The Tonal Basis of Weight Criteria in Final Position

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1 Introduction

Many languages systematically avoid stressing final syllables. This dispreference for final stress can be seen both in languages with weight-insensitive stress and those with weight-sensitive stress. For example, many languages with weight-insensitive stress, e.g. Nahuatl (Wolgemuth 1981), Polish (Comrie 1976), regularly stress the penultimate syllable, the syllable closest to the right edge without being final. Final stress avoidance is also observed in weight-sensitive stress systems in which final syllables reject stress even if the only heavy syllable in a word is the final one, e.g. certain varieties of Mari (Kenstowicz 1994). Final stress repulsion is also evident in weight-sensitive stress systems in which weight criteria are more stringent in final syllables than in non-final syllables. For example, in Chickasaw (Munro and Willmond 1994, Munro 1996, Gordon 1999a) and Klamath (Barker 1964), stress falls on non-final syllables which are either closed (CVC(C)) or contain long vowels (CVV(C)), but only final syllables containing long vowels attract stress. Words (in boldface) illustrating the stress pattern in Chickasaw appear in (1).

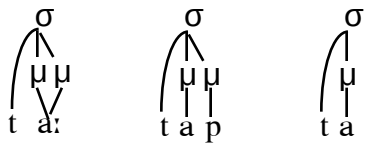
(1) Chickasaw stress
Stress on non-final CVV and CVC(C):
pi.lá:.ʧi 'she sends it'
hò:mál.:i 'they jump'
Stress on phrase-final CVV *but not phrase-final CVC(C)*:
(katàhtá:) **ʧi.hà:.ʃá:**? '(Who) are you angry at?'
(nantá:t) **ła.tá:.pa.tok**? '(What) spilled?'
mál.:i.tam? 'Did she jump?'
(nantá:t) **ɨstóktʃank?** '(What) is a watermelon?'

Both CVV(C) and CVC(C) are thus heavy in non-final position, but only CVV(C) is heavy in final position.

2 Representing final weight criteria

Final vs. non-final weight asymmetries of the Chickasaw and Klamath type present challenges to current phonological models of weight, such as moraic theory (Hyman 1985, Zec 1988, Hayes 1989), in which representations are projected from phonemic contrasts. In moraic theory, moras are assigned on the basis of segmental length contrasts and contrasts in numbers of segments in the rime. CVV(C) is universally bimoraic since it contains a long vowel (which contrasts with a short vowel), and CVC(C) is potentially bimoraic on a language-specific basis (Hayes' 1989 Weight-by-Position parameter), since it contains at least two segments in the rime. CV is monomoraic. Schematic representations of heavy CVV(C), heavy CVC(C), and light CV in moraic theory (after Hayes 1989) appear in (2).

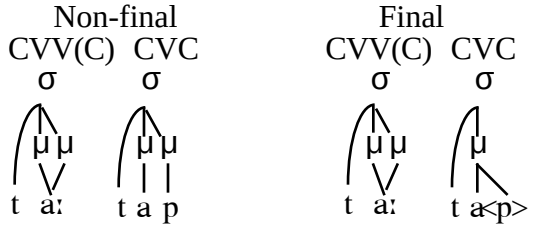
(2) CVV(C) CVC(C) CV



Weight distinctions are thus encoded as differences in mora count: heavy syllables are bimoraic, whereas light syllables are monomoraic.

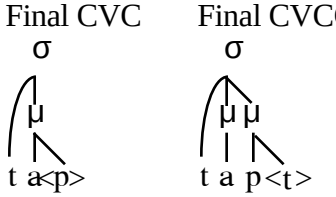
The standard analysis of weight asymmetries between final and non-final syllable appeals to extrametricality, which assumes that elements at the right edge of phonological domains are prosodically vacuous in languages with more stringent weight criteria in final position (Hayes 1979). Under an extrametricality analysis, the coda consonant in Chickasaw and Klamath CVC would be extrametrical in word-final position and would thus not contribute to the mora count and thus the weight of the syllable. Because word-medial consonants are unaffected by extrametricality, non-final CVC is bimoraic and thus heavy. Furthermore, because extrametricality targets only final consonants in Chickasaw and Klamath and not vowels, CVV(C) is bimoraic in both final and non-final positions. Moraic representations of Chickasaw and Klamath CVV(C) and CVC in non-final and final positions appear in (3).

