Weight-sensitive Primary Stress: a Stringent Analysis of Rime Salience

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1. Introduction

PEAK PROMINENCE (Prince and Smolensky 1993), or PK-PROM, is one of several constraints used to predict sensitivity to syllable weight in prominence-driven stress systems. Its particular role in quantity-sensitive languages is to ensure that the heaviest syllable receives main stress. I argue that PK-PROM should be recast into a set of stringent constraints (a la de Lacy 2002) on rime salience, and that this approach enjoys several empirical and conceptual advantages in analyses of both bounded and unbounded languages.

The structure of this paper is as follows: in section 2, I give a brief overview of PK-PROM and its status in the theory, and raise several conceptual problems associated with it. Section 3 introduces new stringent constraints maximizing the rime salience of the syllable bearing primary stress, and discusses the theoretical background behind stringency and scalar markedness. Section 4 follows up on the implications of these constraints for quantity-sensitive stress, lengthening, and asymmetrical stress patterns. In section 5, I summarize the patterns of weight-sensitive main stress predicted by the new constraints and discuss their distribution. Finally, I will conclude with a discussion of avenues for future work in section 6.

2. PK-PROM's status in Optimality Theory

2.1. Background on PK-PROM

In quantity sensitive languages, stress patterns are coupled with syllable weight: stress is naturally attracted to heavy syllables over light syllables. In a majority of quantity sensitive languages, this weight distinction is strictly binary, with syllable weight broadly categorized as either "heavy" or "light." A smaller group of languages discriminate between three or more levels of weight in their placement of primary stress.

Languages may resolve this weight sensitivity in different ways. In bounded systems, syllable weight is tied to footing: heavy feet are footed; they thereby receive minimally secondary stress and are also eligible for primary stress. Unbounded systems, which presumably have no foot pattern to reference, instead look at gradient qualities of intrinsic prominence in determining stress placement, including levels of sonority, tone or weight. The constraint PEAK PROMINENCE (Prince and Smolensky, 1993) has traditionally been used to analyze unbounded systems where stress is determined on the basis of intrinsic prominence.

(1) PEAK-PROMINENCE (PK-PROM): Peak (x) > peak (y) if |x| > |y|: "The element *x* is a better peak than *y* if the instrinsic prominence of *x* is greater than that of *y*." (Prince & Smolensky 1993: 39)

All else being equal, PK-PROM selects a syllable as the "peak" if it is the most prominent in the word. Each possible peak is compared against the others; a violation is incurred when a peak syllable is selected that is lighter than some other candidate (below, L and H are short for "light" and "heavy").

(2)

/LH/	PK-PROM
a. ˈLH	ˈL !
→ b. LˈH	ˈH

Walker (1997) shows that a factorial typology of PK-PROM, NONFINALITY, and peak alignment constraints successfully predict a wide range of patterns found in unbounded languages. In this analysis, violations of PK-PROM are assigned when the most prominent syllable in the word does not have primary stress (the example below comes from an analysis of Sindhi):

(3)

/LH/	PK-PROM	NONFIN
a. ˈLH	*!	
→ b. LˈH		*

Because PK-PROM does not reference foot structure, the typology shows that it is possible to analyze unbounded languages without having to posit unbounded, non-binary feet, or the alignment of a single foot at the word edge (which incorrectly predicts peninitial stress).

2.2. Overview of the problem

McCarthy (2003) argues that unbounded, gradient constraints are unnecessary and therefore problematic for OT; in fact, in some situations the application of PK-PROM requires just this. This becomes apparent only when the most prominent syllable in the word is ineligible for primary stress by some high-ranking constraint, such as NONFINALITY. Assuming violations are assigned categorically, we might expect all of the remaining syllables to incur one violation of PK-PROM if stressed, since the most prominent syllable does not receive main stress. In a binary weight system, the remaining syllables would tie at PK-PROM, and primary stress would be determined by, for example, a peak alignment constraint. In a ternary weight system, however, the two less prominent syllables might also be unequally prominent, and therefore one should be less optimal than the other. In the tableau below, for example, both 'H and 'L violate PK-PROM once, even though H is technically more prominent than L. This causes candidates (a) and (b) to tie by PK-PROM, and ˈL wins on account of rightward alignment.

(4)

/HLH:/	NONFINALITY	PK-PROM	RIGHTMOST
a. ˈHLH:		*	**!
→ b. HˈLH:		*	*
c. HLˈH:	*!		

This is an unexpected and undesirable result: the pattern we want to capture is that the *heaviest available* syllable wins by PK-PROM, since this is the commonly attested pattern. However, we can generate this result only if we assign violations gradiently:

(5)

/HLH:/	NONFINALITY	PK-PROM	RIGHTMOST
→ a. ˈHLH:		*	**
b. HˈLH:		**!	*
c. HLˈH:	*!		

An additional problem is that it is unclear exactly how languages determine the metrics for prominence. For example, CVVC and CVV are often considered equally prominent, but in some languages, CVVC is more prominent than CVV. One hypothesis is that (quantity-driven) prominence is universally determined on the basis of moriac count: each mora projects a certain amount of grid marks, and PK-PROM simply looks at the height of the grid column to determine the most prominent syllable. In this case, however, it becomes unclear how or why a language would discriminate between CV, CVC and CVV. If prominence is not determined on the basis of mora count, and we have no good language-universal metric to replace it, we are forced to the sad conclusion that language specific prominence scales must be stipulated.

3. Towards a stringent analysis of rime weight

It is often implicitly assumed that PK-PROM can be further broken down into binary constraints for sonority, tone and weight. Binary constraints for sonority and tone have been proposed, but not for weight. In an analysis of sonority driven stress, for example, Kenstowicz (1997) interprets PK-PROM as a family of universally ordered constraints (following Prince & Smolensky 1993), which rank the most marked to least marked sonority values for foot peaks and troughs.

