The Weight of Final Syllables in English

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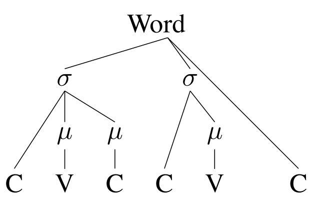
1. Weight at the right edge

Many languages exhibit a CVC weight asymmetry: (C)VC is considered a heavy syllable shape but it behaves as a light syllable word-finally.[1] Because the languages in question generally treat codas as weight-bearing, moraic theory (Hyman 1985, McCarthy and Prince 1986, Hayes 1989) must be augmented to deal with the weight difference of a CVC syllable in word-final position.

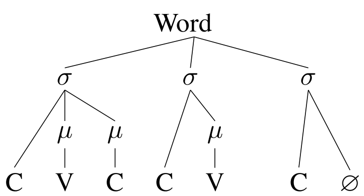
One approach is to treat the final consonant as extrametrical (Mohanan 1979, Steriade 1980). Given that some languages (such as Latin) completely discount the final syllable for metrical structure (that is, exhibit final syllable extrametricality), the option to discount the final consonant is a plausible extension. This structure is illustrated in (1), where the final consonant is treated as if it were not part of the final syllable, and is instead attached to the prosodic structure only at the word level.

(1) Word-final C extrametricality



A similar proposal treats the final consonant as the onset of a final catalectic, or degenerate, syllable (Kiparsky 1991). Here the consonant is not extrametrical, but because the nucleus of the degenerate syllable is empty, the syllable does not play a role in any metrical structure. The final consonant does not contribute weight, as it is an onset, not a coda, as illustrated in (2).

(2) Catalectic final syllable



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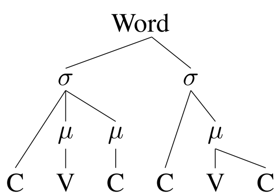
[1] e.g. Arabic (McCarthy 1979), English (Chomsky and Halle 1968), Estonian (Prince 1980), Greek (Steriade 1980), a dialect of Hindi (Hayes 1981, citing Mohanan 1979), Icelandic (Kiparsky 1984), Menomini (Hayes 1995), Norwegian (Kristoffersen 1991), Ponapean (McCarthy and Prince 1986), Romanian (Steriade 1984), Swedish (Riad 1992), and Swiss German (Spaelti 1994).

Both of these proposals treat the final consonant as structurally different in some way that correlates with the weight of the final (non-degenerate) syllable. Both are formal solutions, however, rather than phonetically-grounded ones, as the final consonant is pronounced as part of the final (non-degenerate) syllable. A third proposal provides a phonetic link. Broselow et al. (1997) found a significant correlation between the weight of a syllable and the duration of its components. For example, in Hindi, which has a three-way weight distinction, a long vowel has statistically the same duration in both an open syllable and in a closed one, which results in a VVC rhyme being significantly longer than a VC rhyme. On the other hand, in Jordanian Arabic, which has only a two-way weight distinction, a long vowel in an open syllable is significantly longer than a long vowel in a closed syllable. Broselow et al. use these finding to motivate three moras for a VVC rhyme in Hindi but only two moras for a VVC rhyme in Jordanian Arabic, with the second mora shared between the vowel and the coda. Employing this, we might then suspect that languages that exhibit the CVC weight asymmetry have a VC rhyme that is notably shorter than a non-final VC rhyme, which would motivate a structure as in (3), where the segments of a word-final VC rhyme share a single mora.

(3) Word-final mora-sharing C



Comparison of rhyme durations across different positions of the word would be a possible extension of Broselow et al.'s work. The theory would predict that a final VC would have a shorter duration than a non-final VC; however, phonetic work on syllable duration by position finds that final syllables have *longer* durations than non-final syllables. This is due to the effects of final lengthening at the word level (Lindblom 1968). A comparison of VC rhyme duration across positions, then, seems unlikely to motivate mora sharing by the word-final rhyme segments.

1.1. Capturing English stress in OT

The metrical structure of English is generally taken to consist of moraic trochees from the right (e.g. Hammond 1999). The system exhibits the CVC weight asymmetry since a final CVC syllable behaves as though it were light and fails to form a moraic trochee on its on, as final heavy syllables do. English does not have contrastive vowel length, but tense vowels behave as heavy (e.g. Halle 1977) and so are characterized as bimoraic, whereas lax vowels are light and are therefore monomoraic.