(3)



A crucial feature of extrametricality is its confinement to elements at the periphery of a domain. A consequence of this assumption is that only the final consonant of a syllable may be rendered extrametrical. Thus, although the representations in (2) account for the lighter status of final CVC relative to non-final CVC and CVV(C) and final CVV(C), they fail to account for the fact that syllables closed by two consonants (CVCC) are also light in final position in Chickasaw and Klamath. The first coda in CVCC is predicted to carry its own mora under an extrametricality analysis, thereby making final CVCC bimoraic, as depicted in the representations in (4).

(4)



Although there are languages in which CVCC but not CVC is heavy in final position (see section 4.5), as predicted by the extrametricality account, such languages do not

represent an exhaustive set of languages with final vs. non-final weight asymmetries, as evidenced by the existence of languages like Klamath and Chickasaw.

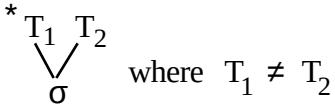
Another aspect of stress systems which the extrametricality analysis fails to explain is the fact that, although final stress avoidance is pervasive cross-linguistically, its left edge counterpart, initial stress avoidance, is quite rare. In his extensive survey of stress systems, Hyman (1977) reports a huge discrepancy between the number of languages with penultimate stress, i.e. stress on the rightmost non-final syllable, and the number with peninitial stress, i.e. stress on the leftmost non-initial syllable. Thus, he found 77 languages with dominant penultimate stress and only 12 with primarily peninitial stress. The virtual confinement of stress repulsion to the right edge must be stipulated under the extrametricality analysis, but should ideally find an explanation.

In summary, although extrametricality is able to capture certain types of final vs. non-final stress asymmetries, it is flawed on both a technical level in its empirical coverage of the cross-linguistic data and on an explanatory level in its failure to offer a principled account of the virtual absence of the left edge counterpart to final stress avoidance.

3 The tonal basis of final stress avoidance

Many of the shortcomings of the extrametricality analysis are remedied if one considers the link between final stress avoidance and tonal factors. As a starting point in exploring this connection, let us first consider tone languages which systematically prohibit contour tones on individual syllables. Such languages are common cross-linguistically, including Iraqw (Mous 1993) and Runga (Nougayrol (1990), among many others (see Zhang forthcoming for a cross-linguistic survey of contour tone prohibitions). Following standard phonological treatments of contour tones, we may assume that contour tones result from the combination of two level tones (e.g. Woo 1969, Hyman 1985, Duanmu 1994a,b). Thus, a rising tone results from the combination of a low tone followed by a high tone, while a falling tone is represented as a combination of a high tone followed by a low tone. Given the compositionality of contour tones, restrictions against contour tones may be assumed to reflect a prohibition against multiple tones crowded onto a single syllable. This banned configuration is schematically shown in (5).

(5)



Now let us consider the hypothesis that final stress avoidance and avoidance of tonal crowding are related, a proposal suggested by Hyman (1977). A crucial ingredient to consider in this hypothesis is the intonational properties associated with the end of large intonational units. Cross-linguistically, the unmarked declarative intonation contour is marked by a final fall in fundamental frequency. In the intonational framework developed by Pierrehumbert (1980) and colleagues, we may say that this unmarked intonation contour is characterized by a final low boundary tone, L%, linked to the terminus of the intonational phrase. In addition to this final boundary tone, languages such as English may optionally have one or more phrasal tones, H- or L-, realized just before the final boundary tone.

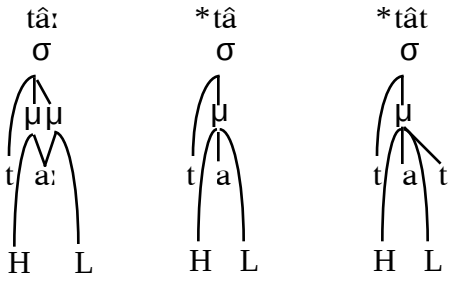
Now let us consider the tonal properties characteristically associated with stress. Cross-linguistically, stressed syllables are typically associated with a peak in fundamental frequency (see Eek 1982 for a cross-linguistic survey). The rightmost stressed syllable in a phrase is characteristically associated with the highest fundamental frequency in the phrase. In Pierrehumbert's terms, we may say that the stressed syllable carrying this pitch peak is the nuclear pitch accented syllable, H*. Given the H* associated with stress and the L% associated with the terminus of the phrase, a stressed final syllable will suffer from tonal crowding if both the pitch accent and the boundary tone are to be realized. In contrast, if stress falls on a non-final syllable, the pitch accent and the boundary tone will not be crowded onto a single syllable. The tonal linkings characteristic of non-final and final stress are shown schematically in (6).

