Vowel Length-Driven Syllable Weight

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0. Introduction

The formal notion of syllable weight has been proposed in order to account for so-called quantity-sensitive (henceforth QS) phonological processes, such as reduplication, word-minimality conditions, compensatory lengthening (henceforth CL), and stress assignment, which are sensitive to the internal structures of a syllable rather than its segmental properties. In such processes, CVC syllables pattern together with either CVV syllables or CV syllables, but CVV syllables never pattern with CV syllables. Accordingly, CVV syllables and CV syllables are called heavy and light respectively, but CVC syllables count as either heavy or light depending on what type of syllable they group with. In order to account for such patterning of syllables, moraic theory (Hyman 1985, McCarthy and Prince 1986, Hayes 1989, 1995) proposes the notion of syllable weight based on mora count: a syllable with two morae is defined as heavy and a syllable with one mora is defined as light. It claims that morae are assigned to nuclei, optionally to coda consonants, but never to onsets. It automatically captures a general tendency that onsets are inert in QS processes.[1] It predicts that CVV syllables with two nucleus slots are invariably heavy, CV syllables with one nucleus slot are invariably light, thus formally accounting for their distinctive patterning. Yet, it does not explicate why the distinction between CVV and CV is sensitive only to certain--specifically QS--processes. The weight of CVC syllables is predicted to be either heavy or light: the rule "weight by position (Hyman 1985)," which assigns a mora to a coda consonant, is optional. Moraic theory, however, does not reveal why and where CVC syllables group wit either CVV or CV syllables. It merely stipulates

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[1] See Davis (1985) and Goedemans (1996) for onset-sensitive stress-systems.

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that CVC syllables are heavy because they are bimoraic, and light because they are momomoraic.

This paper proposes that the primary determinant of syllable weight relevant for stress is phonetic vowel length. I argue that CVV syllables are the best stress targets since long vowels provide the best opportunity to realize the phonetic properties of stress; their longer duration allows the realization of pitch contours which are the major cue to stress. The longer the vowel, the better chance that a pitch contour marking stress will be perceived. Accordingly, in languages with phonemic vowel length, long vowels are better stress targets than short vowels (Khalkha, Hayes 1981). In languages lacking long vowels, low vowels (Chuvash, Kenstowicz 1996) or full vowels (Eastern Cheremis, Kiparsky 1973) are better stress targets than non-low vowels or reduced vowels, since the former have longer duration than the latter.

I further propose that the so-called weight of CVC syllables in QS stress systems follows from a phenomenon of stress avoidance of CV syllables. This proposal is based on 5 independent observations: (i) CVC syllables attract stress over CV syllables only in specific positions: initial, penult and final. (ii) Syllables in initial, penult, and final positions are longer than syllables in other positions (Oller 1973, Klatt 1975, D'imperio and Rosenthall 1997) (iii) Stressed vowels are longer than unstressed vowels (Lehiste 1970). (iv) Vowels in open syllables are longer than vowels in closed syllables (Maddieson 1984), and (v) CVC syllables count as heavy in languages with phonemic vowel length (de Chene and Anderson 1979). The first observation is based on my extensive survey of QS stress systems, and the other 4 observations have been made in the phonology and phonetics literature. Pulling all observations together, I claim that when stress targets word-edge or near word-edge positions with a positional lengthening effect, then CV syllables will undergo extreme vowel lengthening by the cumulative effects of positional and stress-induced lengthening. I propose that such extra lengthening may jeopardize perceived contrast between long and short vowels. As a strategy for maintaining the vowel length contrast, a language may shift stress off a CV syllable in the stress target position at the word-edge, locating it instead on the adjacent word-internal syllable. On the other hand, CVC syllables are not subject to the same degree of phonetic lengthening as CV syllables due to the closed syllable shortening effect. Thus, CVC syllables can maintain their phonemic vowel length even under stress, and therefore make better targets than lengthened CV syllables.

Section 1 remarks on moraic theory and its problems with syllable weight. Section 2 classifies QS languages based on stress position and observes the restricted distribution of heavy CVC syllables. Section 3 explains why CVC syllables should attract stress over CV syllables in certain positions. Section 4 argues for the role of vowel duration in determining syllable weight for QS stress systems. In section 5 and 6, I present constraints relevant to stress assignment and analyze stress patterns of Khalkha and Latin in the framework of Optimality Theory.

1. Syllable Weight: Previous Analyses

Certain phonological processes are sensitive to the internal structure of a syllable rather than to its segmental qualities. For example, stress in Latin (Steriade 1988) falls primarily on penultimate CVV and CVC syllables. When penultimate syllables are CV, stress retracts onto antepenultimate syllables. Reduplicants in Mokilese (Harrison 1976) should be CVV or CVC syllables. When the base morpheme is a monosyllabic CV sequence, a short vowel in the reduplicant undergoes lengthening. In Lardil (McCarthy and Prince 1993) only CVV(C) monosyllabic words are allowed, but not CVC and CV monosyllabic words. To describe these patterns, the notion of phonological weight has been invoked. CVV syllables are termed as heavy, CV syllables are termed as light, and CVC syllables can be either heavy as in Latin and Mokilese, or light as in Lardil.