In (4) we see that verbs and adjectives can be characterized as receiving final stress if the final syllable is heavy (first two columns) and penultimate stress if the final syllable is light (last column), where VC behaves as light, despite having two segments in the rhyme.

(4) English verbs and adjectives exhibit the CVC weight asymmetry

CVV(C)#		CVCC#		CV(C)#	
[oʊ.béɪ]	'obey'	[tɔr.mɛ́nt]	'torment'	[ə.stá.nɪʃ]	'astonish'
[ə.láʊ]	'allow'	[ju.sə́rp]	'usurp'	[də.vɛ́.ləp]	'develop'
[də.váɪn]	'divine'	[roʊ.bʌ́st]	'robust'	[ká.mɪn]	'common'
[də.skrít]	'discreet'	[oʊ.və́rt]	'overt'	[ʌ́l.trə]	'ultra'

This pattern has been captured in Optimality Theory (Prince and Smolensky 1993) by employing the constraint NONFINALITY in conjunction with an extrametrical or catalectic structure (shown in (1) and (2)). I will follow Rosenthall and van der Hulst (1999) in assuming a structure as in (1), where a word-final consonant is appended to the prosodic word (also see Sherer 1994, Rubach and Booij 1990), but there is nothing crucial in the choice of (1) over (2).

(5) NONFINALITY: No head of a prosodic word is final in the prosodic word (Prince and Smolensky 1993)

(6) RIGHTMOST: Align the right edge of the head foot to the right edge of the prosodic word (McCarthy and Prince 1993)

(7) *APPEND-TO-PRWD: No consonant appended to the prosodic word (Rosenthall and van der Hulst 1999)

A language in which final consonants do not contribute to syllable weight (but other coda consonants do) can then be captured by having NONFINALITY undominated, but ranking RIGHTMOST over *APPEND-TO-PRWD, causing the "buffer" between the final foot and the right edge to be truly minimal. This is illustrated in (8).

(8) English verbs and adjectives: consonant-final (*contruct*)

/kʌnstrʌkt/	NON FINALITY	RIGHT -MOST	*APPEND-TO PRWD
☞ a. kən.(strʌ́k).t		t	*
b. kən.(strʌ́kt)	*!		
c. (kʌ́n).strəkt		s,t,!r,ə,k,t	

Candidate (a) wins, even though it has an appended consonant, because this structure allows the best satisfaction of RIGHTMOST, given the high ranking of NONFINALITY. NONFINALITY cannot be undominated in English, however, since we find final stressed diphthongs. In such cases the ranking in (8) makes the wrong prediction.

(9) FOOTBIN: Feet must be binary

(10) English verbs and adjectives: vowel-final (*allow*)

/ʌlaʊ/	NON FINALITY	FOOT BIN	RIGHT -MOST	*APPEND-TO PRWD
☹ a. ə.(láʊ)	*!			
b. ə.(lá).ʊ		*!	ʊ	*
☞ c. (ʌ́.la).ʊ			ʊ	*

Here, candidate (c) incorrectly wins, since NONFINALITY is undominated. It is a puzzle why final stress is allowed in this case. Hammond (1999) solves this problem by breaking up NONFINALITY in a way that references syllable shape. He proposes that NONFINALITY for VC rhymes is undominated but that NONFINALITY for VV rhymes is dominated by RIGHTMOST (NONFIN(VC) >> RIGHTMOST >> NONFIN(VV)).

While this does produce the attested pattern, it raises the question of why NONFINALITY should be sensitive to syllable shape. Is there a reason why, if there is a difference, it's always the consonant-final rhymes that behave as light? Final consonant extrametricality is common, but final mora extrametricality is rare or non-existant (Hayes 1995), and final vowel extrametricality is unknown.

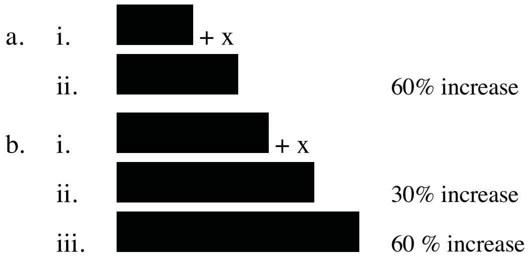
2. Proportional increase theory of weight

Lunden (2006) shows that the rhymes of heavy syllables in Norwegian have a consistent proportional increase over the rhyme of a CV syllable in the same position. Using highly-controlled nonce words (*katapa* with different rhyme shapes) in a carrier phrase, rhyme durations were measured and compared to a short, unstressed V rhyme in the same position of the word. The raw durations differed significantly by word-position: all word-final durations were greater than their non-final counterparts due to word-level final lengthening. However, it was found that the average proportional increase of a larger rhyme over a V rhyme was notably consistent across positions, with the exception of VC rhymes.