(6) *$\text{Trough}_{\text{Foot}}$/a, ä >> *$\text{Trough}_{\text{Foot}}$/e,o >> *$\text{Trough}_{\text{Foot}}$/i,u (low > high)
*$\text{Trough}_{\text{Foot}}$/a, ä, e, o, i, u >> *$\text{Trough}_{\text{Foot}}$/ə (peripheral > central)
*Pk_{Foot}/i,u >> *Pk_{Foot}/e,o >> *Pk_{Foot}/a, ä
*Pk_{Foot}/ə >> *Pk_{Foot}/a, ä, e, o, i, u

De Lacy (2002) argues that prominence (as it relates to sonority and tone) is best analyzed stringently. The goal of this analysis is to account for languages that conflate categories: instead of “x is always more marked than y,” stringent constraints prevent reversals, i.e. “y is never more marked than x”. Whereas the markedness hierarchy proposed by Kenstowicz (1997) predicts that a language banning stressed [i, u] will shift stress to more sonorous vowels [e, o], de Lacy shows that languages also show a tendency to collapse [i, u, e, o] and treat members of this set as all equally marked. This introduces problems for a universally-ordered constraint set. In stringent constraint families, the most marked element is a subset of every constraint, and is thereby penalized the most heavily; this allows not only for conflation of categories but also obviates the need for a universal ranking.

(7) *Head$_\alpha$/x, *Head$_\alpha$/x•y, Head$_\alpha$/x•y•z
*Nonhead$_\alpha$/x, *Nonhead$_\alpha$/x•y, *Nonhead$_\alpha$/x•y•z

Like the tone and sonority-driven systems analyzed by de Lacy, weight-driven stress systems also seem to follow an implicational hierarchy, suggesting that they might also be amenable to a stringent analysis. The general patterns of weight-driven stress across languages are shown in (8), an adapted diagram from Gordon (2006)[1]. Languages can be (but rarely are) sensitive to all four levels of rime weight. More commonly, however, rime types (for example, VV and VC) group together and behave as if they are equally heavy. They do not show reversals (where e.g. VC is considered heavier than V), a prediction in line with a stringent analysis.[2]

(8) Heaviest Lightest
←--→
VXC VV VC V

Gordon (2004) tested the phonetic properties of 55 weight distinctions across three languages: CVV heavy (Khalkha), CVX heavy (Finnish), and CV < CVC < CVV (Chickasaw). Results showed that languages tended to select weight criteria that resulted in more phonetically effective (energetic) stressed rimes. This phonetic effectiveness was correlated with individual phoneme inventories: languages with a higher ratio of voiced to voiceless consonants, and/or sonorants to obstruents, tended to group CVC into the "heavy" category, since VC rimes were reliably more energetic than V rimes.

The constraints I propose below are intended to capture the sensitivity of primary stress patterns to this implicational hierarchy of rime energy or salience. I suggest that PK-PROM's role in many quantity-sensitive systems can be subsumed by (9a-c), which I call "Rime Salience Constraints" (RSC).

(9a)	*Head$_{PrWd}$/V	Incur a violation if the head of the PrWd has a V-rime.
(9b)	*Head$_{PrWd}$/V•VC	Incur a violation if the head of the PrWd has either a V or VC-rime.

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[1] Gordon (2006) also shows that stress systems are sensitive to whether a coda consonant is [+sonorant] or [-sonorant]: his hierarchy of syllable weight also includes a VR (sonorant coda) > VO (obstruent coda) distinction. It is unclear, however, how to work this into the analysis without predicting unattested patterns, such as a five-way weight distinction between CV<CVO<CVR<CVV<CVXC.

(9c) *Head$_{PrWd}$/V•VC•VV Incur a violation if the head of the PrWd has a V, VC or VV-rime.

Four main results come out of this proposal. First, I test the hypothesis that RSC can account for data in Kelkar's Hindi equally as well as PK-PROM. I will show that PK-PROM's role in quantity-sensitive languages – discriminating between multiple weight levels and selecting the heaviest for main stress – can be straightforwardly handled by the constraints proposed above.

Second, I will demonstrate that gradient assignment of violations is no longer required for ternary systems. Since gradient constraints are argued by McCarthy (2003) to be problematic, this gives RSC a theoretical advantage over PK-PROM.

Third, I will explore the additional predictions made by RSC. We will see that, unlike PK-PROM, they can drive patterns of lengthening that would be otherwise puzzling or difficult to account for, such as heavy syllable lengthening (Dutch), and lengthening in primary-stressed syllables only (Wargamay). I will also discuss the nature of the interaction between rime-salience constraints and constraints on moraic quantity (WSP, SWP), and how data from both Dutch and Kuuku Ya'u bear on this issue.

Finally, I will show that a factorial typology of RSC predicts eight patterns, and that many of these can be shown to map to languages. I will discuss the distribution of the patterns, including why some are rarer than others.

4. Applications of Rime Salience Constraints

4.1. Taking over for PK-PROM in Kelkar's Hindi

PK-PROM has been successful at predicting patterns in a number of quantity-sensitive unbounded languages. This means that any constraint(s) attempting to replace it must account for the same patterns equally well. I have chosen Kelkar's Hindi to show that this is the case, since it involves aspects of quantity sensitivity that cannot be analyzed using existing constraints (WSP, SWP), and therefore is crucially tied to PK-PROM.

Kelkar's Hindi has three levels of syllable weight: CV is light, CVV and CVC are heavy, and CVVC and CVCC are superheavy; main stress is attracted to the heaviest available syllable in the word. In the face of a tie, the default stress pattern is to assign stress to the rightmost nonfinal syllable, as shown by the data in (10) (from Hayes 1995).

(10) Ties are resolved in favor of the rightmost nonfinal candidate

a. [CV.'CV.CV]	[sa'mi.ti]	'committee'
b. ['CVC.CVC]	['qis.mat]	'fortune'
c. ['CVVC.CVVC]	['ro:z.ga:r]	'employment'

The data in (10) indicate that a constraint banning final stress conflicts with a rightward alignment constraint: main stress is clearly right-oriented, but doesn't fall on the last syllable in the word. The analysis here, based on that by Prince & Smolensky (1993), uses the constraints NONFINALITY and ALIGN(Pk, R, PrWd, R):

(11) NONFINALITY: The prosodic head of the word does not fall on the word-final syllable. (Prince & Smolensky 1993; Huang 1994)
(12) ALIGN(PK, R, PRWD, R): For all Peaks there exists some Prosodic Word such that the right edge of the Peak and the right edge of the Prosodic Word are shared. (Walker 1997)

When NONFINALITY >> ALIGN(PK, R, PRWD, R) (henceforth ALIGN-PK-R), the resulting forms have main stress aligned as closely as possible to the right side of the word without being PrWd final. This is the generalization we want to capture for Kelkar's Hindi, which is exemplified in the tableau in (13).