In order to account for such patterning of syllables, moraic theory proposes the notion of syllable weight based on mora count, by which syllables with two morae count heavy and syllables with one mora count as light. A mora, a phonological unit of weight, is claimed to be assigned obligatorily to nuclear segments and optionally to coda consonants by a "weight by position" rule. Therefore, CV syllables are monomoraic light and CVV syllables are bimoraic heavy, but CVC syllables are either bimoraic or monomoraic depending on whether the language-specific 'weight by position' rule is active or not.

Accordingly, moraic structure varies from language to language. Yet, the language specific structure of syllable weight was claimed to hold throughout all phonological processes such as CL, stress assignment, minimal word requirements and templates for reduplication (Hayes 1989). Hayes argues that CL is not a language-specific phonological rule, rather it is an automatic result of a universal convention which conserves mora count. For example, in Latin the segment /s/ was lost. The loss of coda /s/ leads to the lengthening of its preceding vowel, but not of the onset /s/ (Ingria 1980). This asymmetry between onset and coda positions is automatically captured since mora is never assigned to onsets under moraic theory. The loss of segment /s/ in coda position involves the loss of a mora, and CL occurs to compensate for this mora loss. In contrast, the loss of onset /s/ does not involve any loss of mora, and, therefore, there is no need for CL.

According to moraic theory, if CL is induced by the loss of a coda, the coda is moraic. If not, then the coda is not moraic. Ultimately, this approach does not predict when and where a coda loss will induce CL. As pointed out in Prince (1987), CL shows up in a variety of languages that lack stress and thus lack metrical structure. Most languages with a QS stress system do not undergo coda loss. There is no way to prove or disprove that a single notion of syllable weight is relevant for both CL process and stress assignment, and that CL occurs in order to preserve the number of morae. Some languages like Finnish do not have CL even if a moraic segment is deleted, long vowels exist, and the relevant deletion processes exist. Hayes argues that such cases arise because CL is optional. Furthermore, within a single language (e.g. Turkish, Sezer 1986), some deletion rules, such as *h*-deletion, induce CL but others, such as morphological vowel deletion, do not. For such cases, Hayes claims that there is no CL if the deletion rule

applies to an entire segment including a mora. It seems that there is no way to falsify the claim that CL occurs to preserve mora count.

Hayes (1995) proposes a two-layered moraic structure, where the weight of CVC syllables differ from a high layer to a low layer, in order to account for the duality of syllable weight. For example, CVC syllables in Tu□batulabal count as light for stress assignment but as heavy for the purpose of reduplication (Crowhurst 1991). In Ancient Greek, CVC syllables are heavy for stress, but are light for minimal word requirements (Steriade 1990). CVC syllables count as heavy for metrics but are light for stress in Telugu (Gordon 1997). Hayes claims that certain phonological processes are sensitive to the higher moraic layer and others are sensitive to the lower moraic layer. The two-layered moraic structure, however, does not predict which phonological processes are sensitive to a high-layer moraic structure or a low-layer moraic structure. Furthermore, stress in Morwin, Kobon, and Eastern Cheremis indicates that vowel qualities like vowel height can also determine syllable weight (Kenstowicz 1996). Stress in Klamath requires the ternary distinction of syllable weight, where both CVV and CVC syllables are heavy but CVV syllables are heavier than CVC syllables.

All problems under moraic theory stem from the assumption that there is a single weight structure functioning for all phonological processes. In this paper, I claim that the notion of syllable weight should be defined differently depending on the phonological process involved. Relevant for stress, I propose that syllable weight is determined solely by phonetic vowel length. Long voweled syllables are heavier or better stress targets than short voweled syllables since the former have a longer vowel duration than the latter. This paper proposes that the heaviness of CVC syllables is a consequence of stress avoidance of CV syllables and an epiphenomenon of preservation of vowel length contrasts. The next section focuses on the distribution of heavy CVC syllables among 5 independent observations which lead to the above proposals.

2. Restricted Distribution of heavy CVC syllables[2]

A survey of 90 languages with a QS stress system reveals the asymmetry between CVV and CVC syllables in terms of their distribution: heavy CVV syllables may appear in any position in a word, while heavy CVC syllables appear only near or at word-edge positions. In other words, in unbounded QS stress systems, where stress falls on the rightmost, leftmost, or non-final rightmost heavy syllable, the heavy syllable refers only to CVV syllables, never to CVC syllables.[3] Languages in (1) stress the heavy syllable in the unbounded way.

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[2] This survey is confined to primary stress. I assume that primary stress assignment is independent from secondary stress assignment, since they have different functions. Primary stress has demarcative and culminative functions (Martinet 1960) so that they prefer to reside on word-edge positions and long voweled syllables. On the other hand, secondary stress has rhythmic function which concerns the interval between two stress peaks.