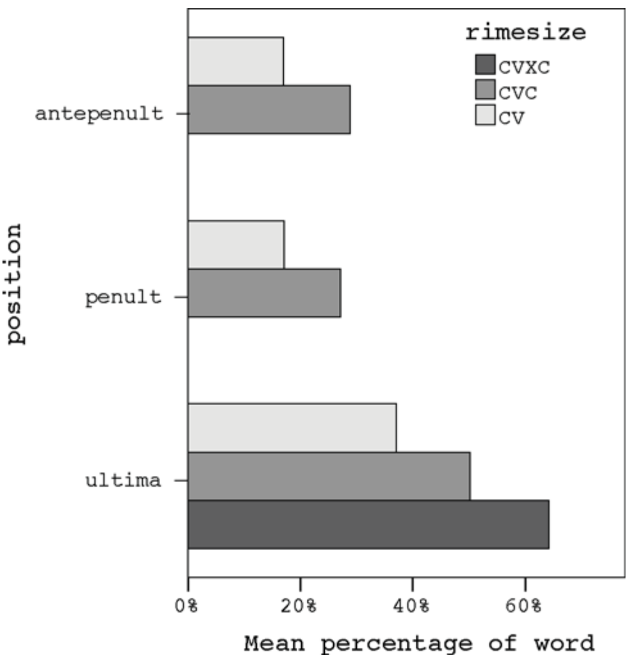
Lunden therefore proposed that there is a minimum proportional increase threshold related to syllable weight. Because the point of comparison, a V rhyme, is notably longer word-finally due to final lengthening, a word-final syllable will need to be strikingly longer to reach the same proportional increase found non-finally. This agrees with Weber's Law, which encodes the finding that in humans, perceptual increases work on a scale of proportional increases, rather than on a scale of raw increases.

The difference between a consistent raw increase and a consistent proportional increase is illustrated schematically in (11) and with respect to Norwegian rhyme durations in (12) (where rhyme durations were divided by length of word to control for rate of speech).

(11) The same raw increase has a lesser effect on larger amounts (Weber's Law)



(12) Rime/word percentage by syllable position and size



In (11), (a-ii) and (b-ii) have the same raw addition of length ("x") to (a-i)/(b-i) but the difference between (a-i) and (a-ii) seems greater than between (b-i) and (b-ii). This is because the proportional increase is twice as great. Because (b-i) started out as longer, the same difference (shown in (b-ii)) does not have as perceptually big an effect. We need quite a bit more raw increase (as (b-iii) has) to reach the same proportional increase of (a-ii) over (a-i). This is exactly what was found in Norwegian rhyme durations (taken as a percentage of the three-syllable word they were spoken in). In (12) we see that in the two non-final positions (the antepenult and penult), a VC rhyme is notably different than a V rhyme. While we find a very similar raw increase word-finally, the perceptional difference is much less, because the proportional increase is much less. However, a VXC rhyme (where X may be a vowel or a consonant) has a similar proportional increase over a final V rhyme that is found between VC and V non-finally. In short, a word-final CVC syllable fails to reach the same proportional increase over a CV that is found for a CVC in a non-final position of the word.

If we take the classification of weight within a language to follow Weber's Law, we require that in order to be classified as heavy a syllable's rhyme to regularly reach a minimum proportional increase threshold over the rhyme of a CV syllable in the same position. This correctly predicts that CVC syllables will be heavy non-finally but light word-finally. This is an improvement over previous accounts since there is a (perceptually and phonetically) grounded reason for the different behavior of a CVC syllable word-finally. And if weight classifications are based on a proportional increase threshold, then different treatment of word-final syllables is not required, as the weight criterion is consistent across all positions.