(13)

/samiti/	NONFINALITY	ALIGN-PK-R
a. ˈsa.mi.ti		*!*
→ b. saˈmi.ti		*
c. sa.miˈti	*!	

Failing a tie, main stress is assigned to the heaviest syllable in the word, regardless of its alignment with the right edge. This would normally indicate that PK-PROM >> ALIGN-PK-R. Here, we assume that some subset of RSC dominate ALIGN-PK-R, but the exact rankings will depend on the specific weight criteria in Hindi.

A VVC rime is favored for main stress over a VV rime, as shown in (14). This is expected given the generalization stated above that CVVC is heavier than CVV, and that Hindi stress is sensitive to this weight difference.

(14) ['CVVC.CVV.CVV] ['re:z.ga:ri:] 'small change'

We derive this result by ranking *σ́/V•VC•VV over ALIGN-PK-R. This ensures that the markedness of a primary-stressed CVV will drive a violation of alignment.

(15)

/re:zga:ri:/	*σ́/V•VC•VV	NONFINALITY	ALIGN-PK-R
→ a. ˈre:z.ga:.ri:			**
b. re:z.ˈga:.ri:	*!		*
c. re:z.ga:.ˈri:	*(!)	*(!)	

(16) shows further that ˈCVV is more harmonic than ˈCV. If Hindi conflated CVV and CV, we would expect to find the default pattern, in which the rightmost nonfinal syllable – or penultimate syllable – is stressed.

(16) [CVV.'CVV.CV.CVV] [ka:'ri:ga.ri:] 'craftsmanship'

To account for this, we rank *σ́/V over ALIGN-PEAK-R. This will ensure that light (CV) syllables are unstressed, even if they are better aligned with the right edge.

(17)

/ka:ri:gari:/	*σ́/V	*σ́/V•VC•VV	NONFIN	ALIGN-PK-R
→ a. ka:.'ri:.ga.ri:		*		**
b. ka:.ri:.'ga.ri:	*!	*		*
c. ka:.ri:.ga.'ri:		*	*!	

Now we must determine the ranking of the final constraint, *σ́/V•VC. If *σ́/V, *σ́/V•VC, *σ́/V•VC•VV >> ALIGN-PK-R, Hindi should have *four* levels of rime weight: V, VC, VV, and VXX. However, we know that CVC and CVV are conflated – CVV is not considered heavier than CVC. This indicates that ALIGN-PK-R dominates *σ́/V•VC. No data could be found in Hayes (1995) exemplifying this conflation, so we illustrate with a hypothetical example in (18).

(18) [CVV.'CVC.CVC]

Since VV and VC are considered equally heavy, rightward alignment will *not* be violated in order to stress a VV. We predict this result with the ranking: *σ́/V, *σ́/V•VC•VV, NONFINALITY >> ALIGN-PK-R >> *σ́/V•VC.

(19)

/CVVCVCCVC/	*σ́/V	*σ́/V•VC•VV	NONFIN	ALIGN-PK-R	*σ́/V•VC
→ a. CVV.'CVC.CVC		*		*	*
b. 'CVV.CVC.CVC		*		**!	

A last piece of data in (20) shows that the heaviest syllable is stressed even in violation of NONFINALITY.

(20) [VC.'CVVC] [as'ba:b] 'goods'

If NONFINALITY dominated the constraints on quantity sensitivity, then we would expect the nonfinal syllable to be stressed even when it is the lightest. Since this is not the case, we end up with the final ranking of *σ́/V, *σ́/V•VC•VV >> NONFINALITY (>> ALIGN-PK-R >> *σ́/V•VC).

(21)

/asba:b/	*σ́/V	*σ́/V•VC•VV	NONFIN	ALIGN-PK-R	*σ́/V•VC
→ a. as.'ba:b			*		
b. 'as.ba:b	*(!)	*(!)		*	*

To summarize, a language typically analyzed with PK-PROM, Kelkar's Hindi, can also be easily analyzed using stringent constraints on rime salience.

4.2 Gradient Violations

Recall now that a major criticism of PK-PROM was the requirement that it assign violations gradiently to predict the correct results. Below, (a) wins only if PK-PROM assigns multiple violations to (b).

(22) Gradient assignment of violations

/CVV.CV.CVVC/	NONFINALITY	PK-PROM	ALIGN-PK-R
→ a. ˈCVV.CV.CVVC		*	**
b. CVVˈCV.CVVC		**!	*
c. CVV.CVˈCVVC	*!		

RSC avoids this problem. We can now obtain the desired results straightforwardly without assigning gradient violations. This is because the most marked element -- ˈCV - is penalized three times, once by each constraint. ˈCVV is penalized only once by *σ́/V•VC•VV, so candidate (a) wins over (b).

(23) Categorical assignment of violations

/CVV.CV.CVVC/	NONFIN	*σ́/V	*σ́/V•VC	*σ́/V•VC•VV	ALIGN-PK-R
→ a. ˈCVV.CV.CVVC				*	**
b. CVVˈCV.CVVC		*(!)	*(!)	*	*
c. CVV.CVˈCVVC	*!				

The new constraints proposed can therefore capture three-way weight distinctions without having to assign violations gradiently, which is theoretically advantageous.

4.3. Lengthening
4.3.1. Heavy syllable lengthening in Dutch

The locus of violation for PK-PROM is the peak; consequently, the only possible repair it can drive is the movement of primary stress onto a different syllable. The situation is somewhat different with RSC, repeated here in (24a-c):

(24a) *Head$_{\text{PrWd}}$/V Incur a violation if the head of the PrWd has a V-rime.
(24b) *Head$_{\text{PrWd}}$/V•VC Incur a violation if the head of the PrWd has either a V or VC-rime.
(24c) *Head$_{\text{PrWd}}$/V•VC•VV Incur a violation if the head of the PrWd has A V, VC or VV-rime.

The locus of violation here is a stressed nonprominent syllable. This means that, in addition to pushing stress onto the heaviest syllable, the constraints can drive repairs to make the stressed syllable more prominent. In the case of weight, we might expect lengthening at the site of the main stress if DEP-μ is dominated. Note that SWP can also drive lengthening, but only on "light" (monomoraic) syllables, whereas lengthening in heavy syllables is not predicted to occur.

