated segments, the moraic structure of the hypothetical syllables in (13) includes subscripted sonority values for each mora. Several clarifications are in order when considering the proposed addition of moraic sonority to moraic structure. First, it is important to emphasize that the only permissible distinctions between moras consist of distinctions between the three levels of the Moraic Sonority Hierarchy. In other words, all obstruent consonants are dominated by identical moras, all sonorant consonants are dominated by identical moras, and all vowels are dominated by identical moras. This constraint on possible distinctions is undergirded by the fact that the cross-linguistic inventory of syllable weight criteria lacks more minute distinctions beyond these three sonority values. For example, the codas in  $\sigma_2$  and  $\sigma_3$  in (13) both bear an obstruent mora and are thereby identical in terms of their weight contributions. That  $[t]$  and  $[\gamma]$  differ in voicing, manner, and place of articulation is irrelevant; both codas are obstruents and thus associate with indistinguishable obstruent moras.

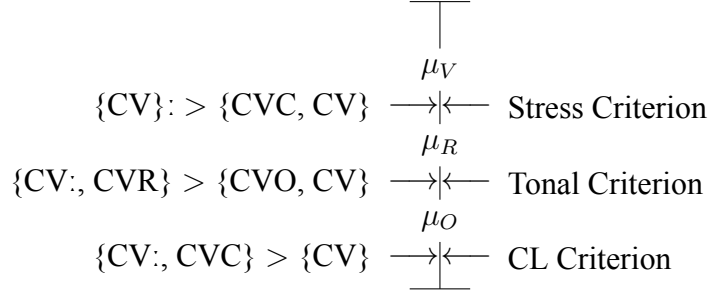
Similarly, moras are not encoded with vowel quality features either, resulting in all vowels bearing an identical vocalic mora regardless of height or peripherality. Though several purported cases of syllable weight divisions based on vowel quality exist (de Lacy, 2002, 2004, 2006; Gordon, 2006; Kenstowicz, 1997; a.o.), more recent research provides compelling evidence disavowing the idea that vowel quality can play a role in stress attraction (Bowers, 2019; Rasin, 2019; Shih, 2019a, 2019b; Shih and de Lacy, 2019). In sum, the Moraic Sonority Metric's inability to make weight distinctions over and above the three sonority levels of the Moraic Sonority Hierarchy in (12) implies that a syllable weight criterion using alternative methods of discrimination besides distinctions between vocalic, sonorant, and obstruent moras does not exist. This assertion seems to enjoy significant empirical backing. Ideally, subsequent investigations would uncover why distinctions in moraic sonority are restricted in this way.

At this point, one may challenge the notion that moras are encoded with the sonority of their associated segments. Nevertheless, this proposal finds implicit support in a large body of previous work (e.g., Steriade, 1991; Blumenfeld, 2011; Davis, 2017; Hyman and Leben, 2020; a.o.). For instance, Blumenfeld (2011, p.225) appeals to moraic sonority distinctions to explain apparent mismatches between minimal feet and minimal words in Chickasaw. Similarly, Hyman and Leben (2020, p.49) call upon vocalic moras to define the behavior of contour tones in some languages. Interestingly, all accounts that implicitly reference moraic sonority also maintain the Variable Weight

approach to syllable weight distinctions, indicating that current moraic theory tacitly requires the ability to reference moraic sonority even though the notion is not formalized. The current proposal formalizes these tacit assumptions and expands the utility of moraic sonority to account for syllable weight distinctions, a task that hitherto has been accomplished by referencing the variable status of coda moraicity. The effect of the Moraic Sonority Metric, then, is the simplification of our theory of moraic structure by eliminating the need to make language-specific parameters on coda moraicity, all without needing to add theoretical machinery to the grammar.

In addition, since syllable moraicity remains uniform per the UMQ, the Moraic Sonority Metric allows for syllable weight scales to be constructed in a process-specific manner, capturing the fact that different processes within a single language often make bifurcations at different points on the Moraic Sonority Hierarchy, resulting in different weight criteria between processes within a single language. This is the case for the three weight-sensitive processes of Lhasa Tibetan discussed in section 2.2: the compensatory lengthening criterion makes a bifurcation below  $\mu_O$  on the hierarchy, thereby including every mora type in its weight computations. The tonal criterion in Tibetan, however, measures syllable weight based on a subset of the available mora types, using only sonorant moras in weight computations by placing the bifurcation point between  $\mu_R$  and  $\mu_O$ . Finally, the stress criterion uses only vocalic moras in its weight computations by placing the bifurcation point between  $\mu_V$  and  $\mu_R$ . In sum, all three Tibetan weight-sensitive processes treat codas differently in terms of weight, as shown in (14). The Moraic Sonority Metric allows for this process-specific variation, whereas the Variable Weight approach does not.

(14) The Moraic Sonority Hierarchy and Tibetan weight processes



### 3.4 Summary

This section introduced a solution that captures the typology of weight-sensitive criteria across phonological processes without relying on variance in moraic structure. Section 3.1 argued that the UMQ — which universally requires every coda consonant to link to its own mora — better adheres to the cross-linguistic empirical evidence of coda behavior in terms of weight. Section 3.2 confirmed that codas tend to behave as weight-bearing cross-linguistically, even in languages where CVC is light for stress. While the survey contradicts predictions by the Variable Weight approach, which asserts that codas are non-moraic when CVC patterns with CV for stress, the results buttress the claims of the UMQ. The Moraic Sonority Metric was proposed in section 3.3 as an alternative method to account for cross-linguistic diversity in weight criteria. By consolidating prominence and quantity metrics into a single mechanism, the Moraic Sonority Metric couples the simplification of syllable weight measurement with uniformity of moraic structure while simultaneously making more accurate predictions about coda moraicity across weight-sensitive processes.

## 4 Moraic Sonority and weight-sensitive stress

The previous section introduced a proposal to account for typological variation in syllable weight criteria across a divergent set of weight-sensitive processes. The remainder of the paper narrows in scope, proposing a formalization of the Moraic Sonority Metric within Optimality Theory (Prince and Smolensky, 1993/2004) to account for the full typology of attested weight-sensitive *stress* criteria specifically. While the claim made here is that the Moraic Sonority Metric serves as a sufficient tool to explain the typology of attested patterns for all weight-sensitive phenomena, the space required to develop proposals for the formal outworkings of the metric for each of the relevant processes exceeds the space available in a treatise of this length. As such, a formalization of the Moraic Sonority Metric as it relates to stress criteria will be the only process covered in detail here. Nevertheless, I briefly return to the issue of formalizations for different processes in section 5, where I explore possible formalizations for weight-sensitive tone and word minimality.

The remainder of this section proceeds as follows. Section 4.1 illustrates how the Moraic Sonority Metric can be translated into Stress-to-Weight Principle (SWP) constraints that penalize stressed light syllables and correspond to bifurcations at different points on the Moraic Sonority Hierarchy. While the standard SWP constraint includes moras of all sonorities in its weight calculations (4.1.1), this constraint can be adapted in such a way that makes it sensitive only to sonorant moras (4.1.2) or only to vocalic moras (4.1.3) respectively. Additionally, when more than one of these constraints is active in a language, the result is a complex stress criterion with more than two levels of weight (4.1.4). In section 4.2, I consider the factorial typology of the proposed Moraic Sonority constraints, discussing predicted languages and gaps in the typology. Section 4.3 provides a summary.

### 4.1 Moraic Sonority and the SWP

#### 4.1.1 When all moras contribute to weight

Several schemas have been proposed in the literature to explain the preference for stress to avoid monomoraic syllables in weight-sensitive languages; one of the most seminal methods is Stress-to-Weight (SWP) (Hammond, 1986; Hayes, 1980; McCarthy, 2003; Ryan, 2019), which penalizes stressed light syllables. The aim at this point in the article is to examine how the adoption of the Moraic Sonority Metric would translate into individual SWP constraints that correspond to different bifurcations on the Moraic Sonority Hierarchy and are therefore sensitive to moraic sonority in their weight calculations for stress. To accomplish this, I utilize the version of SWP presented in Ryan (2019) and depicted in (15). As Ryan points out, the notion of *weight* is a rather vague term, but Ryan’s formulation of SWP in (15) makes explicit the fact that weight refers to bimoraic (or heavier) syllables in this constraint. In addition, as will become apparent in subsequent sections, this explicit representation of weight in the constraint formulation also allows for a relatively straightforward adaptation of the constraint to include references to moraic sonority.

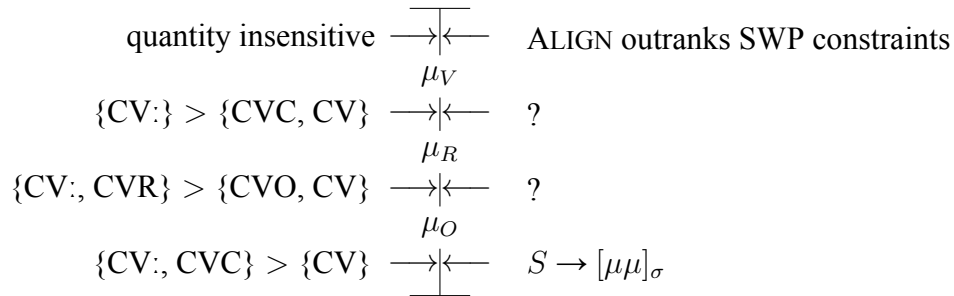
$$(15) \quad S \rightarrow [\mu\mu]_\sigma$$

Assign a violation for every stressed syllable with less than two moras.

As discussed in section 3.3, weight-sensitive processes construct their weight criteria differently depending on the bifurcation point made on the Moraic Sonority Hierarchy. If a weight-

sensitive process makes a bifurcation below all levels of the hierarchy, it allows all mora types to contribute to weight. If, however, a bifurcation is made at any point above the lowest mora type, every mora type below the bifurcation will be ignored in the weight computations. Functionally, then, the standard SWP constraint in (15), which relies on sum total differences in mora count to determine stress placement, operates as if the bifurcation is made below all three mora types. In other words,  $S \rightarrow [\mu\mu]_\sigma$  correlates with a bifurcation on the Moraic Sonority Hierarchy below  $\mu_O$ , as depicted in (16).

(16) The Moraic Sonority Hierarchy and  $S \rightarrow [\mu\mu]_\sigma$



As mentioned in the introduction, Yana’s stress system constitutes one example of a language that treats all bimoraic syllables, regardless of moraic sonority, as heavy and all monomoraic syllables as light. Thus, the bifurcation Yana’s stress system makes on the Moraic Sonority Hierarchy falls below  $\mu_O$ , which means that  $S \rightarrow [\mu\mu]_\sigma$  is active in the language. The following OT analysis of Yana stress demonstrates this point. Primary stress in Yana falls on the leftmost syllable in a word by default, as illustrated by the data in (17i). When one or more heavy syllables are present in a word, stress shifts to the leftmost heavy syllable, as in (17ii). Importantly, (17iii) indicates that both CV: and CVC are treated equivalently by the stress system, such that when both syllable types occur in a word together, stress falls on the leftmost instance indiscriminately.

(17) Primary stress in Yana (data from Hyde, 2006)

i. Default stress on the leftmost syllable

'me.c'i    “coyote”

'i.ri.k'i    “ear ornaments”

ii. Stress on the leftmost heavy syllable

ha.'la:.la.ʔi    “barberry”

ni.'gid.sa.sin.ʒa    “I go to another house”

iii. CVC and CV: are equal in weight

ni.'sa:.tin.ʒa    “it is said I went away”

ha.c'a.'ʒid.p'a:    “Angelica Tomentosa”


The alignment constraint in (18i) explains the preference of stress to fall as close to the left edge of the word as possible, as shown by the tableau in (18ii). ALIGN–L pushes stress to the leftmost edge of the prosodic word when syllable weight is neutral.

(18) Default stress in Yana

i. ALIGN–L

Assign a violation for every syllable that intervenes between the left edge of a prosodic word and the head syllable.


ii. Default stress is word-initial

	irik'i	ALIGN–L
a.	 'I.ri.k'i	
b.	I.'ri.k'i	*!
c.	I.ri.'k'i	*!*


In (19), the presence of a heavy syllable – CV: or CVC – successfully attracts stress away from the left edge. In both (19i) and (19ii), candidate (b) fully satisfies ALIGN–L by positioning primary stress at the left edge of the prosodic word. However, in so doing, both candidates stress a monomoraic syllable, violating the higher-ranked  $S \rightarrow [\mu\mu]_\sigma$  from (15) in the process. The optimal candidates in both tableaux violate ALIGN–L by shifting stress to the right but satisfy the higher-ranked  $S \rightarrow [\mu\mu]_\sigma$  by stressing a bimoraic syllable, thus emerging victorious. Crucially in Yana, then, a syllable weight constraint like  $S \rightarrow [\mu\mu]_\sigma$  must outrank stress alignment constraints.