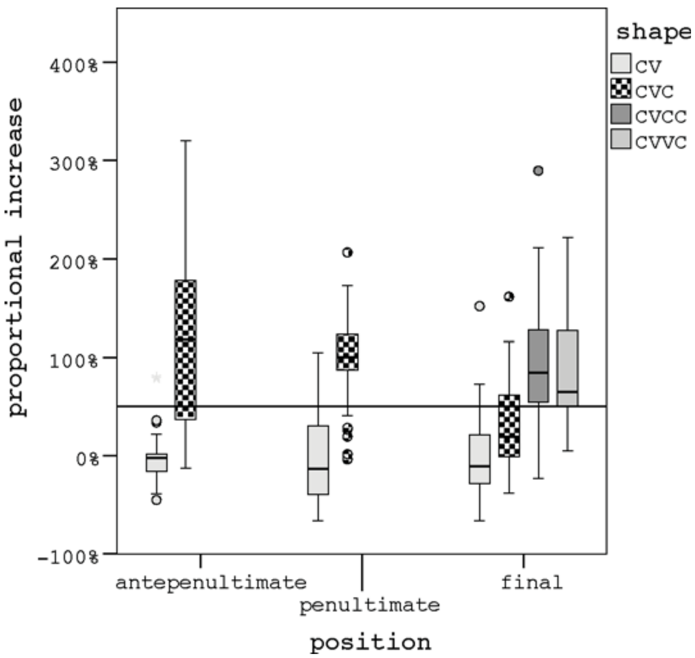
2.1. Weight of final syllables in English

We now turn to the question of whether the proportional increase theory of weight makes the right prediction for word-final syllables in English. If it does, we would expect to find that CVC should pattern as heavy non-finally but light word-finally (like Norwegian), but that CVV should pattern as heavy in all positions of the word.

A production study was undertaken with forty-eight native English speakers (males=10, aged 17-22). Each word had a designated stressless test syllable for representing each possible syllable shape in each of the three positions. Vowels heights and coda consonant manners were varied but not controlled (e.g. *exámple*, *omíssion*, *lávender*, *vámpire*, *perspéctive*, *húrricáne*).[2] For each subject one word from each category was randomized into carrier phrases, and the sentences were then duplicated and the two sets randomized. The duration of the test syllable in the second reading was measured in Praat (Boersma & Weenink 1992-2010).

The findings are shown (13) for CV, CVC, and CVXC syllables. All rhyme durations are shown as a proportional increase over a V rhyme in the same position of the word.

(13) CVC proportional increase asymmetry



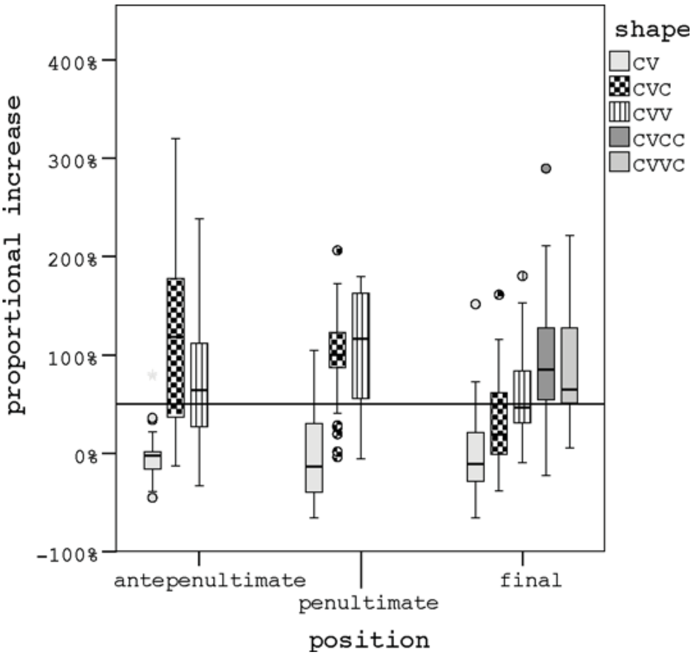
A horizontal line is drawn at 50% as this seems a rough estimate of the proportional increase threshold indicated by the data. We see a significant difference in the proportional increase of VC rhymes by position. While an antepenultimate CVC averages a 120% increase over an antepenultimate CV and a penultimate CVC a 102% over penultimate CV, a word-final CVC has only an 36% increase over a final CV. A comparison of contrasts test (linear mixed model, SPSS) found a significant difference (p=0.001)

[2] Nouns were used in order to get all possible syllable shapes in all positions occurring without primary stress (as final CVXC and CVV syllables will get primary stress in verbs and adjectives). It is assumed that there is nothing different in the phonetics of the rhyme durations of different lexical classes in English, and that the difference in their stress systems lies in the phonology.

between the difference between a non-final CV and non-final CVC compared to the difference between a final CV and CVC. There is no significant difference between a non-final CV and non-final CVC compared to a final CV and final CVCC/CVVC (p=0.095 antepentult∼final; p=0.499 penult∼final).