[3] To the best of my knowledge, there are two apparent counter-examples to my claim that CVC heavy syllables occur only near word-edge positions. First, although there are many conflicting descriptions on Hindi stress (Kelkar 1968, Pandey 1989, Shukla 1990), CVVC syllables in Hindi attract stress over CVV

(1) Languages with an unbounded QS stress system: Stress the leftmost/ rightmost/ nonfinal rightmost heavy syllable.
Aguatec, Selkup, Au, Buriat, Chuvash, Eastern Cheremis, Lhasa Tibetan, Maori, Mari, Morwin, Lushootsee, Western Cheremis, Huasteco, Kara, Kuuku-Ya?u, Komi, Kora, Thitian, Khalkha, Klamath, Southern Sierra Miwok, Mam, Murik.

In the 24 languages in (1), all heavy syllables refer to long voweled syllables. Not even one of these languages counts CVC syllables as heavy. This is a significant observation since it has never been noticed that CVC syllables do not count as heavy in unbounded QS systems. It should be questioned why CVC syllables do not count as heavy in unbounded systems.

In bounded QS stress systems, CVC as well as CVV syllables count as heavy. There are 6 major patterns as shown in (2). The underlined languages count CVC and CVV syllables as heavy, while the other languages only count CVV syllables as heavy.

(2) Languages with a bounded QS stress system
- i) Stress the first syllable if it is heavy; otherwise, the second is stressed.
Southeast Thepehuan, Hopi, Pacific Yupik, Wargamay, Luganda, Maidu, Ossetic, Sierra Miwok
- ii) Stress the second syllable if the first syllable is light and the second syllable is heavy.
Gurkhali, Malayalam, Yil
- iii) Stress the penultimate syllable if it is heavy; otherwise, the antepenultimate syllable is stressed.
Arabic (Maltese, Tunisan, Egyptian, Syrian, Jordanian, Bedouin, Bani-Hassan), Latin, English, Klamath, Passamquiddy

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syllables no matter where they are positioned within a word. Surprisingly, the experimental study on Hindi stress by M. Ohala (1977) reveals that stress is manifested by pitch change, not by increased duration. According to Ohala, stressed vowels are as long as unstressed vowels, but stressed vowels generally have a rising pitch and constantly precede a falling pitch. Given that stress-accent languages mark stress by vowel duration and energy whereas pitch-accent languages like Japanese mark accent mainly by pitch change (Beckman 1986), Hindi might not be a stress language at all, but instead be a pitch-accent language.

The second counter-example is the stress pattern of K'wakwala (Bach 1975, Stonham 1994). Stress in K'wakwala falls on the leftmost heavy syllable, otherwise the final syllable is stressed. Long voweled syllables (CVV) and syllables with a sonorant coda (CVM) are grouped as heavy, but syllables with an obstruent coda count as light. It seems to be contradictory to my proposal that vowel length determines syllable weight. Actually, my proposal does predict the stress pattern of K'wakwala. In section 5, I propose Target constraint hierarchy (1), by which vowels are the best stress targets and other sonorants are the second best stress targets. Because nasals and liquids are periodic sounds which can manifest pitch contour without interruption, even if not as clear as vowels. Therefore, we can expect a language where both Target (N and L) as well as Target (V) are undominated so that all sonorants are stress targets. In such languages, stress would be sensitive to the whole rime duration when sonorants are in a coda position.

iv) Stress the final syllable if it is heavy; otherwise, the penultimate syllable is stressed.
Tongan, Manam, Rotuman, Kawaiisu, Tol, Setani, Berguner-Romansh, Ancient Greek, Diegueno, Fijian, Hawaiian, Inga, Mam, Tiberian Hebrew

v) Stress the final syllable if the penultimate is light and final is heavy; otherwise, the penultimate is stressed.
Maithili, Awadhi, Southwest Tanna, Aklan, Lenakel, Yapese

vi) Stress one of the last two syllables whichever is heavier.
Asheninca, Kobon, Greek

In the 6 bounded types, CVC syllables count as heavy only in types (i, iii, iv, and v) where the primary stress target is initial, penultimate or final position. In other words, CVC syllables attract stress over CV syllables only in one of three positions: initial, penultimate and final. In types (ii) and (vi) where the primary stress target is the second syllable or either one of last two syllables, only long voweled syllables count as heavy.

The above survey reveals that CVC heavy syllables are restricted in their distribution to the three positions, initial, penultimate and final, while CVV heavy syllables can occur in any position of a word. Even though stress pattern in Klamath is a mixed pattern of an unbounded and a bounded stress system, it supports the restricted distribution of CVC heavy syllables. In Klamath (Levin 1985), stress falls on the rightmost long voweled syllable. If there is no long voweled syllables, then the heavy penultimate syllable (CVC) is stressed. Otherwise, stress falls on the antepenultimate syllable. This pattern exactly shows that CVV syllables count as heavy in the unbounded way and CVC syllables count as heavy in penultimate position, in the bounded way. The restricted distribution of CVC heavy syllables is not expected under moraic theory.