(19) {CV:, CVC} > {CV} in Yana

i. {CV:} > {CV}


	hala:laʔi	$S \rightarrow [\mu\mu]_\sigma$	ALIGN–L
a.	 ha.'la:.la.ʔi		*
b.	'ha.la:.la.ʔi	*!	

ii. {CVC} > {CV}

	nigidsasinga	$S \rightarrow [\mu\mu]_\sigma$	ALIGN–L
a.	 ni.'gid.sa.sin.ʒa		*
b.	'ni.gid.sa.sin.ʒa	*!	

The tableau in (20) shows that  $S \rightarrow [\mu\mu]_\sigma$  cannot distinguish between bimoraic CV: and bimoraic CVC. Candidate (c) is ruled out in a similar fashion as seen above because it favors alignment over syllable weight. Both (a) and (b) satisfy  $S \rightarrow [\mu\mu]_\sigma$  because primary stress falls on a bimoraic syllable in both candidates. Thus, the decision falls to ALIGN–L and (a) emerges as optimal; only two syllables intervene between stress and the left edge of the prosodic word for (a), whereas three syllables intervene between stress and the left edge of the prosodic word for candidate (b).

(20) {CV:} = {CVC} in Yana

	ha.c'a.'ʒid.p'a:	$S \rightarrow [\mu\mu]_\sigma$	ALIGN–L
a.	 ha.c'a.'ʒid.p'a:		**
b.	ha.c'a.ʒid.'p'a:		***!
c.	'ha.c'a.ʒid.p'a:	*!	

The Moraic Sonority analysis of weight-sensitive stress in languages like Yana that treat all mora types equally does not yield different results from the standard Variable Weight approach on the surface. Rather, the distinction between the two analyses is underlying. The Variable Weight approach claims that WxP is highly ranked in these types of languages, rendering CVC and CV: equal in weight. The Moraic Sonority approach, in contrast, relies on the UMQ to preclude GEN from generating candidates containing monomoraic CVCs, resulting in universally bimoraic CVC syllables. According to the Moraic Sonority approach, the reason for the equivalence of weight between CVC and CV: in Yana’s stress system hinges on the bifurcation point falling below all mora types, which results in all moras contributing to weight for the stress system. Both approaches arrive at the same result; CVC and CV: are equivalent in weight in the output for Yana’s stress system.

#### 4.1.2 When only sonorant moras contribute to weight

The differences between the Variable Weight approach and the Moraic Sonority approach rise to the forefront in languages in which CVC does not uniformly pattern with CV: for stress. Here, the Variable Weight approach buries WxP into a low-ranked position, thereby generating monomoraic CVCs. In this way, the theory maintains the assertion that coda moraicity is a language-specific stipulation based on the behavior of CVC in the language’s stress system. Since we have already seen how such an analysis is undermined by within-language CVC weight mismatches across phonological processes, we will not entertain the Variable Weight analysis moving forward.

As demonstrated by the Optimality Theoretic analysis of Yana in section 4.1.1, the standard SWP constraint,  $S \rightarrow [\mu\mu]_\sigma$ , is sufficient to capture stress criteria that make a bifurcation at the lowest point on the Moraic Sonority Hierarchy. The reason for this is that  $S \rightarrow [\mu\mu]_\sigma$  does not consider sonority in its computations. As such, this constraint always utilizes the sum total of moras in a syllable to compute weight, which is equivalent to making a bifurcation below all of the sonority levels under the Moraic Sonority Metric outlined in section 3. Thus, in its current form, the SWP framework cannot pair with the Moraic Sonority Metric to account for stress criteria that either treat only syllables with two vocalic moras as heavy ( $\{CV:\} > \{CVC, CV\}$ ) or only syllables with two sonorant moras as heavy ( $\{CV:, CVR\} > \{CVO, CV\}$ ) because  $S \rightarrow [\mu\mu]_\sigma$  only makes distinctions using one of the four possible bifurcations on the Moraic Sonority Hierarchy. If, however, SWP expands to accord with the assertions of the Moraic Sonority Metric, we can model bifurcations at every point on the hierarchy. Specifically, by including moraic sonority values in the formalization of SWP constraints, we can specify which mora types contribute to weight and which do not.

A weight-sensitive stress criterion that utilizes a bifurcation between the  $\mu_R$  and  $\mu_O$  levels of the Moraic Sonority Hierarchy ignores obstruent moras in its weight computations because  $\mu_O$  falls below the bifurcation point. Consequently, CVO syllables are light in such a criterion despite their bimoraicity. To account for the overlooking of obstruent moras within the SWP framework, the constraint must include the sonority value of the moras that are used in weight computations, as demonstrated in (21). Whereas the moras in  $S \rightarrow [\mu\mu]_\sigma$  are unspecified in moraic sonority (resulting in all mora types contributing to weight), the moras in  $S \rightarrow [\mu_R\mu_R]_\sigma$  are specified with a subscripted R, indicating that only sonorant moras ( $\mu_V$  or  $\mu_R$ ) are included in syllable weight analyses. As a result,  $S \rightarrow [\mu_R\mu_R]_\sigma$  penalizes stress that falls on a syllable with less than two

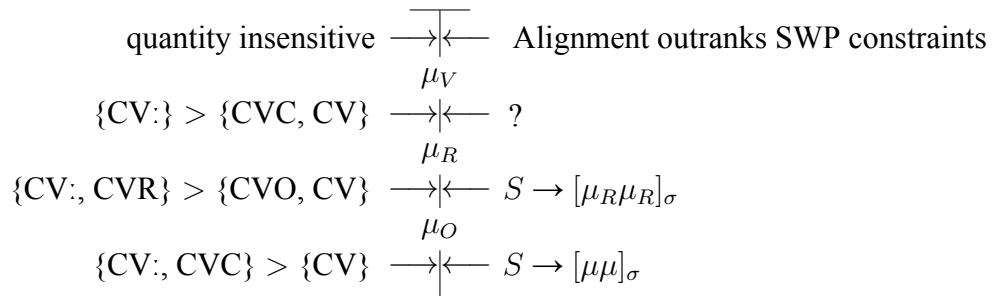


sonorant moras rather than a monomoraic syllable in general. Thus, the violation profile of  $S \rightarrow [\mu_R \mu_R]_\sigma$  expands to include stressed CVO syllables; because CVO only contains a single sonorant mora,  $S \rightarrow [\mu_R \mu_R]_\sigma$  is violated when CVO is stressed, despite its bimoraicity. Crucially, this allows the stress system to ignore mora types that do not meet the minimum sonority threshold in weight calculations.

- (21)  $S \rightarrow [\mu_R \mu_R]_\sigma$   
Assign a violation for every stressed syllable with less than two sonorant moras.

When  $S \rightarrow [\mu_R \mu_R]_\sigma$  outranks the alignment constraints associated with primary stress placement, the stress criterion that emerges treats all syllables with at least two sonorant moras as heavy and all syllables with less than two sonorant moras as light ( $\{CV:, CVR\} > \{CVO, CV\}$ ), which means that  $S \rightarrow [\mu_R \mu_R]_\sigma$  correlates with a bifurcation point between  $\mu_R$  and  $\mu_O$  on the Moraic Sonority Hierarchy, as depicted in (22).

- (22)  $S \rightarrow [\mu_R \mu_R]_\sigma$  and the Moraic Sonority Hierarchy



Kwakw'ala, a Wakashan language spoken in Western Canada, possesses a stress criterion corresponding to a bifurcation between the  $\mu_R$  and  $\mu_O$  levels of the Moraic Sonority Hierarchy and thus provides an appropriate example to demonstrate the efficacy of  $S \rightarrow [\mu_R \mu_R]_\sigma$  in distinguishing syllables with two sonorant moras from syllables with less than two sonorant moras. When no heavy syllable (one with at least two sonorant moras) is present in Kwakw'ala, stress falls on the rightmost syllable, indicating the need for the constraint, ALIGN–R, which requires primary stress to occur at the right edge of the word, as in (23i-ii). When a heavy syllable is present, however, stress shifts from the right edge to fall on it, as in (23iii-iv).<sup>6</sup>


- (23) Primary stress in Kwakw'ala (Bach, 1975, pp.9-10)

- |      |              |                              |
|------|--------------|------------------------------|
| i.   | gə.gə.'ləm   | “ermine”                     |
| ii.  | cat.'xa      | “to squirt”                  |
| iii. | 'dəl.xa      | “damp”                       |
| iv.  | c'ə.'ma:.tud | “melt away something in ear” |

As shown by the tableau in (24),  $S \rightarrow [\mu \mu]_\sigma$  must rank below ALIGN–R in Kwakw'ala so that a bimoraic CVO syllable is unable to draw stress from the default position. Both candidates in the tableau violate  $S \rightarrow [\mu_R \mu_R]_\sigma$  because stress cannot avoid a syllable with less than two sonorant moras no matter which syllable it falls on in *catxa*. Thus, the decision falls to alignment, and candidate (a), which aligns primary stress on the rightmost syllable in the word, emerges as optimal.

<sup>6</sup>Primary stress in Kwakw'ala exhibits a “default to opposite side” pattern in which primary stress falls on the rightmost syllable when no CV: or CVR is present in a word but on the leftmost CV:/CVR when one or more heavies are present. For simplicity, I leave out examples with more than a single heavy syllable.


(24) CVO light in Kwakw'ala

catxa	$S \rightarrow [\mu_R \mu_R]_\sigma$	ALIGN-R	$S \rightarrow [\mu \mu]_\sigma$
a.  cat.'xa	*		*
b. 'cat.xa	*	*!	

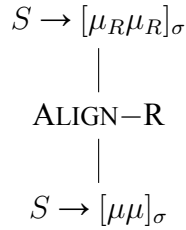
However, when a non-final syllable with two sonorant moras is present in Kwakw'ala, stress shifts from the right edge because  $S \rightarrow [\mu_R \mu_R]_\sigma$  outranks ALIGN-R. As the tableau in (25i) reveals, candidate (b), which aligns stress at the right edge of the word to satisfy alignment, does so at the expense of violating the higher ranked  $S \rightarrow [\mu_R \mu_R]_\sigma$  and is eliminated. Candidate (a), conversely, relocates stress to the non-final CVR syllable and satisfies  $S \rightarrow [\mu_R \mu_R]_\sigma$  because stress falls on a syllable with at least two sonorant moras: *dəl*. Crucially, as demonstrated by the above tableau in (24),  $S \rightarrow [\mu \mu]_\sigma$  is outranked by ALIGN-R in Kwakw'ala and, therefore, cannot be responsible for the movement of stress from its default word-final position in (25i).

(25) CVR heavy in Kwakw'ala

i. CVR > CV in Kwakw'ala

dəlxa	$S \rightarrow [\mu_R \mu_R]_\sigma$	ALIGN-R	$S \rightarrow [\mu \mu]_\sigma$
a.  'dəl.xa		*	
b. dəl.'xa	*!		*

ii. Final Hasse Diagram of Kwakw'ala Stress



To sum up, Kwakw'ala's stress criterion utilizes a bifurcation in the Moraic Sonority Hierarchy between  $\mu_R$  and  $\mu_O$ . The corresponding Moraic Sonority constraint,  $S \rightarrow [\mu_R \mu_R]_\sigma$ , captures the insensitivity of the criterion to the presence of obstruent moras by penalizing stress that falls on syllables with less than two sonorant moras. Consequently, only CV: and CVR satisfy  $S \rightarrow [\mu_R \mu_R]_\sigma$  when stressed, giving rise to the desired syllable weight division in Kwakw'ala's stress criterion.

### 4.1.3 When only vocalic moras contribute to weight

Whereas Kwakw'ala's stress system relies on a bifurcation between  $\mu_R$  and  $\mu_O$ , other languages display stress systems that make a bifurcation between  $\mu_V$  and  $\mu_R$ , resulting in vocalic moras shouldering the full burden of determining syllable weight. The Moraic Sonority constraint,  $S \rightarrow [\mu_V \mu_V]_\sigma$ , in (26i) corresponds to a bifurcation at this level, as shown in (26ii). By requiring stress to avoid syllables with less than two vocalic moras, only syllables with a long vowel or diphthong can satisfy the constraint, resulting in a criterion in which syllables with two vocalic moras are heavy and all others are light for stress when  $S \rightarrow [\mu_V \mu_V]_\sigma$  is high ranked.