(6)

The parallel between final stress avoidance and prohibitions against contour tones in tone languages is thus complete: both are motivated by an avoidance of tonal crowding.

Now let us consider stress languages in which weight criteria are more stringent in final than in non-final syllables, as in Chickasaw and Klamath. Increased stringency of final weight criteria also finds an explanation in terms weight-sensitive tone restrictions which are likewise found in tone languages. In many tone languages, e.g. Tubu (Lukas 1953) and Somali (Berchem 1993), contour tones are restricted to syllables containing long vowels and may not occur on syllables with short vowels. Given the compositionality of contour tones, restrictions against contour tones may be assumed to reflect a prohibition against associations between more than one tone and a single timing position (either skeletal slot or mora) (Hyman 1985, Duanmu 1994a,b). Because a contour tone consists of two tones, it requires two timing positions on which to be realized, one for each element of the contour. For example, the restriction against contour tones on syllables containing short vowels follows if we assume that only vowels are associated with weight bearing timing positions in languages with this restriction. It thus follows that CVV is bimoraic and both CVC and CV in such languages. Only CVV may therefore support a contour tone. Sample moraic representations of a well-formed configuration involving a contour tone on a bimoraic CVV syllable and ill-formed configuration involving contour tones on monomoraic CV and CVC appear in (7).

(7)



Restrictions against contour tones on syllables not containing long vowels find a phonetic explanation in terms of the relative ability of different syllable types to support tonal information. Tones require a sufficiently sonorous backdrop to be perceptually salient. This requirement stems from the fact that tonal information is conveyed not only by fundamental frequency but also by higher harmonics which occur at frequencies which are multiples of the fundamental. Thus, a signal with a fundamental frequency of 200Hz will have harmonics at 400Hz, 600Hz, 800Hz, 1000Hz, and at 200Hz increments thereafter. Harmonics enhance the salience of the fundamental frequency to the point of allowing for recovery of tonal information even when the fundamental itself has been extracted from the signal (see House 1990 and Moore 1995 for review of the relevant psychoacoustic literature). Because vowels have the richest harmonic structure of all segments in terms of intensity of harmonics throughout the spectrum, they are better suited than other segments to carrying tonal information. For this reason, a rime containing a long vowel is phonetically better able to support a contour tone than a rime containing a short vowel either in an open syllable or followed by a coda consonant.

Pursuing the parallel between weight-sensitive tone and final weight criteria, a final stressed syllable is better suited to supporting both the pitch accent associated with stress and the final boundary tone if it contains a long vowel than if it contains a short vowel. The asymmetrical weight status of CVC as heavy in non-final syllables but light in final syllables thus finds an explanation in terms of the tonal conditions present in final position.

4 Residual issues in the tonally-driven model of final stress repulsion

The tonally-driven analysis of final stress avoidance raises a number of issues which we now address in this section.

4.1 Tonal crowding as a phrase- vs. word-level phenomenon

An apparent inconsistency in the analysis developed here is that the intonational properties claimed to motivate final stress repulsion are characteristically limited to phrase-final position, whereas stress is usually conceived to be a word-level phenomenon. There are two avenues for addressing this apparent paradox. First, it does not seem unreasonable that many, perhaps most, stress patterns described in primary sources are those of words uttered in isolation, a context in which the word is equivalent to a larger intonational constituent where the tonal factors claimed to underlie final stress avoidance are present. Pending of course further investigation, the set of languages with final stress avoidance which is amenable to the tonally-driven analysis may thus turn out to be a substantial subset, if not virtually all, languages displaying avoidance of final stress.

In fact, data from the relatively small number of languages for which there are descriptions teasing apart word-level and phrase-level stress offers striking support for the tonally-driven analysis. In a number of languages, including Cayuga (Chafe 1977, Michelson 1988), Onondaga (Chafe 1970, 1977, Michelson 1988), certain varieties of Yupik (Leer 1985, Miyaoka 1985, Woodbury 1987), Chickasaw (Gordon 1999a), and Hill Mari (Ramstedt 1902), stress is repelled from word-final syllables which are also phrase-final but not from word-final syllables which are phrase-medial. This asymmetry between phrase-final and phrase-medial syllables goes in the direction predicted by the tonally-driven account of final stress avoidance. In phrase-final position, where there is potential for tonal crowding, final

stress is avoided, whereas, in phrase-medial position, where tonal crowding is not at stake, final stress is permitted.