From this significant observation, we may conclude that only CVV syllables are true and primary stress attractors. In section 4, I will argue that long voweled syllables are the best stress targets because long vowel duration can manifest phonetic properties of stress best. The next section presents why ĆVC syllables which have relatively short vowel duration attract stress over CV syllables in the three positions: initial, penultimate and final, based on the 5 independent observations mentioned earlier.

3. Why CVC syllables attract stress over CV syllables

We have seen that CVC syllables count as heavy only in three positions: initial, penultimate and final. These three positions have been noted as positions with extra length. Many studies (Oller 1973, Klatt 1975, Crystal and House 1990, and Wightman et all 1992) demonstrate that there is vowel lengthening in word-final or phrasal-final positions cross-linguistically, regardless of the size of words or phrases and regardless of stress. There are other kinds of positional lengthening, which seem to be sensitive to the stress position for the majority of words in a language. Tarnoczy (1965) reports that Hungarian, whose main stress falls on initial syllables, has a lengthening effect toward both

edges of a word: medial syllables tend to be the shortest.[4] Languages which have predominantly penultimate stress tend to lengthen penultimate vowels. A stressed syllable in penultimate position is significantly longer than a stressed syllable in other positions in Chamorro (Chung 1983), Italian (D'imperio and Rosenthall 1997) and Cebuano (Shryock 1993). It seems that word-final lengthening is cross-linguistically common, while word-initial lengthening and penultimate-lengthening depend on the stress pattern of a language. It now becomes clear, then, that the positions of heavy CVC syllables coincide with the positions of vowel extra lengthening.

The other three observations relevant for my proposal are well-known facts. First, stressed vowels are longer than unstressed vowels. At this point, we might suppose a language whose stress falls on one of the positions with extra vowel lengthening effects. In such languages, stressed vowels would be extremely long by the cumulative effects of positional lengthening and stress-induced lengthening. Second, vowels in closed syllables are shorter than vowels in open syllables as attested in Dutch, English and Russian, Finnish, Korean, Thai, and others (Maddieson 1984). Maddieson argues that the closed syllable shortening effect is cross-linguistically common. Consequently, we might predict that stressed vowels in closed syllables would not undergo the same extreme vowel lengthening as stressed vowels in open syllables would undergo in the same positions.

The above prediction turns out to be true. In the languages Cebuano, Chomorro, and Italian, whose stress falls on the penultimate syllable in the majority of words, stressed open penultimate vowels are extreme long, but stressed closed penultimate vowels are not. Since these languages do not have phonemic long vowels, the extreme long stressed penultimate open vowels are sometimes considered as the only long vowels in the languages. D'imperio and Rosenthal (1997) report their experimental result that in Italian, stressed open penultimate vowels are extremely long, compared to stressed closed penultimate vowels and stressed vowels in other positions. Their report clearly reveals positional lengthening effects, closed syllable shortening effects, and the cumulative effects of positional lengthening and stress-induced lengthening.

None of the three languages, Cebuano, Chomorro, or Italian, has phonemic long vowels. What if this extreme stressed open penultimate vowel lengthening were to languages with phonemic long vowels? I predict that the extreme vowel lengthening of stressed penultimate CV syllables by the accumulative effects of positional lengthening and stress-induced lengthening would lead to neutralization of phonemic vowel length. I claim that as a strategy to maintain phonemic vowel length, CV syllables avoid stress under extreme vowel lengthening condition. As a result, only CVC and CVV syllables receive stress in the target position, and the stress retracted from CV syllables moves to an adjacent position where there is no, or less, positional lengthening effect. For example, in

[4] Kirchner (1997) argues that word-initial and phrasal-final vowel lengthening is a cross-linguistically common phenomenon and that these partial lengthening effects are responsible for the restricted vowel centralization of Nawuri, a Kwa language of Ghana, where short non-back vowels are centralized except in word-initial or phrasal-final position. He proposes two constraints Word-Initial Lengthening and Phrase-Final Lengthening.

Latin, stress falls on penultimate syllables if they are heavy, CVV or CVC, syllables. Otherwise, stress falls on antepenultimate syllables. This stress pattern results exactly from stress avoidance of CV syllables in the penultimate position. Otherwise, stressed penultimate CV syllables would neutralize phonemic vowel length by their extreme long vowel duration. The stress repelled from penultimate CV syllables is realized in antepenultimate position, where there is no positional lengthening effect.

In sum, stress attraction of CVC and CVV syllables over CV syllables in positions with extra lengthening effects is a consequence of a strategy of phonemic vowel length preservation. This account automatically and correctly predicts that CVC syllables count as heavy in positions with extra lengthening effects: initial, penultimate and final, and in languages with phonemic long vowels.[5] Under moraic theory, the restricted distribution of CVC heavy syllables cannot be accounted for without stipulations. In the next section, I show why CVV syllables count as heavy in any position of a word, unlike CVC syllables. I propose that CVV syllables are the best stress targets since long vowels manifest phonetic properties of stress the best.