(25) STRESS-TO-WEIGHT (SWP): Stressed syllables are heavy.

Data from Dutch show that heavy syllable lengthening does indeed occur. Additionally, by revising an existing analysis of Dutch stress by Gussenhoven (1999) (building on the work of others; see below), we can make the correct empirical generalization more elegantly. The Dutch stress system is quite complex, and I will not attempt to resolve all issues here.[3] Rather, I abstract away from some of the details that are not relevant to the discussion at hand, but refer the reader to fuller analyses by Gussenhoven (1999), Kager (1989), Nouveau (1994), and Ostendoorp (1995).

Dutch has a bounded stress system: moraic trochees are formed iteratively from right to left. Main stress usually falls on the final foot, resulting in primarily penultimate stress. As with Hindi, there are multiple levels of weight, and Dutch shows interesting sensitivities to this weight scale.

First, CV syllables are never stressed, due to SWP, which bans any type of stress on light syllables. When a stressed vowel is tense, it lengthens as a repair to increase the syllable weight, as shown below. This shows that SWP >> DEP-μ, since it results in an epenthesized mora. (Note that Dutch does not allow stress clash, so candidates like (c) are banned by *CLASH).

(26) /axata/ → [aˈxa:ta] 'Agatha'

/axata/	*CLASH	SWP	DEP-μ
→ a. a(ˈxa:ta)			*
b. a(ˈxata)		*!	
c.(ˌa:)(ˈxa:ta)	*!		**

Short lax vowels (cited as including [ɪ, ʏ, ɛ, ɔ, ɑ]) do not lengthen. Instead, the onset of the following syllable geminates into the coda of the stressed CV. In Gussenhoven's analysis, this is generated by a high-ranking constraint LAX+C (due to Ostendoorp 1995)[4]:

[3] In particular, I do not address the lexical irregularities cited by Gussenhoven as well as the relation of high vowel length to the segment [r]. It is not clear how the latter relates to processes of lengthening found in words with non-high vowels such as [a] or in words without a [r], such as [ka:pita:l], nor the extent of this phenomenon, so I leave it as an open problem for future work.
[4] It was not clear from the data whether gemination is directly related to stress or not. In all of the examples provided, the geminating syllable is in a stressed syllable; therefore gemination could also be thought of as lengthening due to SWP, and lax vowel lengthening is prevented by some other constraint (banning long lax vowels, for example).

(27) Lax+C: A lax vowel must be monomoraic and be followed by a consonant

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          σ
     ____/ \____
    μ
    |
    [+lax]        [+cons]
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Accordingly, an underlying /CVCV/ word is realized as [ˈCVC.CV] via gemination of the second onset. This repair results in the epenthesis of an additional mora, in violation of Dep-μ. It also results in gemination, which is otherwise prohibited due to *Gem.

(28) *Gem: No geminates.

Therefore Lax+C dominates both *Gem and Dep-μ.

(29) /hɛti/ → [ˈhɛt.ti] 'Hetty' (a girl's name)

/hɛti/	Lax+C	*Gem	Dep-μ
→ a. (ˈhɛt.ti)		*	*
b. (ˈhɛ.ti)	*!		
c. (ˈhɛ:.ti)	*!		*

Interestingly, monosyllabic words with closed syllables also show effects of vowel lengthening: /lat/ is realized as [la:t], despite being heavy, and in theory, capable of bearing stress.

Gussenhoven derives this result using SonPeak, a member of the HNuc constraint family proposed by Prince and Smolensky (1993). The effect of this constraint is to "maximize the sonority of the syllable peak." But this solution seems to miss a larger generalization: heavy syllable lengthening occurs only in stressed syllables, and possibly only in primarily stressed syllables. It is crucially not the case that all syllable peaks are maximized via lengthening. It is also not clear why, if sonority is at stake, we would not observe e.g. vowel lowering. Given the markedness of superheavies, a heavy monosyllabic word such as [vir] might be expected to change to [var], which is more sonorous yet has the same moraic structure as the input, instead of lengthening to [vi:r].

I argue that either *σ́/V•VC or *σ́/V•VC•VV (the choice between the two will be discussed below) can derive this result straightforwardly if it is dominated by Lax+C and dominates Dep-μ. This ranking predicts that tense vowels – even in heavy syllables -- will lengthen to increase the weight of the primary stressed syllable.

(30) /lat/ →['la:t] ‘late’

/lat/	LAX+C	*σ́/V•VC•VV	DEP-μ
a. 'lat		*!	
→ b. 'la:t			*

In (31), the lax vowel /ɑ/ cannot lengthen, or it will violate LAX+C, which outranks *σ́/V•VC.

(31) /lɑt/ → [ˈlɑt] (no gloss provided)

(5b) /lɑt/	LAX+C	*σ́/V•VC•VV	DEP-μ
→ a. 'lɑt		*	
b. ˈlɑ:t	*!		*

This ranking also correctly avoids overgeneration in the cases of forms like [virp] ‘threw’, where vowel lengthening is expected under the alternative analysis. Gussenhoven suggests that an additional constraint *μμμμ, interacts to prevent lengthening here. We can avoid this issue, however, if we assume that vowel lengthening is not required in this case, as *σ́/V•VC•VV is satisfied by a VCC rime.

(32) /virp/ → [virp] ‘threw’

/virp/	LAX+C	*σ́/V•VC•VV	DEP-μ
→ a. ˈvirp			
b. ˈvi:rp			*!

When the final consonant in a coda cluster is extrasyllabic – as is the case with post-consonantal [t, s][5] – the VC rime violates *σ́/V•VC•VV and drives lengthening, as shown in (33).

(33) /fir⟨t⟩/→ [fi:r⟨t⟩] ‘celebrate+3sg-pres’

/fir⟨t⟩/	LAX+C	*σ́/V•VC•VV	DEP-μ
→ a. ˈfi:r⟨t⟩			*
b. ˈfir⟨t⟩		*!	

In addition to driving lengthening, *σ́/V•VC•VV can also push main stress onto a more salient rime (i.e., VXX). We will see that there are situations in which it does exactly this.