(26) Sensitivity to vocalic moras

- i.  $S \rightarrow [\mu_V \mu_V]_\sigma$   
Assign a violation for every stressed syllable with less than two vocalic moras.
- ii.  $S \rightarrow [\mu_V \mu_V]_\sigma$  and the Moraic Sonority Hierarchy

$$\begin{array}{c}
 \text{quantity insensitive} \quad \overline{\rightarrow} \left| \begin{array}{c} \leftarrow \\ \mu_V \end{array} \right| \leftarrow \quad \text{Alignment outranks SWP constraints} \\
 \{CV:\} > \{CVC, CV\} \quad \overline{\rightarrow} \left| \begin{array}{c} \leftarrow \\ \mu_V \end{array} \right| \leftarrow \quad S \rightarrow [\mu_V \mu_V]_\sigma \\
 \{CV:, CVR\} > \{CVO, CV\} \quad \overline{\rightarrow} \left| \begin{array}{c} \leftarrow \\ \mu_R \end{array} \right| \leftarrow \quad S \rightarrow [\mu_R \mu_R]_\sigma \\
 \{CV:, CVC\} > \{CV\} \quad \overline{\rightarrow} \left| \begin{array}{c} \leftarrow \\ \mu_O \end{array} \right| \leftarrow \quad S \rightarrow [\mu\mu]_\sigma
 \end{array}$$


Many languages display the stress criterion engendered by  $S \rightarrow [\mu_V \mu_V]_\sigma$ , one of which is Lhasa Tibetan discussed in section 2.2. As previously described, primary stress in Tibetan falls on the initial syllable by default, but the presence of a syllable with a long vowel draws stress away from the default position. Examples elucidating the primary stress criterion in Tibetan from (4) are resupplied in (27):

(27) Lhasa Tibetan Primary Stress Pattern

- 'wo.ma    “milk”  
 'lap.ta    “school”  
 am.'tɔ:    “person from Amdo”  
 lap.'tɛ:    “of the school”  
 'qe:.la:    “teacher”

As demonstrated by the word for “school” in (28), ALIGN–L pulls primary stress to the left edge of the word by penalizing candidates for each syllable that intervenes between the head syllable and the left edge of the prosodic word.

(28) Default primary stress position in Tibetan

lapta	ALIGN–L
a.  'lap.ta	
b. lap.'ta	*!

In (29), however, stress is drawn from the word-initial CVO syllable to fall on CV:.  $S \rightarrow [\mu\mu]_\sigma$  cannot be held responsible for this shift in stress since both CVO and CV: are bimoraic in Tibetan and thereby equally satisfy  $S \rightarrow [\mu\mu]_\sigma$  when stressed. This means that  $S \rightarrow [\mu_V \mu_V]_\sigma$  must rank above ALIGN–L. Candidate (b) satisfies alignment by stressing the word-initial syllable but violates higher ranked  $S \rightarrow [\mu_V \mu_V]_\sigma$  in the process. Candidate (a), on the other hand, violates alignment in order to satisfy  $S \rightarrow [\mu_V \mu_V]_\sigma$  by placing stress on the word-final *tɛ:* and emerges as the winner.

(29) CV: heavy in Tibetan

lapte:	$S \rightarrow [\mu_V \mu_V]_\sigma$	ALIGN-L	$S \rightarrow [\mu \mu]_\sigma$
a. ལའཔ་ཅེ་ lap. 'te:		*	
b. 'lap. te:	*!		

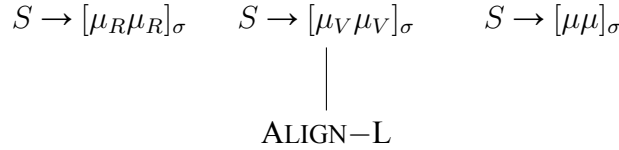
Importantly, while it is possible that  $S \rightarrow [\mu_R \mu_R]_\sigma$  generates the movement of stress to the non-initial CV: in (29), evidence from the tableau in (30i) suggests that this is not the case in Tibetan. Neither  $S \rightarrow [\mu \mu]_\sigma$  nor  $S \rightarrow [\mu_R \mu_R]_\sigma$  make distinctions between the two candidates in (30i) because both syllables are bimoraic with at least two sonorant moras, which indicates that  $S \rightarrow [\mu_V \mu_V]_\sigma$  must be responsible. Candidate (b) maintains stress on the default initial syllable, satisfying ALIGN-L,  $S \rightarrow [\mu \mu]_\sigma$ , and  $S \rightarrow [\mu_R \mu_R]_\sigma$ , but fatally violating  $S \rightarrow [\mu_V \mu_V]_\sigma$ . Conversely, Candidate (a), which violates ALIGN-L by shifting stress to CV:, satisfies  $S \rightarrow [\mu_V \mu_V]_\sigma$  in so doing and materializes as the optimal surface form. A Hasse Diagram depicting the rankings of the stress constraints in Tibetan is provided in (30ii).

(30) CVR light in Tibetan stress

i. CV: > CVR

amɕɔ:	$S \rightarrow [\mu_V \mu_V]_\sigma$	ALIGN-L	$S \rightarrow [\mu_R \mu_R]_\sigma$	$S \rightarrow [\mu \mu]_\sigma$
a. ཨམ་ཅོ་ am. 'ɕɔ:		*		
b. 'am. ɕɔ:	*!			

ii. Final Hasse Diagram of Tibetan Stress



In short, neither  $S \rightarrow [\mu \mu]_\sigma$  nor  $S \rightarrow [\mu_R \mu_R]_\sigma$  account for the primary stress placement pattern in Tibetan, but  $S \rightarrow [\mu_V \mu_V]_\sigma$  does, indicating that the primary stress system relies on a bifurcation point between  $\mu_V$  and  $\mu_R$  that only considers vocalic moras in its computations. All non-vocalic moras, while present and called upon by other weight-sensitive processes in the language to help make syllable weight distinctions (recall the discussion in section 2.2), are irrelevant for the determination of stress.

As demonstrated by the effects of both  $S \rightarrow [\mu_R \mu_R]_\sigma$  and  $S \rightarrow [\mu_V \mu_V]_\sigma$  in Kwakw'ala and Tibetan respectively, the proposed Moraic Sonority constraints successfully capture bifurcations at every point on the Moraic Sonority hierarchy.  $S \rightarrow [\mu \mu]_\sigma$  accounts for stress systems like Yana using the lowest bifurcation point to measure weight.  $S \rightarrow [\mu_R \mu_R]_\sigma$  accounts for Kwakw'ala-like stress systems by only including sonorant moras to measure syllable weight. And  $S \rightarrow [\mu_V \mu_V]_\sigma$  accounts for stress systems similar to Tibetan's, which only treat syllables with two vocalic moras as heavy, ignoring the other two mora types in weight measurements.

#### 4.1.4 When languages utilize complex (suprabinary) stress criteria

Interestingly, a significant number of languages utilize multiple bifurcations on the Moraic Sonority Hierarchy, resulting in complex stress criteria. Mankiyali, an understudied language of Northern Pakistan, is one such language (Paramore, 2021). Data demonstrating the primary stress pattern of Mankiyali is provided in (31). Paramore (2021, pp.43-44) states that primary stress falls on the penultimate syllable by default when syllable weight is neutral, as illustrated by the data in (31i). If, however, a bimoraic syllable (CV:, CVR, or CVO) occurs in the word, it draws stress from a penultimate CV, as shown in (31ii). Additionally, the data in (31iii) demonstrates the superior weight status of CV: over both CVC and CV syllables in Mankiyali. Regardless of its position in a word, when a CV: is present, it attracts primary stress from default CVC and CV syllables. When multiple syllables of the same weight tie for the heaviest syllable, the rightmost nonfinal instance receives primary stress.

(31) Primary Stress in Mankiyali

- i. Default penultimate stress
  - ka.ma.'ka.la “stupid”
  - dʒan.'dar.yoz “locks”
  - 'ka:.rɪ: “millet”
- ii. {CV:, CVR, CVO} > {CV}
  - 'lak<sup>h</sup>.sa.ri “many”
  - ma.'č<sup>h</sup>ɪr “mosquito”
  - 'zaŋ.ga.la “forests”
  - 'ka:.ɣa.za “papers”
- iii. {CV:} > {CVR, CVO, CV}
  - kam.zo.'rɪ: “weakness”
  - muk.'le: “open” (imp)

In sum, the Mankiyali data in (31) signifies the ternary stress criterion in (32) for the language, which results from two bifurcation points on the Moraic Sonority Hierarchy. A bifurcation between  $\mu_V$  and  $\mu_R$  distinguishes syllables with long vowels from syllables with short vowels, and a bifurcation between  $\mu_R$  and  $\mu_O$  distinguishes bimoraic syllables from monomoraic syllables:

(32) Mankiyali Stress Criterion (Paramore, 2021)  
 {CV:} > {CVR, CVO} > {CV}

The following OT analysis demonstrates the Moraic Sonority Metric’s ability to capture the complex pattern found in languages that pattern like Mankiyali. Default penultimate stress indicates that the rightward alignment constraint, ALIGN–R, must be outranked by NONFINALITY, which penalizes stress on the final syllable of a prosodic word. Because of this ranking, when syllable weight is neutral in a word, ALIGN–R draws stress as far right in the word as possible without falling on the final syllable in order to satisfy NONFINALITY while incurring the minimal number of ALIGN–R violations, as in (33).

(33) Default stress in Mankiyali

	kamakala	NONFINALITY	ALIGN–R
a.	☞ ka.ma.'ka.la		*
b.	ka.ma.ka.'la	*!	

As established by the data in (31), however, both CVC and CV: attract stress from CV, which means that  $S \rightarrow [\mu\mu]_\sigma$  is active in the language. Importantly,  $S \rightarrow [\mu\mu]_\sigma$  must outrank NONFINALITY in (34) in order to draw stress to the word-final syllable. Candidate (a) violates NONFINALITY by stressing the word-final syllable, but satisfies the higher-ranked  $S \rightarrow [\mu\mu]_\sigma$  in the process, thereby surfacing as optimal.

(34) CVC heavy in Mankiyali

	mač <sup>h</sup> ir	$S \rightarrow [\mu\mu]_\sigma$	NONFINALITY	ALIGN–R
a.	☞ ma.'č <sup>h</sup> ir		*	
b.	'ma.č <sup>h</sup> ir	*!		*

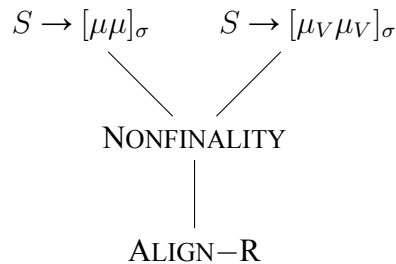
Finally, the data in (31iii), which demonstrates that CV: outweighs CVC in Mankiyali, shows that the moraic sonority constraint that only considers vocalic moras –  $S \rightarrow [\mu_V\mu_V]_\sigma$  – must be active and outrank NONFINALITY alongside  $S \rightarrow [\mu\mu]_\sigma$  in Mankiyali. Because both CVC and CV: are bimoraic, candidates (a) and (b) in (35i) equally satisfy  $S \rightarrow [\mu\mu]_\sigma$ . Nevertheless, stressed *muk* in candidate (b) only contains a single vocalic mora and so violates the high-ranked  $S \rightarrow [\mu_V\mu_V]_\sigma$  and is eliminated from contention. Candidate (a) stresses a CV:, which is both bimoraic and contains two vocalic moras. As a result, it satisfies both constraints on syllable weight that are active in Mankiyali and is chosen as the winner. Importantly, Moraic Sonority Constraints are in a stringency relationship, so their relative rankings do not affect the analysis.

(35) CV: heavy in Mankiyali

i. CV: attracting stress from CVC

	mukle:	$S \rightarrow [\mu_V\mu_V]_\sigma$	$S \rightarrow [\mu\mu]_\sigma$	NONFINALITY	ALIGN–R
a.	☞ muk.'le:			*	
b.	'muk.le:	*!			*

ii. Final Hasse Diagram of Mankiyali Stress Constraints



In sum, whereas many weight-sensitive stress criteria choose a single bifurcation point when determining syllable weight, Mankiyali makes two bifurcations, one between  $\mu_V$  and  $\mu_R$  and another between  $\mu_R$  and  $\mu_O$ . In this way, Moraic Sonority constraints effectively capture the ternary stress criterion of Mankiyali.