4. Vowel Length-Driven Syllable Weight: the best stress targets are CVVs

Stress is manifested by increased vowel duration, pitch change and increased intensity (Lehiste 1970). In this section, I claim that the three acoustic correlates of stress play a role in determining targets of stress, and I further propose relevant constraints in the framework of Optimality Theory. First, pitch helps to determine stress targets. Pitch is the subjective, psychological sensation of sound frequency, and it has positive correlation with fundamental frequency, the rate of repetition of a repeating waveform. A low frequency sound is perceived as a low pitch and a high frequency is perceived as a high pitch. Among speech sounds, only voiced sounds, which are produced with the vibration of the vocal folds, tend to have periodic sound waves. Fricative sounds obstruct airflow above the glottis, and produce aperiodic sound at the point of constriction. Stops, especially phonetically unvoiced ones, also give rise to aperiodic sound on the release of stop closure. Voiced fricatives and affricates have mixed periodic and aperiodic sound waves (Borden and Harris 1984). Given that pitch is the major cue for stress, sonorants such as vowels, glides and nasals will be good sites for manifestation of stress. Among sonorants, vowels are the best target for stress since they have the highest intensity. Vowels have higher energy and richer harmonic structure than other sonorants like laterals and nasals, and therefore constitute the best sites to realize a pitch change. Combining these two factors, pitch and intensity, I propose a hierarchy of Target (Stress) constraints in (3), by which vowels, liquids and nasals, voiced obstruents and voiceless obstruents are suitable targets for stress in the order given.

[5] It has been reported that a few languages (Aljutor, Inga and Maidu) consider CVC syllables as heavy without CVV syllables. I expect that a further study on phonetic manifestation of stress in those languages in terms of pitch and intensity as well as vowel duration will provide an answer to the problematic pattern of such CVC syllables with respect to stress.

(3) Target (Stress) Constraint Hierarchy I
Stress/Vowels > Stress/L&N > Stress/Voiced Obstruents > Stress/Voiceless Obstruents

The Target constraint hierarchy preferentially locates stress peaks on vowels. Languages such as K'wakwala (Bach 1975) or Klamath (Barker 1964) distinguish glottalized vowels from plain vowels and they never put stress on glottalized vowels. This is not surprising since glottalized vowels have irregular pitch perturbation, which hinders the perception of pitch (Rosenberg 1965, Silverman 1995). This evidence points to the importance of pitch realization for the manifestation of stress. In summation, the pitch quality of sounds designates modal vowels as stress targets.

Next, I claim that vowel duration determines syllable weight relevant for stress. Stress placement prefers to reside on long vowels over short vowels. The claim is based on an observation that certain duration is required for a pitch contour to be perceived. Experimental studies of the effects of duration on pitch perception (Liang and Chistovich 1960, Henning 1970) suggest that shorter vowels require larger fundamental frequency differences to be perceived as different in pitch. Accordingly, the longer the vowel duration is, the better the pitch contour can be perceived. This proposal predicts that in languages with phonemic vowel length, long vowels are better stress targets than short vowels. In languages lacking long vowels, low vowels or full vowels are better stress targets than non-low vowels or reduced vowels, since the former have longer duration than the latter.[6] This prediction turns out to be true. In QS stress systems, heavy syllables always refer to long voweled syllables. For example, stress in Khalkha falls primarily on long vowels. If there is no long vowel, then a short vowel is stressed. On the other hand, in languages without long vowels, stress prefers to fall on a syllable with a full, low, or non-high vowel primarily and, as a default, on a syllable with a reduced vowel or a high vowel. Eastern Cheremis locates stress on the rightmost syllable with a full vowel. If a word contains only reduced vowels, then the initial syllable is stressed. Stress in Chuckchee distinguishes non-high vowels from high vowels and schwa from the rest. Stress falls on the heaviest of the two final syllables of a base. These non-structural and multiple weight distinctions cannot be accounted for under moraic theory.[7] To accommodate the effects of vowel duration, I propose another Target (Stress) constraint hierarchy (4). Although the hierarchy (4) is a part of Target constraint hierarchy (3), I distinguish them for the sake of convenience. According to this hierarchy, long vowels are the best targets.

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[6] Beckman (1986) states that other things being equal, a low vowel is longer than a high vowel, since low vowels involve larger articulatory movements from and to the surrounding consonantal constrictions.

[7] Kenstowicz (1996) proposes sonority-driven syllable weight exclusively for the languages whose stress is sensitive to vowel qualities. However, he does not capture the fact that vowel length is a factor for distinguishing long vowels from short vowels and non-low vowels from high vowels. However, all the weight distinctions shown in these three languages are accounted for by Target (Stress) constraint hierarchy in (2).

(4) Target (Stress) hierarchy II
Stress/VV > Stress/V (Stress/Low V > Stress/Mid V > Stress/High V > Stress/Reduced V)

In this section, I have proposed that vowels are the best stress targets among sounds due to their pitch quality, and that long vowels are better targets than short vowels since longer vowel duration better accommodates more pronounced pitch contours. The next section introduces a set of constraints relevant to stress.