[5] Here I follow Booij (1995), who argues for the extrasyllabicity of [t, s] when they follow another consonant.

Before this can become clear, however, we will need to establish the role of other constraints in the metrical system.

First, Dutch has a rule of End Right, but it regularly conflicts with NONFINALITY, banning main stress from the final syllable. Here I use the formulation of RIGHTMOST as defined in Kager (1999), where violations are assigned for every syllable between the head foot and the right edge of the PrWd, although the same results would result from the EDGEMOST formulation (Prince and Smolensky, 1993: 39).

(34) RIGHTMOST / Align(HEADFT,R,PRWD,R)
The head foot is rightmost in PrWd. (Kager 1999)

Secondary stress is freely observed on the final syllable, indicating that *only* final main stress incurs violations, as was the case with Kelkar's Hindi. This leads to words with the following stress pattern:

(35) /maratɔn/ → [ˈma:raˌtɔn] 'marathon'

The heavy final syllable in ['ma:raˌtɔn] is stressed and footed, in accordance with WEIGHT-TO-STRESS (WSP).

(36) WEIGHT-TO-STRESS (WSP): If heavy, then stressed. (Prince 1990)

This rules out candidates (b) and (d) in (37), which have unstressed heavy syllables. Primary stress does not fall on the final syllable, despite this position perfectly satisfying RIGHTMOST; therefore we can conclude that NONFINALITY, *CLASH, WSP >> RIGHTMOST.

(37)

/maratɔn/	NONFINALITY	*CLASH	WSP	RIGHTMOST
→ a. ('ma:ra)(ˌtɔn)				*
b. ma('ra:tɔn)			*!	
c. (ˌma:ra)('tɔn)	*!			
d. ('ma:ra)tɔn			*!	*
e. ma('ra:)(ˌtɔn)		*!		*

With an underlyingly /CV.CVC.CVC/ word, we find the following pattern:

(38) /palɛmbɑŋ/ → [paˈlɛm.bɑŋ] 'Palembang' (place name)

(39)

/palɛmbɑŋ/	NONFINALITY	*CLASH	WSP	RIGHTMOST
a. (ˈpa:lɛm)(ˌbɑŋ)			*	*!
b. pa(ˈlɛm)(ˌbɑŋ)		*!		*
→ c. pa(ˈlɛmbɑŋ)			*	
d. palɛm(ˈbɑŋ)	*!		*	

[(ˈpa:lɛm)(ˌbɑŋ)] ties with the winner [pa(ˈlɛmbɑŋ)] at WSP and ultimately loses by head foot alignment. *CLASH prevents stressing of both heavy syllables in [pa(ˈlɛm)(ˌbɑŋ)] and NONFINALITY again rules out any possibility of main stress on the final heavy in [palɛm(ˈbɑŋ)]. Since the winner incurs a violation of WSP but not NONFINALITY or *CLASH, we can deduce that NONFINALITY, *CLASH >> WSP >> RIGHTMOST.

Now, compare a word ending in a superheavy syllable, in (41), with the form we just saw in (40):

(40) /maratɔn/ → [ˈma:raˌtɔn] ‘marathon’
(41) /kapital/ → [ˌka:piˈta:l] ‘capital’

The final syllable /tal/ is lengthened to [ta:l] and receives primary stress. This example shows first that *σ́/V•VC•VV and not *σ́/V•VC is the relevant constraint; if VV were an acceptable primary stress, then we would expect [ˈka:piˌtal] to win by DEP-μ.

Recall that the lengthening of /lat/ above showed us that [ˈCVVC] is more harmonic than [ˈCVC]. Here, we also see that [ˈCVVC] is more harmonic than [ˈCVV]. Since we have no evidence about whether [ˈCVV] is more harmonic than [ˈCVC], for now we will use just *σ́/V•VC•VV. By ranking *σ́/V•VC•VV above DEP-μ and NONFINALITY, we can predict heavy syllable lengthening, as well as shifting of main stress to the final syllable.

One type of lengthening does *not* occur, however: we do not find forms like ['ka:p.pi.ˌta:l], even though this form would win by NONFINALITY. This indicates that *GEM dominates *σ́/V•VC•VV. Our final rankings, then, are SWP, LAX+C >> *GEM >> *σ́/V•VC•VV >> NONFINALITY (>> WSP >> RIGHTMOST).

(42)

/maratɔn/	SWP	LAX+C	*GEM	*σ́/V•VC•VV	DEP-μ	NONFIN
→ a. 'ma:raˌtɔn				*	*	
b. ˌmara'tɔn	*!			*		*
c. ˌma:ra'tɔn				*	*	*!
d. ˌma:ra'tɔ:n		*!			**	*
e. 'ma:r.raˌtɔn			*!		**	

(43)

/kapital/	SWP	LAX+C	*GEM	*σ́/V•VC•VV	DEP-μ	NONFIN
a. 'ka:piˌtal				*!	*	
b. ˌka:pi'tal				*!	*	*
→ c. ˌka:pi'ta:l					**	*
d. 'ka:p.pi.ˌtal			*!		**	

The approach taken by Gussenhoven (1999) is to posit an additional constraint in the family of WSP, which he terms SUPERHEAVY-TO-STRESS PRINCIPLE (SHSP) formalized as follows:

(44) SUPERHEAVY-TO-STRESS PRINCIPLE (SHSP): Trimoraic syllables are strong foot heads. (Gussenhoven 1999)

If SHSP is similar to WSP, a violation is incurred only if a trimoraic syllable does not bear main stress. Therefore, SHSP cannot be used to drive heavy syllable lengthening. Recall that this is similar to PK-PROM in that stress is attracted to the heaviest syllable, but SHSP is even weaker than PK-PROM. It can't capture the fact that $\acute{\sigma}_{\mu\mu\mu} > \acute{\sigma}_{\mu\mu} > \acute{\sigma}_{\mu}$, much less more subtle differences between CVC and CVV.

There is potentially yet another use of RSC in Dutch. Recall from above that we had no evidence whether ['VV] was more harmonic than ['VC]. In fact, some evidence for this exists:

(45) /ɑrmada/ → [ɑr.'ma:.da] 'id.'

Running this through our constraint rankings, we incorrectly predict the form ['ɑrmaˌda:] to win by WSP, since the attested form has an unstressed heavy.