#### 4.1.5 Coercion, Variable Weight, and complex stress criteria

The theory of Coercion (Morén, 1999; Rosenthal and van der Hulst, 1999) is the traditional method used by the Variable Weight approach to analyze languages like Mankiyali in which the stress criterion makes more than two distinctions in weight. Coercion analyzes the moraic structure of CVC as bimoraic when it attracts stress alongside CV: and as monomoraic in environments where its weight behavior mirrors that of CV. Coercion achieves the three-way weight distinction by “coercing” CVC into bimoraicity in environments where CV: is unavailable for primary stress but allowing it to remain monomoraic elsewhere. This is accomplished by the interaction of the competing constraints in (36) that determine whether the coda contributes a mora to the syllable:


(36) Constraints necessary for Coercion analysis

- i. Weight by Position (WxP)  
Assign a violation for every coda consonant not linked to its own mora.
- ii.  $*\mu_C$   
Assign a violation for every moraic coda consonant.
- iii. WSP (Prince and Smolensky, 1993/2004)  
Assign a violation for every bimoraic syllable that is unstressed.


When WSP outranks WxP and a CV: syllable is present, as in (37i), CVC is realized as monomoraic to avoid the realization of an unstressed bimoraic syllable in violations of the WSP. This generates the hierarchy  $\{CV:\} > \{CVC, CV\}$ . However, when CV: is absent in (37ii), CVC surfaces as bimoraic to satisfy WxP at the expense of the lower-ranked  $*\mu_C$ , establishing the hierarchy  $\{CVC\} > \{CV\}$  in this way. Thus, Coercion separates the ternary scale,  $\{CV:\} > \{CVC\} > \{CV\}$  into two distinct binary scales,  $\{CV:\} > \{CVC, CV\}$  and  $\{CVC\} > \{CV\}$ , which allows the theory to account for ternary scales under a thoroughly “Variable Weight” analysis.

(37) Variable weight of codas under Coercion

i. CVC surfacing as monomoraic

	WSP	WxP
a.  CVC.'CV:		*
b. 'CVC <sub>μ</sub> .CV:	*	
c. CVC <sub>μ</sub> .'CV:	*	

ii. CVC coerced into bimoraicity

	WSP	WxP	$*\mu_C$
a.  CV.'CVC <sub>μ</sub>			*
b. 'CV.CVC		*!	
c. 'CV.CVC <sub>μ</sub>	*!		*

Nevertheless, while Coercion has been shown to correctly predict the primary stress patterns of weight-sensitive languages with complex primary stress systems, the shortcomings of the Variable Weight approach enumerated in section 2 persist with Coercion. That is, despite the contextual moraicity of coda consonants under Coercion, moraic structure remains language-specific rather

than process-specific unless the right conditions for stress require specific CVC syllables to surface with a variable structure. The result still leads to the incorrect prediction that weight-sensitive processes should treat individual codas uniformly within languages. In fact, Ryan (2019, 2020) provides evidence demonstrating that Coercion is untenable for about half of  $\{\text{CV:}\} > \{\text{CVC}\} > \{\text{CV}\}$  stress systems because CVC must be simultaneously monomoraic to yield primary stress to CV: and bimoraic to attract secondary stress. In sum, Coercion’s deficiencies are identical to other aspects of the Variable Weight approach: it relies on variation in moraic structure in an attempt to resolve variation in weight criteria, but that variation in moraic structure wrongly assumes a uniform weight for any given CVC across processes.

#### 4.1.6 A note on variable representation

As demonstrated in this paper, one of the primary features of the Variable Weight approach is its reliance on language-specific variation in coda moraicity to capture cross-linguistic variation in weight-sensitive stress scales. However, because the Variable Weight approach treats coda moraicity as a language-specific option, in which a language either possesses weight-bearing codas or does not, the theory is unable to explain within-language variation in weight scales across different weight-sensitive phenomena, as illustrated in sections 2.2 and 3.2. Conversely, under the UMQ, the representation of coda moraicity remains fixed, and the variation of weight scales – both cross-linguistically and within languages – is captured via the Moraic Sonority Metric, with variation between weight criteria achieved by variation in constraint ranking rather than variation in structural representation. In other words, the Moraic Sonority Constraints –  $S \rightarrow [\mu_V \mu_V]_\sigma$ ,  $S \rightarrow [\mu_R \mu_R]_\sigma$ , and  $S \rightarrow [\mu \mu]_\sigma$  – impact the relative weight status of syllables by dispreferring stress that falls on syllables with less than two moras of a specified sonority, as demonstrated by the scales in (38). Crucially, this method for achieving weight variation does not require language-specific variation in the structural representation of syllables, which means no potential exists for incorrect predictions about language-specific representations because these constraints make no assertions about language-specific representations. Instead,  $S \rightarrow [\mu_V \mu_V]_\sigma$ ,  $S \rightarrow [\mu_R \mu_R]_\sigma$ , and  $S \rightarrow [\mu \mu]_\sigma$  generate variation in the same way as any other markedness constraint: they penalize candidates based on the presence of some disfavored trait, in this case prominence on a syllable with less-than-ideal moraic sonority.

(38) Moraic Sonority Constraints and weight criteria variation

- i.  $S \rightarrow [\mu_V \mu_V]_\sigma$  active:  $\{\text{CV:}\} > \{\text{CVR}, \text{CVO}, \text{CV}\}$
- ii.  $S \rightarrow [\mu_R \mu_R]_\sigma$  active:  $\{\text{CV:}, \text{CVR}\} > \{\text{CVO}, \text{CV}\}$
- iii.  $S \rightarrow [\mu \mu]_\sigma$  active:  $\{\text{CV:}, \text{CVR}, \text{CVO}\} > \{\text{CV}\}$

## 4.2 A Factorial Typology of Weight Sensitive Stress

Every typological proposal is burdened with the task of predicting both the set of attested systems and the set of systems that should not exist. If a theory predicts that a system exists when it does not, the proposal suffers from over-generation. On the other hand, if a theory predicts that a system *should not* exist when it does, the theory must either be abandoned or overhauled to account for the existence of the unexpected system. This section explores the factorial typology generated from the Moraic Sonority Constraints proposed in section 4.1, demonstrating that the Moraic Sonority



Metric successfully captures the cross-linguistic typology of stress criteria while avoiding severe over-generation. The list of predicted stress criteria was generated using OT-Help 2.0 (Staub et al., 2010). The factorial typology consists of the three Moraic Sonority constraints — recapitulated in (39i) - (39iii) — and an alignment constraint described in (39iv). This typology demonstrates the efficacy of the Moraic Sonority Metric in predicting the diverse set of weight-sensitive stress criteria present in the world’s languages.<sup>7</sup>

(39) Constraints in the Factorial Typology

- i.  $S \rightarrow [\mu\mu]_\sigma$   
Assign a violation for every stressed syllable with less than two moras.
- ii.  $S \rightarrow [\mu_R\mu_R]_\sigma$   
Assign a violation for every stressed syllable with less than two sonorant moras.
- iii.  $S \rightarrow [\mu_V\mu_V]_\sigma$   
Assign a violation for every stressed syllable with less than two vocalic moras.
- iv. ALIGN–L  
Assign a violation for every syllable that intervenes between the left edge of a prosodic word and the head syllable.

The factorial typology of the proposed constraints results in the eight predicted languages in (40), five of which are attested. Languages 1 - 4, which comprise all of the criteria that make binary distinctions in syllable weight, are attested. Of these binary systems, languages 1, 2, and 4 are robustly attested, while language 3 is quite rare, though still attested, as a stress criterion. The stress criteria in languages 5 - 8 make at least two distinctions in syllable weight, and only one of these languages, the criterion in 5, is attested, though it is also quite rare according to Gordon’s survey.

(40) Languages predicted by Moraic Sonority Constraints

	<b>Ranking</b>	<b>Stress Criterion</b>	<b>Attested?</b>
1	ALIGN » $[\mu\mu]_\sigma$ , $[\mu_R\mu_R]_\sigma$ , $[\mu_V\mu_V]_\sigma$	quantity insensitive	Mohawk (Chafe, 1977)
2	$[\mu\mu]_\sigma$ » ALIGN » $[\mu_R\mu_R]_\sigma$ , $[\mu_V\mu_V]_\sigma$	{CV:, CVR, CVO} > {CV}	Yana
3	$[\mu_R\mu_R]_\sigma$ » ALIGN » $[\mu\mu]_\sigma$ , $[\mu_V\mu_V]_\sigma$	{CV:, CVR} > {CVO, CV}	Kwakw’ala
4	$[\mu_V\mu_V]_\sigma$ » ALIGN » $[\mu\mu]_\sigma$ , $[\mu_R\mu_R]_\sigma$	{CV:} > {CVR, CVO, CV}	Lhasa Tibetan
5	$[\mu\mu]_\sigma$ , $[\mu_V\mu_V]_\sigma$ » ALIGN » $[\mu_R\mu_R]_\sigma$	{CV:} > {CVR, CVO} > {CV}	Mankiyali
6	$[\mu\mu]_\sigma$ , $[\mu_R\mu_R]_\sigma$ » ALIGN » $[\mu_V\mu_V]_\sigma$	{CV:, CVR} > {CVO} > {CV}	-
7	$[\mu_V\mu_V]_\sigma$ , $[\mu_R\mu_R]_\sigma$ » ALIGN » $[\mu\mu]_\sigma$	{CV:} > {CVR} > {CVO, CV}	-
8	$[\mu_V\mu_V]_\sigma$ , $[\mu_R\mu_R]_\sigma$ , $[\mu\mu]_\sigma$ » ALIGN	{CV:} > {CVR} > {CVO} > {CV}	-

A straightforward explanation for the three unattested languages in (40) exists. Namely, it is

<sup>7</sup>The factorial typology does not include stress criteria that distinguish superheavy syllables from heavy/light syllables. I entrust it to subsequent analyses to explore how the current proposal could be expanded to include these languages.

possible that these three languages represent accidental gaps in the typology based on the rarity of the distinctions employed. Notice that each of the three unattested criteria makes use of a combination of two distinctive patterns that are relatively rare in their own right: a minimally ternary distinction in syllable weight as well as a distinction based on the bifurcation between  $\mu_R$  and  $\mu_O$ , in which CVR and CVO syllables disjoin into separate levels on the scale. In Gordon’s (2006) survey of weight-sensitive systems, only 15 of 107 languages (14%) with weight-sensitive stress exhibit a ternary weight distinction. Furthermore, only 3 of those 107 languages (3%) involve criteria that disjoin CVR from CVO (Kwakw’ala, Nootka, and Quechua Inga). Given the paucity of each of these patterns on their own, the fact that a criterion wielding both patterns simultaneously has not been discovered is rather unsurprising (Gordon, 2002).

### 4.3 Summary

This section sought to develop a formal account of weight-sensitive stress using the theoretical frameworks of a theory of Uniform Moraic Quantity and the Moraic Sonority Metric introduced in section 3. In addition, this section demonstrated the ability to seamlessly enfold the Moraic Sonority Metric into a constraint family like SWP, which penalizes stress on light syllables. To do so, I proposed two additional Moraic Sonority constraints within the SWP framework ( $S \rightarrow [\mu_R \mu_R]_\sigma$  and  $S \rightarrow [\mu_V \mu_V]_\sigma$ ) that, when coupled with  $S \rightarrow [\mu \mu]_\sigma$ , accurately predict the cross-linguistic inventory of stress criteria. While three of the stress criteria predicted by the constraints are currently unattested, I contended that the combined rarity of the distinctions utilized by these predicted criteria explains why they have yet to be encountered.

## 5 Discussion

### 5.1 Codas, syllable weight variation, and geminate consonants

In this paper, I’ve proposed the elimination of variable moraicity of codas such that the moraic structure of coda consonants is uniform cross-linguistically. Such a proposal conforms to the empirical reality that codas overwhelmingly behave as moraic entities, but it does not provide a way to account for syllable weight variation, either cross-linguistically or within languages. To solve this, I made explicit the idea that moras are encoded with the sonority of the segment to which they are linked. Moras can be either vocalic (if linked to a vowel), sonorant (if linked to a sonorant consonant), or obstruent (if linked to an obstruent consonant). As previously stated in section 3.3, the idea that moras are encoded with the sonority of the segment to which they are linked is not without precedent. The current proposal simply makes this notion explicit, which allows constraints to reference mora type based on three discrete sonority levels during candidate assessment. Thus, weight variation no longer relies on variable moraicity but is achieved by constraints that are sensitive to the differences in mora type between syllables. Because constraints can reference mora types, they can be selective in terms of what mora types are relevant and, thus, what mora types do and do not contribute to syllable weight. Accordingly, variation is achieved by enabling constraints to treat different syllable types (e.g., CVR vs. CVO) as structurally distinct. In effect, even though both CVR and CVO are equivalent in their overall number of moras, they can be distinguished by the fact that CVR has two sonorant moras while CVO only has one.