5. Constraints for vowel length-driven syllable weight

Besides Target (Stress) constraints, I present constraints relevant to stress. First, the Lengthening (Stress) constraint in (5) requires a stressed vowel to be longer than its corresponding unstressed vowel.

(5) Lengthening (Stress): A stressed vowel is longer than its unstressed counterpart.
(6) Final-Lengthening (Kirchner 1997): Vowels are partially lengthened in word-final position
(7) Initial-Lengthening (Kirchner 1997): Vowels are partially lengthened in word-initial position
(8) Penult-Lengthening: Vowels are partially lengthened in word-penultimate position

Constraints from (6) to (8) are Positional-Lengthening constraints which capture the vowel lengthening effect on three positions: initial, penultimate, and final. These constraints play a different role from Lengthening (Stress). The Penultimate-Lengthening constraint forces a vowel in penultimate position to lengthen regardless of whether the vowel is stressed or not. On the other hand, Lengthening (Stress) makes a vowel lengthen under stress no matter where the vowel is positioned. Constraints (5-8) are all subphonemic constraints. When stress falls on positions where positional lengthening constraints (6 to 8) are effective, the vowel lengthening effects by position and stress can be cumulative and induce the suspension of phonemic contrast for vowel length. That is, the conjunction of two subphonemic constraints can affect the phonemic system.[8]

A conjunctive constraint (9) captures the cumulative lengthening effect and it conflicts with a faithfulness constraint (10) which requires the phonemic contrast of vowel length to be maintained.

(9) Lengthening (Position & Stress): Vowels undergo an extreme lengthening in a particular position under stress.
(10) Contrast (Vowel Length): The phonemic contrast of vowel length is maintained.

[8] Subphonemic constraints help to account for phonological processes as asserted in Ohala (1983), Steriade (1993), Silverman (1995), and Kirchner (1997).

Cross-linguistically, penultimate extreme lengthening occurs only on open stressed syllables. Closed syllables never undergo penultimate extreme lengthening. This asymmetry between open and closed syllables is forced by the Shortening (Closed) constraint in (11), which compels a closed vowel to shorten, and therefore protects such vowels from extreme lengthening.

(11) Shortening (Closed): A vowel in a closed syllable is shorter than a vowel in an open syllable.[9]

6. Case Studies: Khalkha and Latin

In Khalkha the first long vowel in a word is stressed (12a), otherwise the initial syllable is stressed (12b).

(12) Kenstowicz (1994:582)

a.	bariˈaad	'after holding'
	xoyərduˈgaar	'second'
	gaˈraasaa	'from one's own hand'
b.	ˈali	'which'
	ˈxətəbərə	'leadership'

The left-orientation of stress arises from the Align (Left) constraint in (13), which requires to locate a prosodic head to the left-edge of a word. Align (Left) can be violated to satisfy the higher ranking constraint Target (Stress/VV) in (14), which requires a prosodic head to locate on long voweled syllables. As a result, stress may fall on non-initial syllables if they are the first long voweled syllables in a word.

(13) Align Left (H, Prwd): Align a prosodic head to the left-edge of a word.
(14) Target (Stress/VV): The prosodic head (stress) targets the long voweled syllable.

Tableaux (15) and (16) show how stress is assigned to the words *gaɬaasaa* 'from one's own hand' and *ˈali* 'which'. In Tableau (15), candidate (a) surfaces as the optimal output, by satisfying the constraints best among the candidates. Candidate (b) is ruled out by violating the higher-ranked Target (Stress/VV). Candidate (c) is ruled out by violating Align (Left) one more time than the optimal output. In the case of *ɬali*, candidate (16b) is ruled out because it incurs a violation of Align (L), which the optimal output (16a) satisfies, even though both candidates violate Target (Stress/VV) once each. As a result, candidate (16a) surfaces.

[9] Shortening (Closed) constraint ranks relatively low in mora-timed languages such as Japanese (Homma 1981), which has no vowel shortening in closed syllables.

(15)

	Target (Stress/VV)	Align (Left)
# a. ga'raasaa		*
b. 'garaasaa	!*	
c. garaa'saa		* !*

(16)

	Target (Stress/VV)	Align (Left)
# a. 'ali	*	
b. a'li	*	!*

Therefore, the stress pattern of Khalkha is accounted for by the interactions of the two constraints Target (Stress/VV) and Align (Left).

In Latin (Steriade 1988), stress falls on the penultimate syllable if it is CVV or CVC. Otherwise, the antepenultimate syllable is stressed. In other words, stress falls on the penultimate syllable except when the penultimate is an open short syllable.

(17) Hayes (1995:91)
a.'miikus
'simulaa
do'mestikus

Penultimate-oriented stress is enforced by the interaction between Nonfinality (18) and Align (R) (19). When Non-finality is higher-ranked than Align (R), then stress falls on the penultimate syllable, as in (20).