(46)

/ɑrmada/	SWP	LAX+C	*GEM	*σ́/V•VC•VV	DEP-μ	NONFIN	WSP
→ a. 'ɑrmaˌda:				*	*		
☹ b. ɑr'ma:da				*	*		*!
c. ˌɑrma'da:				*	*	*!	
d. 'ɑ:rmada:		*!		*	**		

If we add in *σ́/V•VC, however, we predict ['VV] to be more harmonic than ['VC]. This is precisely what we need to obtain the correct result, since the attested form has a primary-stressed [VV] rime, against a [VC] rime. *σ́/V•VC is crucially ranked above WSP: as we saw above, a ranking of WSP >> *σ́/V•VC would select candidate (a).

(47)

/ɑrmada/	LAX+C	*GEM	*σ́/V•VC	*σ́/V•VC•VV	DEP-μ	NONFIN	WSP
a. 'ɑrmaˌda:			*!	*	*		
→b. ɑr'ma:da				*	*		*
c. ˌɑrma'da:				*	*	*!	
d. 'ɑ:rmada:	*!			*	**		

In order to avoid generating *['pa:lɛmˌbɑŋ], now, our final ranking of *σ́/V•VC must be below DEP-μ. This ensures that a 'VV rime is preferred to a 'VC rime, but only when if it doesn't affect the overall number of epenthesized moras. The choice between ['ɑrmaˌda:] and [ɑr'ma:da] ties at DEP-μ, since one mora is epenthesized in either form. But in the case of ['pa:lɛmˌbɑŋ] and [pa'lɛmbɑŋ], the former would require an epenthesized mora, and the latter would not.

(48) /palɛmbɑŋ/ → [paˈlɛm.bɑŋ] 'Palembang' (place name)

/palɛmbɑŋ/	LAX+C	*GEM	*σ́/V•VC•VV	DEP-μ	*σ́/V•VC	NONFIN	WSP
a. 'pa:lɛmˌbɑŋ			*	*!			*
→b. pa'lɛmbɑŋ			*		*		*

The approach taken by Gussenhoven is to assume that closed syllables preceding main stress are monomoraic, so [ɑr] in [ɑr'ma:da] does not violate WSP. This is an interesting example of the advantage of separating rime salience from moraic quantity: although moraic quantity and rime salience usually dovetail, there could be cases where CVC is moraically equivalent to CVV, but its rime is considered less salient. This is precisely the case for Dutch, where we see lengthening and stress driven by both types of weight, but in different ways. This gives the outward appearance of variable CVC weight, which would seem to be problematic for moraic theory. In this analysis, however, Dutch CVC and CVV are uniformly bimoraic, but differ in the inherent salience of their rime, obviating the need for a stipulative constraint such as the following:

(49) WbP': From the main stress onward, a coda consonant projects a mora (Gussenhoven 1999)

To summarize, Dutch is an interesting case study in how RSC can work together with constraints governing moraic quantity-sensitivity, WSP and SWP, causing complex interactions between stress and weight. We saw that the newly proposed constraints are the only ones that can drive heavy syllable lengthening, and, as with Hindi, can also cause stress to shift to the heaviest available syllable. In the next section we will see that they can also act *independently* of SWP, resulting in asymmetrical lengthening in primary stressed syllables only.

4.3.2. Asymmetrical lengthening in primary-stressed syllables

In the last section, we saw RSC pair with SWP in Dutch, resulting in lengthening in both primary and secondary stressed syllables, but to different degrees. While SWP drove general lengthening, RSC drove heavy syllable lengthening. This section focuses on a slightly different prediction made by the constraints: lengthening in primary stressed syllables only, when RSC operates independently from SWP.

We will look at two cases of asymmetric lengthening highlighted in McGarrity (2003) to see what happens when we get the following ranking: RSC >> DEP-μ >> SWP. This ranking can be found in Wargamay, a bounded trochaic language with vowel lengthening, and Kuuku Ya'u, an unbounded prominence-driven language with consonant gemination.

4.3.2.1 Vowel lengthening in Wargamay

An example of asymmetrical stress is given in McGarrity's analysis of Wargamay, based on data by Dixon (1981), in which it is shown that primary stressed syllables undergo lengthening, but secondary stressed syllables do not. Such lengthening cannot be predicted with the constraint STRESS-TO-WEIGHT, which should drive lengthening in all stressed syllables; it also cannot be predicted by iambic lengthening, since Wargamay is not iambic.

Wargamay is analyzed by Hayes (1995) as a quantity-sensitive trochaic language that constructs feet from right to left. Main stress generally falls at the left edge and degenerate feet are banned. Syllables with underlying long vowels attract main stress from the peninitial syllable in odd-syllabled words:

(50)	/gagara/ → [ga.'ga.ra]	'dilly bag'
(51)	/gi:bara/ → ['gi:ba.ra]	'fig tree'

Dixon (1981) notes an additional rule of lengthening in primary stressed syllables (indicated with a · symbol).

(52)	/gagara/ → [ga.'ga·.ra]	'dilly bag'
(53)	/giɟawulu/ → ['gi·ɟaˌwu.lu]	'freshwater jewfish'
(54)	/muŋanda/ → [mu'ŋa·n.da]	'mountain-LOC'
(55)	/ɟuɽagaymiri/ → [ɟu'ɽa·.gayˌmi.ri]	'Niagara-Vale-FROM'

Separate from the other facts of Wargamay stress, primary stress lengthening indicates that *σ́/V•VC >> DEP-μ. Below, lengthened candidate (a) wins over (c) because it avoids giving a light syllable primary stress. The ranking DEP-μ >> SWP bans general lengthening, eliminating candidate (b).

(56)

/giɟawulu/	*σ́/V•VC	DEP-μ	SWP
→ a. 'gi·ɟaˌwu.lu		*	*
b. 'gi·ɟaˌwu·.lu		**!	
c. 'gi.ɟaˌwu.lu	*!		**

Note that the use of *σ́/V•VC instead of *σ́/V predicts that CVC syllables will also undergo lengthening. This is indeed what we observe in forms like [mu'ŋa·n.da], where a primary stressed CVC incurs a fatal violation of *σ́/V•VC.