We are thus potentially left with a relatively small set of languages in which final stress avoidance is truly a word-level phenomenon. For such cases, which include English (Hayes 1982), we may hypothesize that final stress avoidance at the word level is driven by phrase-final instantiations of words and that stress patterns of phrase-medial words are constrained to mimic their phrase-final counterparts. Analogical extension of phonological properties from environments in which they are phonetically well-motivated to other environments in which their phonetic motivation is less transparent has been claimed to be productive for phenomena other than stress. Typically, though not always, properties tend to be extended from phrase-final forms to phrase-medial forms. For example, obstruent devoicing is phonetically well-motivated in utterance final position where aerodynamic factors militate against sustained voicing of obstruents (Westbury and Keating 1986). Many languages extend devoicing to affect obstruents in final position of smaller domains, such as the word and/or the syllable, even though the phonetic conditions driving obstruent devoicing are not as compelling in these positions. Formally, the extension of properties from one context to another context can be captured in a constraint-based grammar by output-output correspondence constraints, such as IDENT constraints (Benua 1995) and Paradigm Uniformity constraints (Steriade 1996) requiring instantiations of a word in one context to be phonological identical to instantiations arising in other contexts (see section 5 for analysis).

4.2 Tonal crowding as a function of tonal specifications

The tonally-based model of final stress repulsion also predicts that final stress avoidance would be dependent on the types of boundary tones and pitch accents associated with the right edge and stress, respectively. In particular, we would expect final stress avoidance to be observed only in cases where the pitch accent and the boundary tone are different and not in cases where both tones are the same. For example, whereas tonal crowding is an issue for final syllables in case the pitch accent is a high tone and the boundary tone is a low tone or in case the pitch accent is a low tone and the boundary tone is high, tonal crowding will not necessitate retraction of stress from the final syllable if both the pitch accent and the boundary tone are high or both are low. Given this prediction, we might expect to find a language in which final stress avoidance is only evident in cases where the boundary tone and the pitch accent are different.

The difficulty in testing this prediction is similar to the difficulty in testing the prediction that final stress avoidance should be stronger in phrase-final position than in phrase-medial contexts. There is simply a paucity of published descriptions exploring interactions between stress and various intonational contours. Chickasaw (Munro and Willmond 1994, Munro 1996, Gordon 1999a), however, is one language with exactly the predicted pattern of final stress avoidance conditioned by the nature of the boundary tone and the pitch accent. The Chickasaw stress facts reported in section 1 involving repulsion of stress by final syllables other than CVV(C) pertain only to questions where the boundary tone is a low tone, L%: katáːt **málːitok?** 'Who jumped?' In statements, interestingly, the boundary tone is a high tone, H%, and final syllables are consistently stressed regardless of their weight: faláːt **màlːitók** 'The crow jumped.' In both questions and statements, the nuclear pitch accented is associated with high tone, H*. Thus, in statements, the pitch accent and the final boundary tone agree and there is no need to retract stress

off the final syllable (8). In questions, on the other hand, because the pitch accent and the final boundary tone disagree, only syllables containing long vowels provide an adequate backdrop for realizing both the pitch accent and the boundary tone.

(8)

Statements	Questions	
σ]	* σ]	unless σ=CVV(C)
H* H%	H* L%	

This asymmetry in final stress avoidance between questions and statements in Chickasaw provides strong support for the tonally-driven analysis of final stress repulsion.

4.3 Asymmetries conditioned by coda sonority

Yet another prediction of the tonally-driven analysis of final stress avoidance is that there should exist languages in which weight criteria for final syllables should be sensitive to the sonority of coda consonants. Given that the ability of a syllable to support multiple tones hinges on the overall sonority of the rime combined with the greater sonority of sonorant consonants relative to obstruents, we would expect to find languages in which final syllables closed by a sonorant (CVR) can support contour tones whereas final syllables closed by an obstruent (CVO) cannot. Although I am not aware of any languages which asymmetrically stress non-final CVO but not final CVO but stress both non-final and final CVR, there is at least one language which positions primary stress on final CVR but not final CVO. In Inga Quechua (Levinsohn 1976) final CVR is stressed but not final CVO. (Inga Quechua lacks CVV.) This weight distinction in final syllables is sensible from a phonetic standpoint, assuming that Inga Quechua observes the unmarked pattern whereby large intonational constituents characteristically end in a low boundary tone and stress is associated with high tone. Paipai (Joel 1966) also observes a weight distinction between final CVR and final CVO for stress, although this distinction is obscured somewhat by morphological interactions with the stress system.