(18) Nonfinality (Prince & Smolensky 1993): The prosodic head of the word does not fall on the word-final syllable.[10]

(19) Align R (H, PrWd): Align the prosodic head to the right edge of a prosodic word.

(20)

	Nonfinality	Align (R)
a. CVCVC 'CV	!*	
# b. CV 'CVCCV		*
c. 'CVCVCCV	!*	* !*

In tableau (20), candidate (a) is out because it violates the undominated Nonfinality and candidate (c) is out because it violates Align (R) twice. The higher ranking of Nonfinality over Align (R) assigns stress to penultimate syllables.

[10] See Walker (1996) for phonetic reinterpretation of the Nonfinality constraint.

As shown by the data in (17), stress falls on the antepenultimate syllable when the penultimate syllable contains a short open vowel. Antepenultimate stress arises from the outranking of the conjunctive constraint Lengthening (Penult & Stress) (9), Contrast (Vowel length) (10), and Nonfinality (18) over Align (R). Tableau (21) shows why stress is assigned to the antepenultimate syllable when the penultimate is a short open vowel syllable.

(21)

	Nonfinality	Lengthening (P&S)	Contrast (VL)	Align (R)
# a. ˈCVCVCV				**
b.CV ˈCV[11]CV			!*	*
c. CV ˈCVCV		!*		
d. CVCV ˈCV	!*			

Three candidates (b, c, and d) are ruled out by violating one of the higher-ranked three constraints, Nonfinality, Lengthening (P&S) and Contrast (VL). Candidate (b) violates Contrast (VL) by its overlong penultimate short vowel. Candidate (C) violates Lengthening (P&S) by keeping its short vowel duration. Candidate (d) violates Nonfinality by locating stress on its final syllable. As a result, candidate (a) turns out to be the optimal output by satisfying all three high-ranked constraints, Nonfinality, Lengthening (P & S), and Contrast (VL), even if it incurs two violations of Align (R).

Tableau (22) shows that the Shortening (Closed) constraint in (11) outranks Lengthening (P&S) since penultimate CVC syllables receive stress by keeping their short vowel duration, with violation of Lengthening (P&S) and satisfying Shortening (Closed) constraints. Candidate (b) is ruled out by violating the undominated Shortening (Closed) and Candidate (a) surfaces as the output with the violation of a lower-ranked Lengthening (P&S).

(22)

	Shortening (Closed)	Lengthening (P&S)
# a. CV ˈCVCCV		*
b. CV ˈCVCCV	! *	

The stress pattern in Latin shows that the dominance of Lengthening (P&S), Contrast (VL) and Nonfinality over Align (R) accounts for the antepenultimate stress when penultimate syllables are short open. The dominance of Shortening (Closed) over Lengthening (P&S) tells why CVC syllables receive stress in the penultimate position.

[11] Underlined vowels stand for vowels which undergo extreme lengthening in order to satisfy the conjunctive constraint Lengthening (Penult & Stress).

7. Conclusion

I have argued that phonetically long voweled syllables are the true stress attractors and define heavy syllables, since long vowel duration allows for the best realization of phonetic properties of stress. On the other hand, CVC syllables attract stress over CV syllables because CV syllables avoid stress in the stress target position. Otherwise, CV syllables would undergo extreme vowel lengthening by the accumulative effects of positional lengthening and stress-induced lengthening, which may lead to neutralization of phonemic vowel length. CVC syllables are protected from this extreme vowel lengthening due to the closed syllable shortening effect. This perspective on the weight of CVC syllables accounts for the restricted distribution of heavy CVC syllables: CVC syllables count as heavy in certain positions where positional lengthening effects have been reported, and CVC syllables count as heavy in languages with phonemic vowel length.

References

Bach, E. 1975. Long vowels and stress in Kwakiutl. Texas Linguistic Forum 2: 9-19.

Barker, Chris. 1964. Klamath Grammar. University of California Publications in Linguistics 32. Berkeley: University of California Press.

Beckman, Mary. 1986. Stress and Non-stress Accent. Dordrecht-Holland: Foris Publications.

Borden Gloria J. and Katherine S. Harris. 1984. Speech Science Primer. Williams & Wilkins.

Chung, Sandra. 1983. Transderivational relationships in Chamorro phonology. Language 59: 35-66

Crowhurst, Megan. 1991. Demorification in Tûbatulabal: evidence from initial reduplication and stress. In Northeastern Linguistic Society 21: 49-63.

Crystal, T. H. and A. S. House. 1990. Articulation rate and the duration of syllables and stress groups in connected speech. Journal of the Acoustical Society of America 83: 1553-1573.

D'imperio M. and Sam Rosenthall. 1997. Phonetics and phonology of main stress in Italian. Presented at Mid Continental workshop of Phonology 3.

Davis, Stuart M.1985. Topics in Syllable Geometry. Doctoral dissertation. University of Arizona: Tucson.

De Chene, E. G. and S. R. Anderson. 1979. Compensatory lengthening. Language 55, 505-535.