The concept of moraic sonority adopted in this paper is similar in spirit to the sonority threshold constraints of Zec (1995, 2003, 2007), but the crucial distinction lies in the different assumptions the two theories make concerning the moraic structure of codas. Specifically, Zec argues that her theory of sonority thresholds should not be regarded as an additional metric of syllable weight. Instead, she asserts that moraic quantity ought to remain the only adjudicator of weight, with sonority threshold constraints preventing segments that don't meet the threshold from projecting a mora at all (Zec, 2003, p. 123). Consequently, sonority threshold constraints inevitably lead to the variable moraicity of codas cross-linguistically. The theory of moraic sonority undergirding constraints based on the Moraic Sonority Metric, on the other hand, affirms the universal moraicity of coda consonants.

Nevertheless, in positing a theory of Uniform Moraic Quantity such that every coda bears its own mora, we must reckon with the implications the theory has on the similarities and differences between singleton and geminate consonants. Specifically, if codas are universally moraic, this begs the question of how geminates can be distinguished from singleton consonants. First, it is worth noting that in many instances, singleton and geminate consonants behave identically for weight-sensitive phenomena, so no distinction between the two types of consonants is necessary. For example, Ryan (2019, pp. 64–81) surveys languages with quantity-sensitive stress, singleton codas, and geminates (CVG) and finds that CVG patterns with CVC in terms of weight for 94% of the languages he surveys. When CVC is heavy alongside CV:, CVG is heavy as well. Conversely, when CVC patterns as light and CV: heavy, CVG almost always patterns as light with CVC. At best, then, cases of geminates serving as heavy but CVC serving as light represent the exception rather than the rule.

However, while weight-sensitive stress systems largely treat CVG and CVC uniformly, numerous cases exist in which geminates behave differently than singletons for other weight-sensitive processes. Koya (Davis, 2011; Sherer, 1994; Tyler, 1969), a Dravidian language spoken in central and southern India, represents one example. In the language, syllables with long vowels closed by a singleton coda are permissible (41a), but syllables with long vowels closed by a geminate consonant are prohibited to the extent that stem-final long vowels shorten when followed by a geminate suffix (41b) but not when followed by a singleton suffix (41c).

(41) Syllable template restrictions in Koya (data from Davis (2011, p.11))

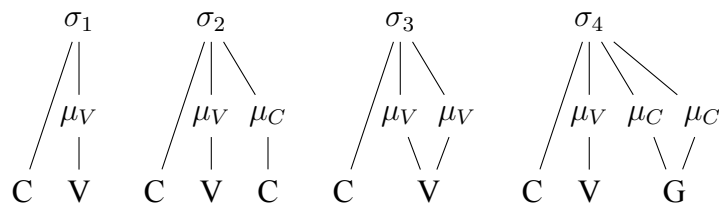
- |    |                        |   |                 |                 |
|----|------------------------|---|-----------------|-----------------|
| a. | /le:ŋga/               | → | le:ŋ.ga         | “calf”          |
| b. | /ke: + tt + o:ŋdu/     | → | ket.to:ŋ.du     | “he told”       |
| c. | /tunŋ + ana: + n + ki/ | → | tunŋ.ga.na:ŋ.ki | “for the doing” |

Any theory of weight must account for the fact that geminate consonants are sometimes indistinguishable from singleton codas for weight-sensitive phenomena such as stress in most relevant languages and other times pattern differently, as in the example of syllable template restrictions for Koya. The present theory rests on the claim that coda consonants always surface as moraic, and this includes geminates. It remains agnostic, however, as to the specific underlying moraic representation of these two classes of consonants. Previous scholarship has teased apart singleton consonants from geminate consonants by arguing that singleton consonants are underlyingly non-moraic, while geminates are inherently moraic. However, such a distinction is not informative under the UMQ since all codas surface as moraic. Alternatively, it seems plausible to assume that all segments – both vowels and consonants alike – are underlyingly moraic, with an onset weight prohibition constraint like the one proposed by Hyman (1985, pp. 15–16) that precludes onsets from

retaining their mora on the surface except in rare cases (see Topintzi (2008, 2010) for examples).

Regardless of their underlying representations, cases in which geminates outweigh singletons can no longer be explained as a byproduct of surface differences in moraicity induced by Weight-by-Position (Davis, 2011; Hayes, 1989). One potential explanation is that just as singleton vowels are considered monomoraic and geminate/long vowels bimoraic, the same distinction also exists for consonants. That is, a singleton coda consonant is monomoraic, and a geminate consonant is bimoraic, as illustrated by the proposed moraic structures in (42). In addition to providing a uniform representation for the difference between singleton and geminate segments in general, postulating bimoraic geminate consonants in conjunction with the Moraic Sonority Metric has the potential to explain cases in which CVG patterns with CVC as well as cases in which CVG behaves distinctly from CVC. For instance, in cases of weight-sensitive stress where both CVG and CVC pattern as heavy with CV:,  $S \rightarrow [\mu\mu]_\sigma$  is active and allows all syllables with two or more moras to attract stress. Crucially, the proposed trimoraic status of CVG syllables in  $\sigma_4$  of (42) compared to the bimoraic status of CVC in  $\sigma_2$  is irrelevant for this constraint, since all syllables with at least two moras of any sonority satisfy  $S \rightarrow [\mu\mu]_\sigma$ . The same is true when both CVG and CVC pattern as light, and only CV: attracts stress.  $S \rightarrow [\mu_V\mu_V]_\sigma$  is active and ignores consonantal moras in its weight computations, so the presence of an additional consonantal mora in CVG syllables makes no difference in its ability to attract stress compared to CVC; both syllable types violate  $S \rightarrow [\mu_V\mu_V]_\sigma$  because they contain only a single vocalic mora.

(42) Proposed moraic structure of singletons and geminates



For cases in which geminates behave differently than singletons, however, positing the bimoraicity of geminates provides clarity as to why the distinction exists. Consider the Koya data in (41) above. Under previous moraic analyses, CV:G is argued to be prohibited in such languages due to a ban on trimoraic syllables, whereas CV:C is permitted since the final consonant is analyzed as non-moraic. Under the UMQ in tandem with the bimoraic analysis of geminates, a restriction on maximum syllable weight also provides an explanation; rather than avoiding trimoraic syllables, these languages institute a restriction against tetramoraic syllables evinced by their preclusion of CV:G. Conversely, since CV:C is only trimoraic, the languages permit these syllables to surface.

Another interesting prediction that follows from the twofold proposition that geminates are bimoraic and every coda consonant links to its own mora is that geminates should behave in step with coda clusters in terms of weight. If geminates are truly bimoraic and each coda in a cluster contributes its own mora to the syllable, we should expect to find weight-sensitive processes in which CVG and CVCC syllables behave similarly to the exclusion of bimoraic CVC syllables since both CVG and CVCC are trimoraic. Intriguingly, Topintzi and Davis (2017) find that final geminates and coda clusters overwhelmingly pattern together in terms of weight across weight-sensitive phenomena, either both acting as heavy or both acting as light. One example they cite in which CVG and CVCC behave as heavy and CVC as light comes from the Cairene Arabic stress

system. As shown in (43a-b), both final syllables with clusters and final syllables with geminates attract stress, whereas final syllables closed by a singleton do not (43c). Under the analysis that both CVG and CVCC syllables are trimoraic, the stress facts in Cairene Arabic can be accounted for with a constraint preferring stress to fall on superheavy syllables.

(43) Geminates and clusters in Cairene Arabic (Topintzi and Davis, 2017, pp. 263–265)

- a. ka.'**tabt** “I wrote”
- b. ʔa.'**xaff** “lightest”
- c. 'ka.tab “he wrote”

In any case, a comprehensive treatment examining the relationship between geminate and singleton consonants cross-linguistically is warranted, given the drastic reinterpretation of coda consonants under the theory of Uniform Moraic Quantity proposed here. Nevertheless, analyzing geminates as bimoraic seems like a promising avenue to pursue.

## 5.2 Stress-repelling schwa

As noted in section 3.3, recent work argues convincingly against syllable weight distinctions based on differences in vowel quality. With that said, a handful of languages reportedly provide evidence for a non-moraic schwa that repels stress. One particularly compelling example comes from Piuma Paiwan, a language of southern Taiwan (Shih, 2019b). Primary stress in Piuma Paiwan falls on the penultimate syllable by default, as in (44a-b). However, according to Shih, if the penultimate syllable contains a schwa, stress shifts away from the default position to the final syllable, regardless of whether the final syllable contains a full vowel (44c-d) or another schwa (44e-f). To account for the distribution of stress without referring to vowel sonority differences, Shih contends that Piuma Paiwan utilizes three types of schwa: a bimoraic schwa that occurs in the head syllable of a foot (the final syllable in (44e-f)), a monomoraic schwa that occurs in the non-head syllable of a foot (44b), and a non-moraic schwa that only arises when a syllable is left unfooted (the penultimate syllable in (44c-f)). One of Shih’s justifications for the analysis of penultimate schwa as non-moraic relies on the unique acoustic properties of the penultimate schwa compared to word-final schwas. Shih conducted experiments on the acoustics of schwa in disyllabic words and found that the duration of the penultimate schwa is drastically shorter than other vowels, and the vowel quality is significantly more variable. On the other hand, the word-final stressed schwa in (44e-f) is significantly longer than both the penultimate schwa and the word-final unstressed schwa, which Shih argues is a consequence of their differences in mora count.

(44) Stress in Piuma Paiwan (Shih, 2019b)

- a. 'tsa.viʔ “year”      b. 'tu.lək “to direct”
- c. kə.'ri “small”      d. kə.'man “to eat”
- e. [ə.'ʕət “lip”      f. tsə.'məʔ “grass”

Given the current proposal, it seems reasonable to propose an additional tier to the Moraic Sonority Hierarchy to account for the apparent weight distinction in Piuma Paiwan between full and reduced vowels. However, at least three reasons militate against such a proposal. To begin with, the nature of the distinction between full and reduced vowels is categorically different than the moraic sonority constraints considered in this paper. The constraints associated with the Moraic Sonority Metric assign violations based on the number of moras of a specified sonority

and not based on sonority alone. Adding a vowel quality constraint to distinguish full vowels from central vowels, on the other hand, necessarily relies solely on moraic sonority without regard to moraic quantity. For example, the Moraic Sonority constraint  $S \rightarrow [\mu_V \mu_V]_\sigma$  penalizes stress on syllables with less than two vocalic moras, thereby distinguishing between syllables with one vocalic mora and syllables with more than one vocalic mora. A hypothetical constraint like  $S \rightarrow [\mu_F]_\sigma$  that penalizes stress on syllables without a full vowel, in contrast, cannot rely on quantity distinctions of one/more than one like  $S \rightarrow [\mu_V \mu_V]_\sigma$  since the nature of the contrast is based on the presence/absence of a full vowel. Instead, a constraint like  $S \rightarrow [\mu_F]_\sigma$  would be similar in kind to the standard vowel sonority constraints proposed in de Lacy (2006) and Kenstowicz (1997) rather than the Moraic Sonority constraints presented in this paper. Second, an additional schwa tier is unwarranted because the constraint would not accurately predict primary stress in Piuma Paiwan anyway, as penultimate schwas in the language yield stress to both full and schwa vowels alike. If the reason for the stress shift in Piuma Paiwan were based on a constraint dispreferring stress on syllables with reduced vowels, we would not expect penultimate schwa to yield stress to a word-final schwa, as in (44e-f). Thus, something else must underly the apparent repulsion of stress from the penultimate schwa. Finally, I am unaware of any other syllable weight process besides stress that ostensibly distinguishes syllables based on the presence of a full versus reduced vowel. Since weight distinctions correlating with the Moraic Sonority Hierarchy apply to all syllable weight processes, the inclusion of a schwa tier would inaccurately predict the presence of weight distinctions between full and reduced vowels for all other weight processes. Considering these facts, proposing a sonority constraint that penalizes stress on reduced vowels to account for the weak schwa in languages like Piuma Paiwan is undesirable.