4.4 Right edge vs. left edge asymmetries in stress avoidance

We are now in a position to explain a cross-linguistic observation made earlier about the relative frequency of languages which resist stressing initial syllables compared to those which display final stress avoidance. Recall that initial stress avoidance is quite rare, as reflected in the number of languages with peninitial stress, whereas final stress avoidance, as reflected in the number of languages with penultimate stress, is extremely common.

This distributional asymmetry finds an explanation in terms of tonal asymmetries between initial and final syllables. While final boundary tones are extremely common cross-linguistically, perhaps universal, initial boundary tones are much rarer. Typologically speaking, there is thus less likely to be potential for tonal crowding between a boundary tone and the tone associated with stress at the left edge of a phrase than at the right edge. Furthermore, even in languages with initial low tones not attributed to stress, such as French (Jun and Fougeron 1995) and Korean (Jun 1993), the low tones are characteristically associated with domains larger than a word but smaller than large intonational domains and are not as low phonetically as low boundary tones associated with major intonational constituents. For this reason, even in languages with the potential for tonal crowding in initial

position, the transition from low to high tone is less precipitous and therefore requires less time to execute (all else being equal, in particular, the height of the pitch accent) on an initial syllable than on a final syllable where the boundary tone is phonetically lower. In summary, both the relative rarity of initial low tones and their less low phonetic realization conspire to render initial stress repulsion less common than final stress repulsion.

4.5 Weight asymmetries between final CVC and final CVCC

There is one type of attested final vs. non-final weight asymmetry not accounted for by the tonally-driven analysis of final stress avoidance. In a small set of languages, including many varieties of Arabic (cf. Angoujard 1990 for a summary), Stoney Dakota (Shaw 1985), Spanish (Harris 1983), and Romanian (Steriade 1984), final CVCC but not final CVC is heavy, whereas non-final CVC is light. To complete the picture, CVV(C) is heavy in both final and non-final syllables in certain languages, meaning that they differ minimally from languages discussed earlier which treat CVCC as light in final position. The variety of Estonian described by Hint (1973) also falls into this set of languages , though the Estonian stress data is the subject of considerable controversy (see Eek 1982 for an alternative description) and should therefore be regarded with considerable caution.

Given the tonally-driven account of final stress avoidance we would not expect CVCC to be any better suited to supporting multiple tones than CVC, since CVCC is not necessarily more sonorous than CVC; in fact, CVCC is presumably poorer suited to realizing multiple tones than CVC in cases where CVCC contains two obstruent codas.

In accounting for the thus far unexplained greater weight of final CVCC relative to final CVC in certain languages, it is useful to observe that, in several languages of the world, superheavy syllables, i.e. those with three timing positions or moras in the rime, are weightier than other syllables, including CVC and CVV, in terms of their stress attracting ability. In these languages, e.g. Hindi (Kelkar 1968), Eipomek (Heeschen 1983), Pulaar Fula (Niang 1995), superheavy syllables include CVVC and CVCC, if present. (Note that the Hindi stress pattern reported by Kelkar is rather controversial; see Ohala 1977 for discussion.) Crucially, the greater weight of superheavy syllables relative to other syllables is not limited to final position in these languages; thus, the weight effects observed in these languages are independent of any final vs. non-final weight asymmetries of the type observed in languages such as Arabic, Spanish, Romanian, and Stoney Dakota. Gordon (1999b) shows that the greater weight of certain syllables relative to others in stress systems in which weight distinctions are not limited to final position is a function of their prominence along the phonetic dimension of auditory energy (the integration of perceptual loudness over time). Weightier syllables have greater auditory energy than less weighty syllables. Superheavy syllables are thus claimed to possess greater auditory energy than other syllables, a phonetic distinction which is encoded as a phonological weight distinction in certain languages.