Goedemans, Rob. 1996. Syllable weight and prominence. Stress Patterns of the World. Holland Academic Graphics: The Haugue.

Gordon, Matthew. 1997. A Phonetically-driven account of syllable weight. Ms. UCLA.

Harrison, Sheldon. 1976. Mokilese Reference Grammar. University of Hawaii Press.

Hayes, Bruce. 1981. A Metrical Theory of Stress Rules. Doctoral dissertation. MIT: Cambridge.

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. Linguistic Inquiry 20: 253-306.

Hayes, Bruce. 1995. Metrical Stress Theory. University of Chicago Press.

Henning, G. Bruce. 1970. A comparison of the effects of signal duration on frequency and amplitude discrimination. In The Proceedings of the International Symposium on Frequency Analysis and Periodicity Detection in Hearing: 350-359.

Homma, Y. 1981. Durational relationships between Japanese stops and vowels. Journal of Phonetics 9:273-281.

Hyman, Larry. 1985. A Theory of Phonological Weight. Publications in Language Sciences 19. Foris: Dordrecht.

Ingria, Robert. 1980. Compensatory lengthening as a metrical phenomenon. Linguistic Inquiry, 11, 3, 465-495

Kelkar, Ashok. 1968. Studies in Hindi-Urdu I: Introduction and word Phonology. Poona: Deccan College.

Kenstowicz, Michael. 1994. Phonology in Generative Grammar. Blackwell: Oxford.

Kenstowicz, Michael. 1996. Sonority-driven stress. ms., MIT.

Kiparsky, P. 1973. Elsewhere in phonology. In s. Anderson and P. Kiparsky (eds.) A Festschrift for Morris Halle. New York: Holt, Rinehart and Winston.

Kirchner, R. 1997. Contrastiveness and Faithfulness. Ms. UCLA

Klatt, Dennis. 1975. Vowel lengthening is syntactically determined in a connected discourse. Journal of Phonetics 3: 129-140.

Lehiste, Ilse. 1970. Suprasegmentals. MIT press.

Levin, Juliette. 1985. A Metrical Theory of Syllabicity. Doctoral dissertation. MIT.

Liang, Chih-an, and L. A. Chistovich. 1960. Frequency difference limens as a function of tonal duration. Soviet Physics-Acoustics 6: 75-80.

Maddieson, Ian. 1984. Phonetic cues to syllabification. In UCLA Working Papers in Phonetics 59: 85-101.

Martinet, A. 1960. Elements of General Linguistics. Chicago: University Press.

McCarthy, John and Alan, Prince 1986. Prosodic morphology. Ms. Dept. of Linguitics. University of Massachusetts: Amherst.

McCarthy, John. and Alan. Prince. 1993. Prosodic morphology I: constraint interaction and satisfaction. Ms. University of Massachusetts, Amherst, & Rutgers University.

Ohala, J.1983. The origin of sound patterns in vocal tract constraints. The production of Speech. New York: Springer.

Ohala, M. 1986. A search for phonetic correlates of Hindi stress. South Asian Languages: structure, convergence and diglossia. Delhi: Motilal Banarsidass: 81-100.

Oller, O. K. 1973. The effect of position in utterance on speech segment duration in English. Journal of the Acoustical Society of America 54: 1235-1247.

Pandey, P 1989. Word Accentuation in Hindi. Lingua 77: 37-73.

Prince, Alan. 1987. Planes and copying. Linguistic Inquiry 18: 491-510.

Prince, Alan and Paul Smolensky. 1993. Optimality theory: constraint interaction in generative grammar. ms.

Rosenberg, A. 1965. Pitch discrimination of jittered pulse trains. JASA 39: 920-28.

Sezer, E. 1986. An Autosegmental anlysis of compensatory lengthening in Turkish. Studies in Compensatory Lengthening. eds. by L. Wetzels and E. Sezer: 227-250.

Shryock, Aaron. 1993. A metrical analysis of stress in Cebuano. Lingua 91: 103-148.

Shukla, S. 1990. Syllable structure and word stress in Hindi. Georgetown Journal of Language and Lingusitics 1: 235-247.

Silverman, Daniel. 1995. Phasing and Recoverability. Doctoral dissertation. UCLA.
Steriade, Donca. 1988. Greek accent: a case for preserving structure. Linguistic Inquiry 19:271-314.
Steriade, Donca. 1990. Moras and other slots. In Proceedings of the Formal Linguistics Conference of the Midwest.
Stonham, John. 1994. All moras are not created equal. In Cashiers Linguistiques d'Ottawa 21: 1-25
Tarnoczy, T. 1965. Can the problem of automatic speech recognition be solved by analysis alone? Rapports du 5 Congres International d'Acoutique, *Vol. II*: 371-387.
Walker, Rachel. 1996. Prominence-driven stress. Ms.
Wightman, Colin W., Stefanie Shattuck-Hufnagel, Mari Ostendorf, and Patti J. Price. 1992. Segmental durations in the vincinity of prosodic phrase boundaries. Journal of the Acoustical society of America 91: 1707-17.

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