(57)

/muŋanda/	*σ́/V•VC	DEP-μ	SWP
→ a. mu'ŋa·n.da		*	
b. mu'ŋan.da	*!		*

Because primary stressed syllables have long vowels without exception, *σ́/V•VC and *σ́/V are undominated. By contrast, a VV-VXX weight distinction is not made, indicating that *σ́/V•VC•VV is at the bottom of the rankings. Its position below DEP-μ, or *GEM, ensures that 'CVV syllables will not undergo e.g. gemination to become superheavy.

To summarize briefly, the ranking of RSC >> DEP-μ >> SWP predicts lengthening in primary stressed syllables. The particular choice of RSC constraint determines the extent of lengthening: above, both open and closed syllables undergo lengthening. It would be equally plausible, however, to imagine a language where only open (CV) syllables undergo lengthening, indicating *σ́/V >> DEP-μ >> SWP, *σ́/V•VC, *σ́/V•VC•VV.

4.3.2.2. Gemination in Kuuku Ya'u

A similar case study is presented in McGarrity's analysis of Kuuku Ya'u, based on data by Thompson (1976). Here CV and CVC are light syllables, while CVV and CVVC are heavy. Primary stress falls on the rightmost heavy:

(58a)	/pa:la/	→	['pa:la]	'behind'
(58b)	/kula:n/	→	[ˌku'la:n]	'possum'
(58c)	/mu:ma:ɲa/	→	[ˌmu:'ma:ɲa]	'rub'
(58d)	/tawura:lu/	→	[ˌtawu'ra:lu]	'with a knife'

Since primary stress is oriented towards the right edge, but such orientation is violable, we can posit here that *σ́/V•VC >> ALIGN-PK-R.

(59)

/pa:la/	*σ́/V•VC	ALIGN-PK-R
→ a. 'pa:la		*
b. pa:'la	*!	

If there are no long vowels, primary stress falls on the initial syllable:

(60a) /kulkul/ → ['kulkul] 'skin/bark'
(60b) /kunpantin/ → ['kunpantin] 'flog'

The "else leftmost" nature can be captured by the constraint COINCIDE($\acute{\sigma}_{\mu}$, leftmost(σ, word)), proposed by Zoll (1996) and applied by Walker (1997) to Kuuku Ya'u. This constraint is violated by a stressed light syllable that does not fall at the left edge of the prosodic word.

(61) COINCIDE($\acute{\sigma}_{\mu}$, leftmost(σ, word)
- (i) For all x (x is a stressed light syllable) → there exists y (y = leftmost(σ, word) ∧ coincide (x, y))
- (ii) Assess one mark for each value of x for which (i) is false.

If COINCIDE($\acute{\sigma}_{\mu}$, PRWD) dominates ALIGN-PK-R, main stress will forgo rightward alignment when it falls on a monomoraic syllable.

(62)

/kulkul/	*$\acute{\sigma}$/V•VC	COINCIDE($\acute{\sigma}_{\mu}$, PrWd)	ALIGN-PK-R
→ a. 'kul$_{\mu}$kul$_{\mu}$	*		*
b. kul$_{\mu}$'kul$_{\mu}$	*	*!	

Note additionally that all "strong" syllables have either primary or secondary stress:

(63) /mu:ma:ɲa/ → [ˌmu:'ma:ɲa] 'rub'

This indicates that WSP forces stress on all bimoraic syllables, even though the resulting stress causes stress clash.

(64)

/mu:maɲa/	WSP	*CLASH
→a. ˌmu:$_{\mu\mu}$'ma:$_{\mu\mu}$ɲa		*
b. mu:$_{\mu\mu}$'ma:$_{\mu\mu}$ɲa	*!	

The stress facts outlined so far clearly support the fact that CVC is light: as we saw above, heavy syllables have either primary or secondary stress (repeated in 65a). But the data below show that CVC syllables in (65b) may be unstressed, patterning with CV syllables.

(65a) /<u>mu:</u>ma:ɲa/ → [<u>ˌmu:</u>'ma:ɲa] 'rub'
(65b) /kul<u>kul</u>/ → ['kul<u>kul</u>] 'skin/bark'

Even though CVC syllables are considered light for secondary stress assignment, McGarrity (2003) reports that primary stressed CV syllables undergo gemination from the following onset. That is, a /CV.CV/ word will become ['CVC.CV] via gemination. Unlike Wargamay, vowels do not lengthen, presumably because vowel length is phonemic in Kuuku Ya'u and lengthening would neutralize this contrast.

(66a) /waliʔi/ → ['wal.li.ʔi] 'spotted lizard'
(66b) /miyumana → ['miy.yu.ma.na] 'be angry'
(66c) /wukuturu/ → ['wuk.ku.tu.ru] 'coral cod'

Consonant lengthening is strictly limited to primary stress – it does *not* occur in secondary stressed syllables. Below, the gemination into the initial secondary stressed syllable is not possible in (67). Therefore we know that *σ́/V – not SWP – drives lengthening by dominating *GEM.

(67) /miya:ɲina/ → [ˌmi.'ya:.ɲi.na], *[ˌmiy.'ya:.ɲi.na] 'show himself'

The example in (68) shows us additionally that CVV syllables are exempt from gemination, so *GEM must dominate *σ́/V•VC•VV.

(68) /tawura:lu/ → [ˌta.wu.'ra:.lu], *[ˌta.wu.'ra:l.lu] 'with a knife'

Finally, primary stressed monomoraic (CV/CVC) syllables are always at the left edge of the word. If CV and CVC are both monomoraic, as claimed, then this should mean that we find /CVCVC/ becomes ['CVC.CVC] and not [CV.'CVC], even though the latter avoids a geminate coda and satisfies *σ́/V. This indicates that COINCIDE($\acute{\sigma}_{\mu}$, PRWD) also crucially dominates *GEM. (No specific data are given in McGarrity 2003 to illustrate this point, so we use a hypothetical example here).