That being said, an alternative explanation to the proposal that these weak schwas are non-moraic is available. That is, weak schwas may represent cases of vowel intrusion as described by Hall (2006) and Bellik (2018). Unlike lexical and epenthetic vowels, intrusive vowels are not vowels at all. Instead, they are perceived vowel-like intervals that occur between consonants due to gestural timing relations between those two consonants (Browman and Goldstein, 1993). Importantly, intrusive vowels do not correspond to their own segment, and, consequently, cannot participate in phonological processes or be targeted for stress assignment, which would explain why these vowels appear to repel stress. In addition, the apparent non-moraic schwa in Piuma Paiwan, and other languages like it, bears all the features characteristic of a typical intrusive vowel: it is significantly shorter in duration than other vowels and is heavily influenced by the quality of nearby segments. Chen (2009) also notes that, unlike other vowels, schwa in Piuma Paiwan never appears word-initially or adjacent to another vowel but only between consonants, lending further credence to the proposal that these weak schwas may, in fact, be intrusive vowels.

Subsequent work on weak schwas should examine their cross-linguistic phonetic and phonological behavior to determine their influence (or lack thereof) on other phonological processes beyond stress. Additionally, it would be interesting to examine whether these weak schwas exhibit other characteristics typical of intrusive vowels discussed by Hall (2006) and Bellik (2018).

### 5.3 The Moraic Sonority Metric and Vowel Prominence

A theory of Uniform Moraic Quantity with the combined use of the Moraic Sonority Metric to compute syllable weight could lead to similar predictions as the Vowel Prominence approach to


$\{CV:\} > \{CVC\} > \{CV\}$  stress criteria proposed in Ryan (2019, 2020), but the latter approach would need to be expanded in specific ways to capture the full typology of weight outlined in this paper. Nevertheless, even if expanded, a crucial difference exists between the two theories in that the Vowel Prominence approach does not offer an explanation for why moraic quantity combines with sonority to determine weight and not any other segmental feature, such as voicing or place of articulation. In its original form, the Vowel Prominence approach provides an explanation for languages with a ternary  $\{CV:\} > \{CVC\} > \{CV\}$  primary stress criterion. As discussed in the present work, weight scales like  $\{CV:\} > \{CVC\} > \{CV\}$  are often incompatible with the Variable Weight Approach since CVC must be simultaneously monomoraic and bimoraic in the same environment for different weight-sensitive processes within the same language. As a solution, the Vowel Prominence approach asserts that, only in languages with the  $\{CV:\} > \{CVC\} > \{CV\}$  stress criteria, both CV: and CVC must be uniformly bimoraic, and the vowel prominence constraint in (45) distinguishes between CV: and CVC by preferring stress to fall on syllables with a long vowel.

(45) MAIN  $\rightarrow$  VV (Ryan, 2019)

Assign a violation for primary stress that falls on a short vowel.

A tableau demonstrating the efficacy of the constraint in (45) is provided in (46) below. Because both CV: and CVC are bimoraic,  $S \rightarrow [\mu\mu]_\sigma$  is unable to distinguish between candidate (a), which stresses CV: and candidate (b), which stresses CVC, but MAIN  $\rightarrow$  VV is violated by candidate (b) because it places primary stress on a syllable with a short vowel. As a result, candidate (a) emerges as optimal.

(46) CVC attracting stress from CV

	CV:CVC	MAIN $\rightarrow$ VV	$S \rightarrow [\mu\mu]_\sigma$
a. 	'CV: <sub><math>\mu\mu</math></sub> .CV <sub><math>\mu</math></sub> C <sub><math>\mu</math></sub>		
b.	CV: <sub><math>\mu\mu</math></sub> 'CV <sub><math>\mu</math></sub> C <sub><math>\mu</math></sub>	*!	

While MAIN  $\rightarrow$  VV (which analyzes segments) and  $S \rightarrow [\mu_V\mu_V]_\sigma$  (which analyzes moras) utilize different levels of the phonology to compute weight, the constraints have identical violation profiles because CV and CVC violate both constraints when receiving primary stress. And while the Vowel Prominence approach is argued only to be relevant for languages with the  $\{CV:\} > \{CVC\} > \{CV\}$  stress criterion, the proposal could be expanded to account for the typology of weight presented in this paper. Specifically, the Vowel Prominence approach would make similar predictions to the Moraic Sonority Metric if it assumed the universal implementation of the UMQ and adopted an additional Prominence constraint that mimicked  $S \rightarrow [\mu_R\mu_R]_\sigma$  to penalize stress on a syllable with only a single sonorant segment in the rhyme, as in (47):

(47) MAIN  $\rightarrow$  RR

Assign a violation for primary stress on a syllable with one or less sonorant segment in the rhyme.

Nevertheless, while the expansion of the Vowel Prominence approach is possible, it is undesirable compared to the Moraic Sonority Metric because it does not restrict the possibility of other segmental features as possible contributors to syllable weight. For instance, the Prominence constraints MAIN  $\rightarrow$  VV and MAIN  $\rightarrow$  RR must access information on the segmental level to determine segmental sonority before weight can be computed. The requirement that these Prominence

constraints be able to access the segmental level of representation is problematic because access to the segmental level entails access to all of the featural information present there. The question arises under the Vowel Prominence approach, then, as to why sonority is the only segmental feature used in weight computations. In other words, the Prominence approach does not constrain the relevant information for syllable weight to sonority in its current form. The Moraic Sonority Metric, in contrast, proposes a theory of what information can be relevant (sonority) and a way of encoding this information in such a way that other segmental information cannot be accessed (in moras). As a result, the theory makes a particular set of restrictive predictions about syllable weight. Namely, only sonority and moraic quantity contribute to weight. The question is, can we find instances in which sonority and mora count demonstrably behave separately or contrary to one another for weight? The claim made here is that we should not be able to do so.

## 5.4 Alternative Representations of Syllable Weight

The claims set forth in this paper operate under the assumption that the mora functions as the apparatus best equipped to tackle the wide array of linguistic processes judged as sensitive to syllable weight. Despite this assumption, the argument for uniform moraic quantity advanced in this proposal seriously undermines one of the central components buttressing moraic theory. Notably, many proponents of moraic theory argue that the variable moraicity of codas provides some of the strongest support in favor of the mora. After all, if coda moraicity were consistent, as proposed here, much of the work managed by the mora could be achieved by other means, thus weakening the surety of moraic structure as an indispensable component of syllable weight theory. This section briefly considers another mechanism used in the literature to analyze weight sensitivity – skeletal slot theory – as an alternative to the mora.

Skeletal slot/CV theory, as conceived by McCarthy (1981) and Clements and Keyser (1983), among others, provides an avenue to explain many phonological phenomena that seem to operate independent of the segmental level, similar in many ways to the function of the moraic tier but with important differences. One substantial distinction separating skeletal slot theory from moraic theory is the assertion in skeletal slot theory that every short segment, regardless of its syllabic identity as an onset, nucleus, or coda, links to a timing slot, and every long segment links to two timing slots. Standard moraic theory, on the other hand, upholds that only vowels and codas may project a mora and that coda consonants sometimes do not project a mora when treated as weightless for stress. As outlined in section 3, the variable moraicity of codas professed by traditional moraic theorists falters under closer inspection of the facts, which ostensibly provides support in favor of the skeletal slot model of syllable weight. In fact, Gordon (2006, pp.2-8) cites the inability of moraic theory to treat syllable weight as process-specific rather than language-specific as a major justification for utilizing skeletal timing slots over the mora. In order to capture distinctions between syllable types that have an identical number of timing slots but that differ in sonority values, Gordon (2006, p. 44) argues that skeletal slots can be differentiated for weight-based purposes by the featural associations to which they are linked. The main advantage of Gordon's version of skeletal slot theory over moraic theories of weight is that weight representations remain constant cross-linguistically and within languages.

With that said, skeletal slot theory has largely been jettisoned in favor of moraic theory for several reasons. For instance, Prosodic Morphology (McCarthy and Prince, 1995) provides com-



elling evidence that prosodic units – of which the mora acts as an essential ingredient – are vital for explaining the shape of templates used in morphological phenomena such as reduplication and root-and-pattern systems. Crucially, alternative theories relying on segmental (rather than prosodic) structure fail to make the correct generalizations about these templates. In other words, cross-linguistic morphological patterns require the ability to reference a prosodic constituent equivalent to the mora to account for these phenomena accurately.

The necessity of the mora is further bolstered with evidence from compensatory lengthening, in which a segment is deleted, and another segment in the word is lengthened to compensate (Hayes, 1989). Importantly, compensatory lengthening effects are not necessarily local in their application (Borgeson, 2022). That is, while most cases of synchronic CL occur between two segments that are either directly adjacent or in adjacent syllables, as in (48i), evidence from Slovak and Estonian indicates that CL effects can cross multiple syllable boundaries in a word as well, as shown by the example in (48ii). These long-distance CL effects mystify segment-based theories attempting to explain the phenomenon without referencing an abstract unit of weight such as the mora. Additionally, whereas moraic theory explains why CL effects triggered by onsets are, at best, vanishingly rare – onsets are not typically mora-bearing – segmental approaches offer no such explanation. Altogether, the empirical reality of long-distance CL, coupled with the asymmetric behavior of codas/nuclei compared to onsets with respect to CL, demonstrate that the mora is crucial to explaining compensatory lengthening.

(48) Examples of compensatory lengthening

i. Adjacent CL in Latin and Middle English (Hayes, 1989)

/kasnus/ → ka:nus “gray”  
 /talə/ → ta:l “tale”

ii. Long-distance CL in Estonian (Borgeson, 2022, pp. 269–273)

/ka:lu-ta/ → ka::lu “weight-PART”  
 /kotti-ta/ → kot:ti “bag-PART”

Other issues with skeletal slot theory include the lack of explanation for onset/coda asymmetries and its usurpation by prosodic structure as the best tool for constraining various syllable properties like segment count and syllabicity (Broselow, 1995). In sum, an adequate theory of weight requires reference to abstract weight units distinct from the segmental level. Thus, moraic theory endures as the most effective mechanism for capturing weight-sensitive phenomena. When combining the shortcomings of skeletal slot theory with the theory of moraic structure fleshed out in this paper, which offers a solution to the main complaints against moraic theory raised by Gordon (2006), it seems that skeletal slot theory faces an uphill battle in achieving the status as the best method for representing weight distinctions.

## 5.5 Preliminary thoughts on other weight-sensitive phenomena

One of the central claims advanced in this paper is the assertion that all weight-sensitive phenomena rely solely on the Moraic Sonority Metric to make syllable weight distinctions. Nonetheless, I only provide a comprehensive formal account of one weight-sensitive process: stress. This raises the question of how formalizations of the Moraic Sonority Metric for other processes will be achieved. I offer some preliminary speculations regarding formalizations for tone and word minimality here

without exploring the adequacy of the proposals in detail.

### 5.5.1 Weight-sensitive tone

Something comparable to the constraint set in (49) has the potential to cover the tonal criteria's typological inventory.

(49) Tonal Moraic Sonority Constraints

- i. *NoContour* –  $\mu$  (Ito and Mester, 2019)  
Assign a violation for every contour tone linking to a syllable with less than two moras.
- ii. *NoContour* –  $\mu_R$   
Assign a violation for every contour tone linking to a syllable with less than two sonorant moras.
- iii. *NoContour* –  $\mu_V$   
Assign a violation for every contour tone linking to a syllable with less than two vocalic moras.
- iv. *NoContour* –  $\sigma$  (Ito and Mester, 2019)  
Assign a violation for every contour tone linking to a syllable.

Much like the Moraic Sonority stress constraints in section 4, each of the tonal constraints in (49) penalizes candidates based on a specific subset of the available mora types, thereby corresponding to a bifurcation at a different level of the Moraic Sonority Hierarchy, as depicted in (50). *NoContour* –  $\mu$  penalizes any contour tone that links to a syllable with less than two moras, regardless of mora type. Consequently, only bimoraic syllables (CV: and CVC) are heavy and able to host a contour tone. Because every mora type contributes to syllable weight when *NoContour* –  $\mu$  is active, this corresponds to a bifurcation below the lowest mora type,  $\mu_O$ , and results in a general distinction between bimoraic and monomoraic syllables. About 5% of languages in Gordon's (2006) weight survey that exhibit weight-sensitive tone utilize this constraint to form their tonal criteria.