Turning to final position, there is a potential conflict between the phonetic prerequisites imposed by the intonational system and the general non-positionally limited requirement that syllables possessing a certain amount of auditory energy attract stress. Attraction of stress by final superheavy syllables and final CVV but not by final CVC reflects the language-specific prioritization of the energy-driven weight requirement that superheavy syllables be stressed above the tonally-driven requirement that final syllables not containing a long vowel be unstressed. In contrast, in languages in which both final CVCC and final CVC are unstressed but

final CVV(C) is stressed, the tonally-driven restriction against final stress on syllables not containing long vowels takes precedence over the energy-driven constraint requiring that superheavy syllables be stressed. We will see in section 5 that this conflict between two phonetic dimensions can be modeled in a constraint-based paradigm in which tonally-driven weight constraints can be freely ranked relative to energy-driven weight constraints.

5 A constraint-based analysis of final stress avoidance

The tonal factors motivating final stress avoidance can be directly encoded in constraints within an Optimality-theoretic analysis of stress. The relevant family of constraints prohibits multiple tones crowding onto a single syllable, where the type of syllable on which tonal crowding is banned differs depending on the particular member of the constraint family. One constraint formulated in (9) bans multiple tones associated with a single syllable. Note that, for the constraint in (9) and for subsequent tonal crowding constraints, T_1 crucially differs from T_2 in height.

(9)

* T_1* T_2% (with T_1 and T_2 associated to σ) : Contour tones may not occur on a single syllable.

This constraint has essentially the same effect as NONFINALITY (e.g. Prince and Smolensky 1993, Walker 1996)) which also bans final stress, though it differs from NONFINALITY in directly encoding the tonal motivation behind the constraint. It is highly ranked in languages which systematically ban final stress regardless of the weight of the final syllable.

Another constraint bans contour tones on all rimes except for those containing two moras associated with the feature [+syllabic] (10). This constraint has the effect of banning multiple tones on syllables except for those containing long vowels.

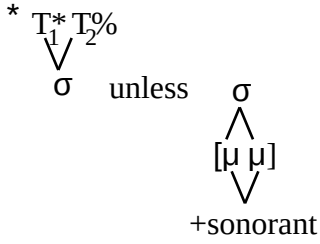
(10)

* T_1* T_2% (with T_1 and T_2 associated to σ) unless σ dominating [μ μ] dominating +syllabic : Contour tones may only occur on CVV.

This constraint is highly ranked in languages like Klamath which only allow stress on final syllables containing a long vowel.

Finally, another constraint bans tonal crowding on all syllable rimes except those containing two moras associated with the feature [+sonorant] (11). This constraint has the effect of banning multiple tones on syllables except for those containing either a long vowel or a sonorant coda.

(11)



: Contour tones may only occur on CVR or CVV.

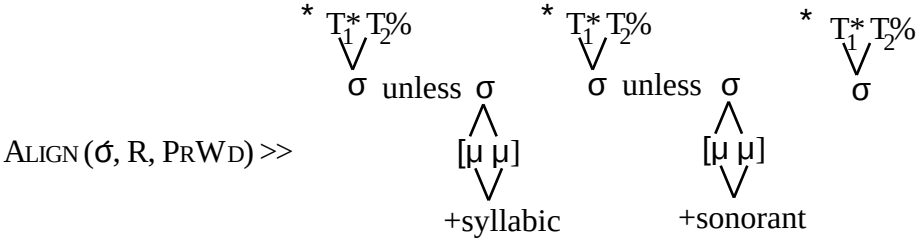
It should be noted that the formulation of the constraints in (10) and (11) using moras rather than skeletal slots (Levin 1985) is an arbitrary one. It would also be possible to express the constraints with reference to skeletal slots belonging to the rime.

The constraints in (9)-(11) are in competition with other constraints requiring that final syllables be stressed. These constraints may belong to several constraint families, including ALIGN constraints (McCarthy and Prince 1993), constraints banning stress lapses (Green and Kenstowicz 1995), and perhaps foot formation constraints requiring that syllables be parsed into feet (e.g. Kager 1994). When all of the tonally-driven constraints banning final stress are subordinate to constraints requiring final stress, final stress obtains. When at least one of the tonally-driven stress repulsion constraints is ranked above the relevant constraints requiring final stress, final stress avoidance effects emerge. Different final stress avoidance patterns emerge depending on which of the tonal crowding constraints is highly ranked in a given language.