The graph in (14) shows the same findings with the addition of the diphthongs (CVV) in every position. It can been seen that there is some variety in the proportional increase of the diphthongs over a CV syllable in the same position, but that they appear to pattern with the heavy syllables.[3]

(14) Diphthongs and the proportional increase categorization of weight



A comparison of contrasts test found no significant difference between a non-final CV and CVV compared to a final CV and CVV (p=0.423 antepenult∼final; p=0.058 penult∼final). This is markedly different from the findings for CVC syllables, where a word-final CVC and CV did have a significantly different relationship from such pairs non-finally.

The proportional increase theory of weight therefore seems a good fit for modeling the weight of syllables in English verbs and adjectives. The difference in behavior between a final CVC (which rejects stress) and a final CVV (which does not) is thus explained: as vowels are generally inherently longer than consonants, a CVV syllable has a proportional increase over a final CV that is similar to the proportional increase found between heavy and light syllables non-finally, but a final CVC does not. If syllable weight is determined on this basis, then there is a grounded reason for the the seemingly-exceptional behavior of final CVC syllables.[4] It is interesting to note that NONFINALITY does not play a role in this account, as all final segments are crucially taken to be part of the final syllable; which receives primary stress if it regularly passes the proportional increase threshold (i.e. is heavy).

The tested rhyme that did not behave as predicted was tense vowels. They are known to pattern with heavy syllables, but they failed to do so phonetically across all positions of the word, as shown in (15).

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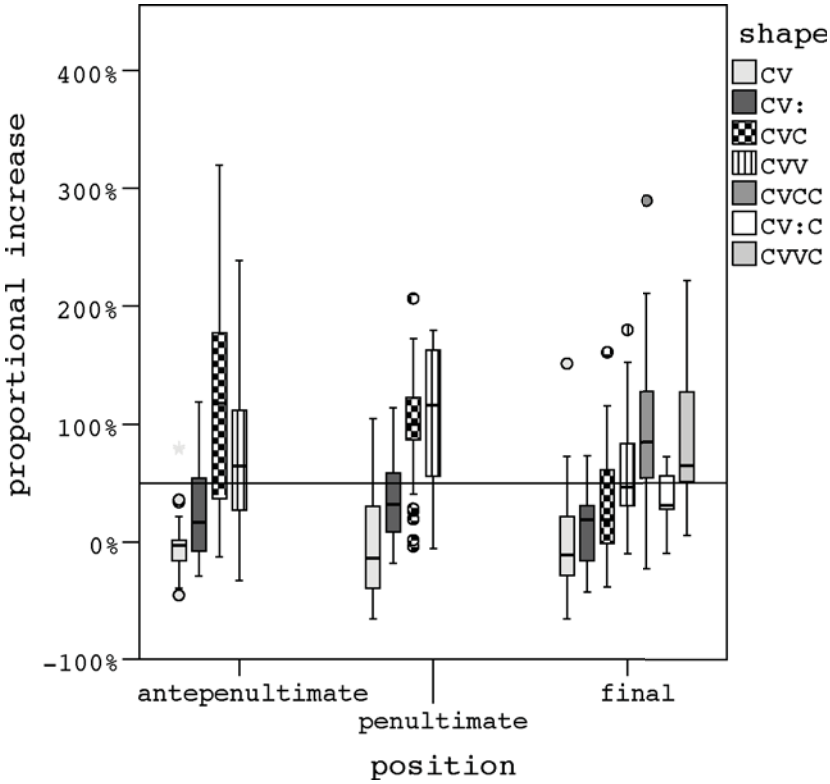
3 The difference is probably due to the different diphthongs included: although [eɪ] and [oʊ] are diphthongs in American English, it is not clear that they phonetically pattern with other diphthongs.

4 More research is needed to see whether the requirement of a consistent proportional increase across positions for heavy syllables is part of GEN or whether it should be derived through constraint rankings. See Gordon et al. 2010 for data from Egyptian Arabic and Kabardian which is also in agreement with the proportional increase theory of weight.

(15) Tense vowels fail to pattern with heavy syllables in all positions



The behavior of tense vowels, which behave as heavy in English, raises questions about other factors that may be at work in the categorization of syllable weight. Historically, English did have vowel length, and the long vowels of Middle English by and large became the tense vowels of Modern English. It is therefore possible that these vowels are continuing to act as heavy although they no longer phonetically pattern as heavy (as they presumably once did).

3. Conclusion

The proportional increase theory of weight gives a *consistent* analysis of weight across all positions and is couched in known facts of human perception. The theory correctly classifies final CVC syllables as light and final diphthongs as heavy in English, which matches the observed pattern. It avoids the ranking issue shown in (10) as the classification of weight is phonetically and perceptually grounded.

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