(50) The Moraic Sonority Hierarchy and Tonal Constraints

Contour Tones Prohibited	$\overrightarrow{\text{---}} \text{---} \overleftarrow{\text{---}}$	<i>NoContour</i> – $\sigma$
	$\mu_V$	
{CV:} > {CVC, CV}	$\overrightarrow{\text{---}} \text{---} \overleftarrow{\text{---}}$	<i>NoContour</i> – $\mu_V$
	$\mu_R$	
{CV:, CVR} > {CVO, CV}	$\overrightarrow{\text{---}} \text{---} \overleftarrow{\text{---}}$	<i>NoContour</i> – $\mu_R$
	$\mu_O$	
{CV:, CVC} > {CV}	$\overrightarrow{\text{---}} \text{---} \overleftarrow{\text{---}}$	<i>NoContour</i> – $\mu$

Conversely, when *NoContour* –  $\mu_R$  is active, only syllables with two sonorant moras (CV: and CVR) are heavy and able to host a contour tone. This constraint corresponds to a bifurcation between  $\mu_O$  and  $\mu_R$  and results in obstruent moras not contributing to weight. In other words, even though CVO is bimoraic under the UMQ, *NoContour* –  $\mu_R$  ignores the obstruent mora linked to the obstruent consonant in CVO and thus treats CVO as light for tonal criteria when active in a language. The resulting weight criterion that surfaces when *NoContour* –  $\mu_R$  is active makes up

about 49% of languages in Gordon’s (2006) syllable weight survey that possess a weight-sensitive tonal system.

*NoContour* –  $\mu_V$ , in contrast to both *NoContour* –  $\mu_R$  and *NoContour* –  $\mu$ , penalizes any syllable hosting a contour tone that has less than two vocalic moras. Consequently, when *NoContour* –  $\mu_V$  is active, only syllables with long vowels host a contour tone, thereby producing the scale,  $\{CV:\} > \{CVR, CVO, CV\}$ , which corresponds to a bifurcation between  $\mu_R$  and  $\mu_V$  on the Moraic Sonority Hierarchy in (50). This constraint is active in about 46% of the language in Gordon’s survey.

The final bifurcation on the Moraic Sonority Hierarchy above  $\mu_V$  corresponds to the constraint *NoContour* –  $\sigma$ . Because no mora type falls above the bifurcation point when *NoContour* –  $\sigma$  is active, moras are ignored across the board, and contour tones are prohibited on every syllable type without regard to moras.

In sum, the three Moraic Sonority constraints for tone in (49i-iii) account for about 99% of the languages with weight-sensitive tonal systems in Gordon’s (2006) survey. Nevertheless, it may be challenging to explain the tonal criterion of Cantonese, which seems to diverge from the general pattern of weight-sensitivity maintained in this paper (Gordon, 2006, pp. 93–95). Specifically, it is unexpected that CVO and CV:O syllables cannot host contour tones in Cantonese, while CV and CVR syllables are able to do so. However, an anonymous reviewer points out that the shape of the Cantonese tonal criterion may be attributed to historical consequences of tonogenesis, as well as in other Southeast Asian languages, in which similar tonal patterns have emerged.

### 5.5.2 Word minimality

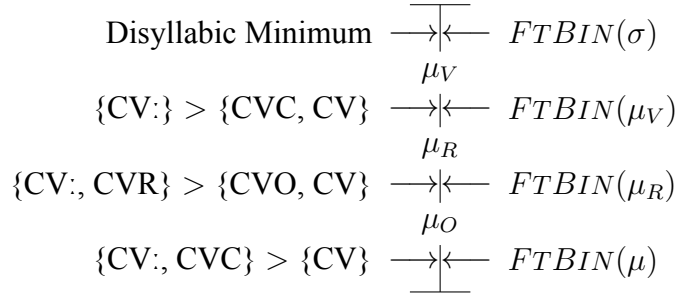
Since at least Prince (1980), linguists have linked word minimality with foot minimality, arguing in favor of a Prosodic Minimality Hypothesis (PMH) in which the smallest allowable prosodic word must be the same size as the smallest allowable foot, often a single heavy syllable (e.g., Blumenfeld, 2011; McCarthy and Prince, 1986). However, since the conception of the PMH, further research has shown that the theory is too restrictive in its strongest form because many languages brandish a mismatch in size between minimal feet and minimal words (Garrett, 1999; Gordon, 2006). With that said, most word minimality conditions can be explained in terms of binarity at some level of prosodic analysis, which makes the phenomenon amenable to analyzing minimality constraints as a requirement of foot binarity. Importantly, though the exact kind of binarity required for minimal words is often at odds with the foot binarity requirements for metrical stress, Blumenfeld (2011) argues that these mismatches arise from independent constraints that affect monosyllabic words differently than longer words. Though Blumenfeld couches his argument within the theory of Coercion, his rationale also applies under the present proposal. Namely, foot binarity underpins both minimal foot size and minimal word size, but conflicting constraints such as *DEP $\mu$*  and *LX=PR* (Prince and Smolensky, 1993/2004) frequently result in surface mismatches between minimal words and minimal feet. With this assumption in mind, I tentatively propose the family of *FTBIN* constraints in (51) to account for word minimality effects, each of which correlates with a different bifurcation on the Moraic Sonority Hierarchy.

(51) Word minimality Moraic Sonority Constraints

- i.  $FTBIN(\mu)$   
Assign a violation for every foot without two moras.
- ii.  $FTBIN(\mu_R)$   
Assign a violation for every foot without two sonorant moras.
- iii.  $FTBIN(\mu_V)$   
Assign a violation for every foot without two vocalic moras.
- iv.  $FTBIN(\sigma)$  (Prince and Smolensky, 1993/2004; among many others)  
Assign a violation for every foot without two syllables.

Instead of a generic  $FTBIN$  constraint requiring binarity at either the syllable or mora level (Prince and Smolensky, 1993/2004), Moraic Sonority  $FTBIN$  constraints stipulate a specific type of binarity to which feet must adhere. For instance,  $FTBIN(\mu)$  falls below all levels of the Moraic Sonority Hierarchy in (52), thereby allowing every mora type to contribute to the satisfaction of binarity. In terms of minimality, this means that any bimoraic word, regardless of mora type, satisfies the constraint, leading to a CVC minimal word requirement for languages in which  $FTBIN(\mu)$  is active. In Gordon’s (2006) survey, of the 127 languages that permit codas and have a minimum word size requirement, about 63% impose the CVC minimum.

(52) The Moraic Sonority Hierarchy and Word Minimality



It is unclear whether languages exist in Gordon’s survey that utilize  $FTBIN(\mu_R)$ , which would result in a CVR minimum. Four of the languages in the survey (3%) potentially impose this constraint, but these languages also prohibit obstruent codas altogether, obscuring which  $FTBIN$  constraint –  $FTBIN(\mu_R)$  or  $FTBIN(\mu)$  – is responsible for the minimality requirement. The lack of obvious cases in which  $FTBIN(\mu_R)$  applies could be due to the fact that divisions between obstruent and sonorant consonant moras are relatively rare across most weight-sensitive phenomena. Additionally, it is possible that cases of CVR minima have been misreported by grammatical descriptions as cases of generic CVC minima. Obviously, this line of reasoning is merely speculative, so further research is necessary.

$FTBIN(\mu_V)$  only permits vocalic moras to contribute to binarity, corresponding to a bifurcation above  $\mu_R$ . The activity of this constraint is widely attested, with about 15% of the languages in Gordon’s survey enacting a CV: minimum. Finally, when languages make a bifurcation above  $\mu_V$ , all mora types are ignored, and binarity is instead satisfied at the syllable level using  $FTBIN(\sigma)$ . The result is a disyllabic minimum that about 17% of the languages in Gordon’s survey implement.

Altogether, the four proposed Moraic Sonority  $FTBIN$  constraints in (51) account for approximately 98% of the languages in Gordon’s survey that institute a minimal word restriction. The

remaining 2% of languages establish a minimum that requires words to contain at least three moras of various sonorities. However, as Blumenfeld (2011) notes, almost all apparent cases of minimality not neatly explained by binarity fall out from other components of the phonological grammar in these languages, such as vowel lengthening in closed syllables in Menominee (Milligan, 2005). Whatever the facts may be, the elements impacting an exhaustive analysis of the minimal word typology are diverse and complex. As such, a thorough examination of the full typology of word minimality is needed, including an exploration into the influence of the proposed *FTBIN* constraints on the interaction between minimality and metrical foot structure.

## 6 Conclusion

This paper outlined a theory of moraic structure that treats weight sensitivity as a process-specific (rather than language-specific) phenomenon. In section 2, I showed that the traditional outworkings of moraic theory do not allow for syllable weight to vary across processes within a single language, which contradicts data from most languages. As such, I proposed an alteration to moraic theory in section 3 in the form of the Uniform Moraic Quantity Theory – which requires coda consonants to link to their own moras – and the Moraic Sonority Metric, which establishes syllable weight divisions based on the number of moras of a specified sonority in a syllable rather than the sum total of moras in a syllable. If adopted, the UMQ and the Moraic Sonority Metric improve our formal analysis of syllable weight in a number of ways. First, by positing uniform moraicity and using moraic sonority values to distinguish syllables, moraic theory successfully captures the empirical realities of weight sensitivity as a process-specific phenomenon. Second, the theory of moraic structure is simplified by ridding the grammar of language-specific (WxP) and context-specific (Coercion) moraicity stipulations. Finally, the Moraic Sonority Metric is claimed to account for syllable weight criteria across processes and languages, which, if proven true, would mean that a single metric is capable of capturing a diverse set of processes that hitherto have required several disconnected approaches to be accounted for. In section 4, I formalized the Moraic Sonority Metric for weight-sensitive stress to demonstrate the efficacy of the metric in accounting for a weight-sensitive process with a diverse inventory of criteria. The factorial typology of these Moraic Sonority Constraints was explored in section 4.2, revealing that only the most complex set of criteria that the framework predicts are unattested, an unsurprising fact given the combined rarity of the distinctions employed in these predicted systems.

Transferring the explanation of syllable weight mismatches from variation in moraic structure to differences in moraic sonority has some meaningful ramifications. Specifically, it suggests that any phenomenon related to syllable weight ought to exhibit the hierarchical divisions enumerated by the Moraic Sonority Metric. The present paper focused mainly on stress and gave brief overviews for potential analyses of weight-sensitive tone and word minimality. Future research exploring the veracity of the theory explicated here should test its predictions against other weight-sensitive processes to see if its claims are substantiated. Promising areas of work include NC clusters in Bantu languages (Hyman, 1992), in which preconsonantal nasals exhibit variable weight across processes. Additionally, there are some interesting patterns of reduplication – especially recent work by Mellesmoen (2023) on reduplication in Salish – that seem to corroborate the concepts presented in this paper since certain reduplicative affixes require reference to moras of specific

sonorities in their prosodic templates. Other areas of interest include syllable template restrictions, meter, onset/coda inventory asymmetries, and compensatory lengthening.

## 7 Acknowledgements

I’m extremely thankful to Rachel Walker, Ryan Bennett, Jaye Padgett, Brett Hyde, and audiences at MidPhon 27 and AMP 2022 for their helpful feedback on this project. In addition, I’m grateful for the thorough reviews and suggestions from three anonymous *Phonology* reviewers and an anonymous associate editor. All remaining errors are mine.

## 8 Appendix

### Examples of additional languages found to exhibit coda moraicity in Gordon’s (2006) survey

- Cayuga (Hatcher, 2022, pp. 24–25): Codas block penult vowel lengthening.  
 /hě.na:.do.was/ → hě.na:.do:.was “sky”  
 /de.wa.ga.da.wě̃n.yě/ → de.wa.ga.da.wě̃n.yě “I’m moving out”
- Cherokee (Uchihara, 2013, pp. 131–137): Codas instantiate vowel shortening.  
 /gini:-na:di/ → ki.ni:-na:.ti “for you and I to set it (FLEXIBLE) down”  
 /gini:-hdi/ → ki.ni.h.ti “for you and I to set it (COMPACT) down”
- Malecite (LeSourd, 1993, p. 41): Codas (except h) block lengthening in stressed syllables.  
 /nwí.sə.kè.ləm/ → nwí:sə.gè:.ləm “I laughed hard”  
 /éh.pit/ → ‘e:h.pit “woman”  
 /níh.ka.nát.pat/ → ní:h.ka.nát.pat “head (of an organization)”
- Malto (Mahapatra, 1979, p. 55): CVC minimal content word restriction.  
 nin “you” toq “to finish”  
 a “that” je “that”
- Tidore (Pikkert and Pikkert, 1995): CVC minimal word restriction.  
 cam “to question” gam “village”  
 dun “daughter-in-law” xad “week”  
 \*CV

## References

- Abbott, Stan. (1985). A tentative multilevel multiunit phonological analysis of the Murik language. *Papers in New Guinea Linguistics*, 22, 339–373.
- Bach, Emmon. (1975). Long vowels and stress in Kwakiutl. *Texas Linguistic Forum*, 2, 9–19.
- Bellik, Jennifer. (2018). An acoustic study of vowel intrusion in Turkish onset clusters. *Laboratory Phonology*, 9(1), 1–23.
- Blumenfeld, Lev. (2011). Coercion and minimality. *The Linguistic Review*, 28(2), 207–240.
- Borgeson, Scott. (2022). *Long-distance compensatory lengthening* (Doctoral dissertation). Stanford University.