Let us now consider the crucial rankings which yield the patterns discussed in this paper. For expository purposes it will be assumed that the constraint which acts antagonistically toward the tonal crowding constraints is ALIGN (σ́, R, PRWD), which requires that the stressed syllable be aligned with the right edge of the prosodic word, or, in other words, occur in final position. It will also be assumed that undominated constraints not formulated here require that both the nuclear pitch accent and the final low boundary tone surface. These constraints ensure that tonal crowding is resolved by retracting the tone associated with stress onto a non-final syllable rather than by failing to realize either the boundary tone or the tone associated with stress. Finally, other constraints ensure that the pitch accent and stress occur on the same syllable.

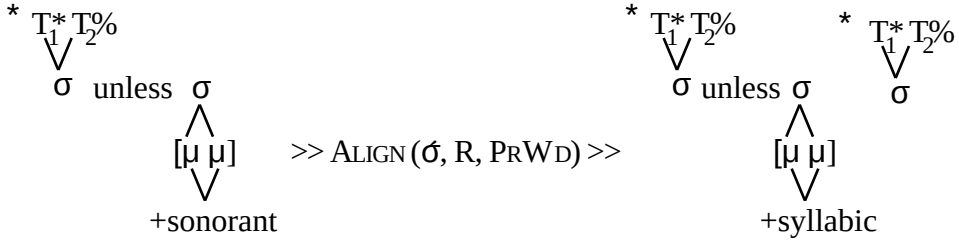
If ALIGN (σ́, R, PRWD) is ranked above all the tonal crowding constraints, final stress obtains (12).

(12) Final stress on all syllables



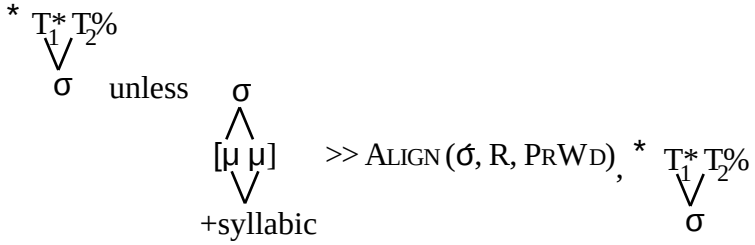
If the tonal crowding constraint banning crowding on syllables not containing two sonorant moras is ranked above ALIGN (σ, R, PRWD), which in turn is ranked above the other tonal crowding constraints, we get stress on final CVV and CVR but not on final CV or CVO, the Inga Quechua pattern (13).

(13) Final stress on CVV, CVR



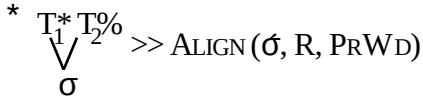
If the tonal crowding constraint banning crowding on syllables not containing two syllabic moras is ranked above ALIGN (σ, R, PRWD), which in turn is ranked above the constraint banning tonal crowding on all syllables, we get stress on final CVV but not on final CV, CVO, or CVR, the Klamath pattern (14). Note that the constraint banning tonal crowding on syllables other than those containing two sonorant moras does not play a crucial role in languages in which only final CVV is stress attracting.

(14) Final stress on CVV



If the most stringent tonal crowding constraint banning multiple tones on all syllable types is ranked above ALIGN (σ, R, PRWD), then the final syllable is consistently unstressed, a pattern found in languages with penultimate stress (15). Note that the other tonal crowding constraints do not serve a crucial function in stress systems in which the general constraint banning tonal crowding on all syllables is undominated.

(15) No final stress

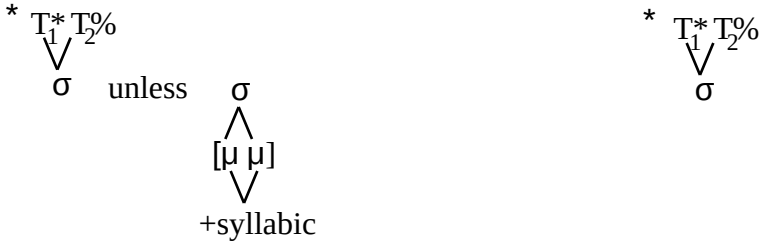


The next case to consider involves stress falling on both final and non-final CVV(C) and CVCC and on non-final CVC, but not on final CVC. In these languages, the challenge is to account for stress being repelled from final CVC but not final CVCC. As discussed in section 4.5, the attraction of stress by final CVCC reflects a preference for stressing superheavy syllables, which are prominent by virtue of their