(69)

/CVCVC/	COINCIDE($\acute{\sigma}_{\mu}$, PRWD)	*σ́/V	*GEM	*σ́/V•VC•VV
a. 'CV$_{\mu}$.CVC$_{\mu}$		*!		*
b. CV$_{\mu}$.'CVC$_{\mu}$	*!			*
→ c. 'CVC$_{\mu}$.CVC$_{\mu}$			*	*

These data present an interesting puzzle, however: as with Wargamay, we see effects of lengthening in primary stressed syllables only, presumably to increase the weight or prominence of the primary stressed syllable. But CVC syllables are considered light according to stress assignment rules, so in theory gemination shouldn't make a difference here. McGarrity analyzes this as a case of "Weight-by-position by position" (Rosenthall and van der Hulst, 1999), where the weight of a closed syllable may fluctuate depending on its position in the word.

I suggest that, as with Dutch, the variable behavior of CVC highlights an important characteristic of Rime Salience Constraints: they do not look at moraic count to determine prominence. Their aim is simply to maximize the perceptual salience of the primary stressed rime, which can be accomplished by coda gemination. Lengthening may or may not result in an additional mora, depending on the language – this is beside the point. In contrast, general constraints on quantity-sensitivity – including WSP and SWP – are binary because they are tied to moraic count. They are satisfied when a bimoraic syllable is stressed, and violated when a monomoraic syllable is stressed. Interestingly, the variable behavior of CVC syllables has also been analyzed by Lunden (2006) as resulting from phonetic and perceptual factors in a study of Norwegian final lengthening.

To conclude, RSC can account for asymmetrical consonant lengthening in Kuuku Ya'u. The data further show that Kuuku Ya'u is similar to Dutch, in that moraic quantity and rime salience are not perfectly aligned, resulting in seemingly inconsistent weight patterns. Recall that in Dutch, CVC and CVV were moraically equivalent, but CVV was considered perceptually more salient. In this case, CVC is moraically equivalent to CV, but considered perceptually more salient than CV. Both of these cases were analyzed previously as exceptions to general WEIGHT-BY-POSITION, but these cumbersome exceptions are potentially unnecessary assuming the analysis presented here.

5. Factorial Typology

Having looked in depth at the application of Rime Salience Constraints to weight-driven stress in Hindi, Dutch, Wargamay and Kuuku Ya'u, I now turn to a bigger-picture discussion of the patterns predicted by these constraints. A factorial typology computed on OTSoft reveals that we predict exactly eight patterns of weight-driven primary stress. For example, in type (1) languages, all four rime structures will be treated as differently weighted; main stress prefers VXX, then VV, then VC, then V. In (2), VV and VXX are conflated, so for purposes of primary stress V < VC < VV, VXX.

	Rime salience conflation	*Language*	*No VXX syllables*
1	V < VC < VV < VXX (quaternary)	Puular (Wiltshire 2006) Dutch (Gussenhoven 1999)	Chickasaw (Gordon 2004)
2	V < VC < VV, VXX (ternary)	Kashmiri (Bhatt 1989) Klamath (Hayes 1995) Kuuku Ya'u (McGarrity 2003)	
3	V < VC, VV < VXX (ternary)	Hindi (Prince & Smolensky 1993)	Sindhi Yana (Hyde 2006)
4	V < VC, VV, VXX (binary)	Carib (?) (Dixon & Aikhenvald, 1999)	
5	V, VC < VV < VXX (ternary)		
6	V, VC < VV, VXX (binary)	Khalkha, Buriat (Walker (1997) Wargamay (McGarrity 2003)	

7	V, VC, VV < VXX (binary)	Stony Dakota (Shaw 1985)
8	V, VC, VV, VXX	Main stress insensitive to rime salience (any quantity-insensitive language)

Figure 1. A Factorial typology of rime weight in main-stressed syllables

These patterns were determined by using input containing all possible syllable types (including VXX). Note, however, that languages with no VXX rimes can be cross-classified in several patterns. For example, patterns (1) and (2) are indistinguishable except for their treatment of VXX rimes; if a language has no VXX rimes, then it is not clear whether they fall into (1) or (2).

For some patterns, no relevant languages could be found. I tentatively group Carib into pattern (4), since the description of it hints that it is an unbounded language where CVC, CVV and CVXX are all heavy syllables attracting main stress, but no relevant data are given to exemplify this. However, it seems likely that a language fitting this pattern can be found, since Gordon (2006) cites CVV(C), CVC as the second most common weight distinction used by stress systems.

Pattern (5), on the other hand, could be exceptionally difficult to find: if V and VC pattern together, moraic theory predicts VV and VVC to also pattern together, since codas should be uniformly either moraic or nonmoraic. So for the majority of languages, where moraic weight and rime salience pattern together, this pattern may not apply. It may be possible to find languages with a ternary vowel length distinction (for example, Estonian) that influences main stress placement. The general rarity of documented unbounded systems with a three-way weight distinction, and additional markedness of VXX syllables, also makes it difficult to confirm or reject this possibility.

6. Conclusion and Further Work

A proposal of Rime Salience was put forth in attempt to solve some of the conceptual problems associated with PK-PROM. It was shown that a stringent reformulation of PK-PROM, where violations are assigned categorically, could also account for unusual patterns of lengthening in several bounded and unbounded languages. We further established that the division of prominence from moraic quantity could account for the seemingly variable weight of CVC syllables, previously accounted for by a positing position-specific moraic quantity. Finally, we looked at the predicted conflation patterns in weight-sensitive stress, including attested and currently unattested ones.

The assumptions underlying this proposal are that there is a fundamental division between moraic weight and salience-based weight. Additionally, they predict that primary stress may show unique sensitivities to gradient measures of rime prominence/weight that are absent in secondary stressed syllables. Work by McGarrity (2003) suggests that primary stressed syllables are the “strongest of the strong” and therefore may be subject to constraints that do not apply to weaker positions such as secondary stress. However, the particular salience patterns advocated here are untested with regard to secondary stress, so it remains to be seen whether rime salience is also important in this domain.

Another potential avenue for future work is a closer look at the *DTE, *-DTE (Designated Terminal Element) notation used by de Lacy (2002). Although he shows that sonority-driven stress is sensitive to both Head and Nonhead constraints, it is unclear whether such symmetry exists for weight-sensitive primary stress as well. In particular, is there a place for *Nonhead$_{PrWd}$ constraints on rime salience (which predict neutralization of a prominent syllable without main stress)? Additionally, if we intend to incorporate secondary stress into the *DTE notation, *Head$_{Foot}$ might undergenerate, since prominence based systems are potentially footless.

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