- Bowers, Dustin. (2019). Positional vs. sonority-driven stress in Gujarati: New experimental evidence. *Phonological Data and Analysis*, 1(1), 1–28.
- Broselow, Ellen. (1995). Skeletal positions and moras. In John A. Goldsmith (Ed.), *The Handbook of Phonological Theory* (pp. 175–205). Oxford: Blackwell.
- Browman, Catherine P. & Goldstein, Louis. (1993). Dynamics and Articulatory Phonology. *Haskins Laboratories Status Report on Speech Research*, SR-113, 51–62.
- Chafe, Wallace. (1977). Accent and related phenomena in the Five Nations of Iroquois languages. In Larry Hyman (Ed.), *Studies in stress and accent* (pp. 169–178). Southern California Occasional Papers in Linguistics.
- Charney, Jean. (1993). *A grammar of Comanche*. Lincoln: University of Nebraska Press.
- Chen, Chun-Mei. (2009). Documenting Paiwan phonology: Issues in segments and non-stress prosodic features. *Concentric: Studies in Linguistics*, 35, 193–223.
- Clements, George N. & Keyser, Samuel Jay. (1983). *CV phonology: A Generative theory of the syllable*. Cambridge, MA: MIT Press.
- Davis, Stuart. (2011). Geminates. In Marc van Oostendorp, Colin J. Ewen, Elizabeth V. Hume, & Keren Rice (Eds.), *The Blackwell Companion to Phonology*. Wiley-Blackwell.
- Davis, Stuart. (2017). Weight-manipulating phonology in Chuukese. In Haruo Kubozono (Ed.), *The phonetics and phonology of geminate consonants* (pp. 230–259). Oxford University Press.
- Dawson, Willa. (1980). *Tibetan phonology* (Doctoral dissertation). University of Washington.
- de Lacy, Paul. (2002). *The formal expression of markedness* (Doctoral dissertation). University of Massachusetts, Amherst.
- de Lacy, Paul. (2004). Markedness conflation in Optimality Theory. *Phonology*, 21, 145–199.
- de Lacy, Paul. (2006). *Markedness: Reduction and preservation in phonology*. Cambridge: Cambridge University Press.
- Garrett, Edward. (1999). Minimal words aren't minimal feet. In Matthew Gordon (Ed.), *Papers in phonology 2: UCLA working papers in linguistics* (pp. 68–105). Los Angeles, CA: UCLA.
- Goedemans, Rob, & van der Hulst, Harry. (2013). Weight-sensitive stress. In Matthew S. Dryer & Martin Haspelmath (Eds.), *The world atlas of language structures online*. Max Planck Institute for Evolutionary Anthropology. <https://wals.info/chapter/15>
- Goldsmith, John A. (1976a). *Autosegmental phonology* (Doctoral dissertation). MIT.
- Goldsmith, John A. (1976b). An overview of Autosegmental phonology. *Linguistic Analysis*, 2, 23–68.
- Gordon, Matthew. (2002). A factorial typology of quantity-sensitive stress. *Natural Language & Linguistic Theory*, 20(3), 491–552.
- Gordon, Matthew. (2006). *Syllable weight: Phonetics, phonology, typology*. New York: Routledge.
- Hale, Kenneth. (1985). A note on Winnebago metrical structure. *International Journal of American Linguistics*, 51, 427–429.
- Hale, Kenneth, & White Eagle, Josie. (1980). A preliminary metrical account of Winnebago accent. *International Journal of American Linguistics*, 46, 117–132.
- Hall, Nancy Elizabeth. (2006). Cross-linguistic patterns of vowel intrusion. *Phonology*, 23, 387–429.
- Hammond, Michael. (1986). The Obligatory-Branching Parameter in metrical theory. *Natural Language and Linguistic Theory*, 4, 185–228.
- Harrell, Richard. (1957). *The phonology of colloquial Egyptian Arabic*. New York: American Council of learned Societies.

- Harrell, Richard. (1960). A linguistic analysis of Egyptian Radio Arabic. In Charles Ferguson (Ed.), *Contributions to Arabic linguistics* (pp. 3–77). Cambridge: Harvard University Press.
- Hatcher, Richard John. (2022). *The phonetics and phonology of Cayuga prosody* (Doctoral dissertation). State University of New York at Buffalo.
- Hayes, Bruce. (1980). *A metrical theory of stress rules* (Doctoral dissertation). Massachusetts Institute of Technology.
- Hayes, Bruce. (1989). Compensatory lengthening in moraic phonology. *Linguistic Inquiry*, 20, 253–306.
- Hyde, Brett. (2006). Towards a uniform account of prominence-sensitive stress. In Eric Bakovic, Junko Ito, & John McCarthy (Eds.), *Wondering at the natural fecundity of things: Essays in honor of Alan Prince*. UCSC Linguistics Research Center.
- Hyman, Larry. (1985). *A theory of phonological weight*. Dordrecht: Foris.
- Hyman, Larry. (1992). Moraic mismatches in Bantu. *Phonology*, 9, 255–265.
- Hyman, Larry, & Leben, Robert. (2020). Tone systems. In Carlos Gussenhoven & Aoju Chen (Eds.), *The Oxford Handbook of Language Prosody* (pp. 45–65). Oxford University Press.
- Ito, Junko, & Mester, Armin. (2019). Pitch accent and tonal alignment in Kagoshima Japanese. *The Linguistic Review*, 36(1), 1–24.
- Kenstowicz, Michael. (1997). Quality-sensitive stress. *Rivista di Linguistica*, 9, 157–188.
- Langdon, Margaret. (1977). Stress, length, and pitch in Yuman languages. *Southern California Occasional Papers in Linguistics*, 4, 239–259.
- LeSourd, Philip. (1993). *Accent and syllable structure in Passamaquoddy*. New York: Garland.
- Levinsohn, Stephen H. (1976). *The Inga language*. The Hague: Mouton.
- Mahapatra, B. P. (1979). *Malto: An ethnosemantic study*. Central Institute of Indian Languages.
- McCarthy, John. (1979a). *Formal problems in Semitic phonology and morphology* (Doctoral dissertation). MIT.
- McCarthy, John. (1979b). On stress and syllabification. *Linguistic Inquiry*, 10, 443–465.
- McCarthy, John. (1981). A prosodic theory of nonconcatenative morphology. *Linguistic Inquiry*, 10, 443–466.
- McCarthy, John. (2003). OT constraints are categorical. *Phonology*, 20, 75–138.
- McCarthy, John, & Prince, Alan. (1986). *Prosodic morphology*. University of Massachusetts and Brandeis University.
- McCarthy, John, & Prince, Alan. (1995). Prosodic morphology. In John A. Goldsmith (Ed.), *Handbook of phonological theory* (pp. 318–366). Cambridge, Massachusetts: Blackwell.
- Mellesmoen, Gloria. (2023). Monomoraic syllables with non-moraic vowels in Salish: The structure of a monomoraic syllable in Como-Sliammon reduplication. *WCCFL* 41.
- Milligan, Marianne. (2005). *Menominee prosodic structure* (Doctoral dissertation). U. of Wisconsin.
- Morén, Bruce T. (1999). *Distinctiveness, Coercion, and sonority* (Doctoral dissertation). University of Maryland, College Park.
- Morrison, Heather. (1994). *Morphological influences on Winnebago accent* (Master's thesis). UCLA.
- Munro, Pamela. (1976). *Mojave syntax*. New York: Garland.
- Munro, Pamela, Brown, Nellie, & Crawford, Judith G. (1992). A Mojave dictionary. *UCLA Occasional Papers in Linguistics*, 10.
- Paramore, Jonathan Charles. (2021). *Mankiyali phonology: Description and analysis* (Master's thesis). University of North Texas. <https://digital.library.unt.edu>.



- Piggot, Glyne, & Grafstein, Ann. (1983). *An Ojibwa lexicon*. Ottawa: National Museums of Canada.
- Pikkert, Joost, & Pikkert, Cheryl. (1995). A first look at Tidore phonology. In Wyn Laiding (Ed.), *Descriptive studies in languages of Maluku* (pp. 43–70). Jakarta: Badan Penyelenggara Seri Nusa, Universitas Katolik Indonesia Atma Java.
- Prince, Alan. (1980). A metrical theory of Estonian quantity. *Linguistic Inquiry*, 11, 511–562.
- Prince, Alan, & Smolensky, Paul. (1993/2004). *Optimality Theory: Constraint interaction in Generative grammar*. Malden, Mass: Blackwell Publishers.
- Rasin, Ezer. (2019). Evidence against sonority-driven stress in Nanti. *NELS 49: proceedings of the Forty-Ninth Annual Meeting of the North East Linguistic Society*.
- Robinson, Lila. (1990). *Comanche dictionary and grammar*. Dallas: Summer Institute of Linguistics.
- Rosenthal, Sam, & van der Hulst, Harry. (1999). Weight-by-Position by position. *Natural Language and Linguistic Theory*, 17(3), 499–540.
- Ryan, Kevin M. (2019). *Prosodic weight: Categories and continua* (Vol. 3). Oxford University Press.
- Ryan, Kevin M. (2020). VV > VC > V for stress: Coercion vs. Prominence. *Linguistic Inquiry*, 51(1), 124–140.
- Sapir, Edward, & Swadesh, Morris. (1960). Yana dictionary. *University of California Publications in Linguistics*, 22.
- Sherer, Tim D. (1994). *Prosodic phonotactics* (Doctoral dissertation). University of Massachusetts, Amherst.
- Shih, Shu-hao. (2019a). On the existence of sonority-driven stress in Gujarati. *Phonology*, 35, 327–364.
- Shih, Shu-hao. (2019b). The phonetics and phonology of non-moraic schwas: New evidence from Piuma Paiwan. *Proceedings of the 49th Annual Meeting of the North East Linguistic Society*.
- Shih, Shu-hao, & de Lacy, Paul. (2019). Evidence for sonority-driven stress. *Catalan Journal of Linguistics*, 18.
- Staub, Robert, Becker, Michael, Potts, Christopher, Pratt, Patrick, McCarthy, John, & Pater, Joe. (2010). *OT-Help 2.0 software package*. Amherst, MA: University of Massachusetts Amherst.
- Steriade, Donca. (1991). Moras and other slots. *Proceedings of the Formal Linguistics Society of MidAmerica*, 1, 254–280.
- Topintzi, Nina. (2008). On the existence of moraic onset geminates. *Natural Language and Linguistic Theory*, 26, 147–184.
- Topintzi, Nina. (2010). *Onsets: Suprasegmental and prosodic behaviour*. Cambridge: Cambridge University Press.
- Topintzi, Nina, & Davis, Stuart. (2017). On the weight of edge geminates. In Haruo Kubozono (Ed.), *The phonetics and phonology of geminate consonants* (pp. 260–282). Oxford University Press.
- Tyler, Stephen. (1969). *Koya: An outline grammar*. Berkeley: University of California Press.
- Uchihara, Hiroto. (2013). *Tone and accent in Oklahoma Cherokee*. Oxford University Press.
- Wagner-Nagy, Beáta. (2019). *A grammar of Nganasan*. Boston: Brill.
- Walker, Rachel. (1996). *Prominence-driven stress* [Available on Rutgers Optimality Archive, ROA-172, <http://ruccs.rutgers.edu/roa.html>], University of California, Santa Cruz.
- Zec, Draga. (1994). *Sonority constraints on prosodic structure* (1st ed.). Routledge.
- Zec, Draga. (1995). Sonority constraints on syllable structure. *Phonology*, 12, 85–129.

- Zec, Draga. (2003). Prosodic weight. In C. Féry & R. Vijver (Eds.), *The syllable in Optimality Theory* (pp. 123–144). Cambridge: Cambridge University Press.
- Zec, Draga. (2007). The syllable. In Paul de Lacy (Ed.), *The Cambridge Handbook of Phonology* (pp. 161–198). Cambridge: Cambridge University Press.