relatively high degree of auditory energy. In Optimality Theory, the stress-attracting ability of superheavy syllables is most transparently modeled by a constraint requiring that superheavy syllables, i.e. those with three weight units in the rime, be stressed, e.g. PROMINENCE constraints (cf. Prince and Smolensky 1993, Kenstowicz 1994). If the relevant PROMINENCE constraint, P/μμμ, is ranked above the tonal crowding constraint banning multiple tones linked to syllables other than those containing two syllabic moras, which in turn is ranked above ALIGN (σ, R, PrWd), stress will fall on final CVCC and CVV(C), but not on final CVC or CV (16). The blanket tonal crowding constraint banning multiple tones associated with all syllable types is necessarily ranked below ALIGN (σ, R, PrWd) (15).

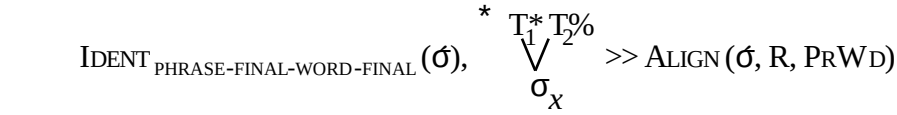
(16) Attraction of stress by final CVCC and CVV(C) but not final CVC or CV

P/μμμ >> >> ALIGN (σ, R, PrWd) >>



Finally, we must consider stress systems in which final stress avoidance is truly a word-level phenomenon. In these languages, an output-output correspondence constraint requiring phonological identity with respect to stress between intonation phrase-final and intonation phrase-medial word-final syllables is undominated together with the relevant tonal crowding constraint producing final stress avoidance in intonation phrase-final position. Both the correspondence constraint, which is formulated below as an IDENT constraint (McCarthy and Prince 1995, Benua 1995) and the tonal crowding constraint are crucially ranked above ALIGN (σ, R, PrWd). This scenario is shown schematically in (17), where the subscripted $_x$ in the tonal crowding constraint is a variable standing for the relevant tonal crowding in a given language.

(17) Correspondence between word-level and phrase-level stress:



Before concluding discussion of the constraint rankings which yield final stress avoidance, let us consider a small typology of other final stress repulsion patterns generated by the proposed constraints. In constructing this typology, we will set aside output-output correspondence constraints on stress, since, for reasons discussed earlier, we are not in a position to assess the cross-linguistic frequency with which they are highly ranked.

If the ranking of the tonal crowding constraint banning multiple tones linked to syllables not containing two syllabic moras and the tonal crowding constraint banning multiple tones on all syllable types is reversed from that of (165), then we get stress on final superheavy syllables not on other final syllables, including CVV. This corresponds to a stress pattern which appears to occur in the pronunciation of

Classical Arabic words by speakers of certain modern varieties of Arabic (see McCarthy 1979 and Hayes 1995 for discussion).

If the tonal crowding constraint banning multiple tones linked to syllables not containing two syllabic moras is replaced with the constraint banning multiple tones linked to syllables not containing two sonorant moras in (16), we produce a pattern in which stress falls on final superheavies and on final CVV and CVR. Although I do not know of any languages with exactly this pattern, I would claim that such a pattern is not pathologic, and might turn out to be attested as our cross-linguistic data base of thoroughly worked out stress patterns broadens.

6 Conclusion

In summary, this paper has claimed that the cross-linguistically pervasive phenomenon of final stress avoidance is attributed to the intonational factors unique to final position. In order to avoid tonal crowding between the high tone characteristically associated with stress and the low final boundary tone found in unmarked declarative statements, languages either systematically ban final stress or restrict stress to more sonorous syllable types which are phonetically better suited to realizing multiple tones than less sonorous syllables. The avoidance of tonal crowding claimed to motivate final stress avoidance in stress languages parallels tonal crowding avoidance effects found in tone languages ranging from complete bans against contour tones to restrictions against contour tones on less sonorous syllable types. This parallel between final stress avoidance and tonal crowding restrictions in tone languages is not surprising given that both phenomena are constrained by their reliance on the same phonetic dimension. The tonal factors driving final stress avoidance are effectively modeled within Optimality Theory by interleaving constraints governing permissible associations between tones and syllables with competing constraints requiring that stress fall on final syllables.

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