Syllable weight and high tone in Moro[1]

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1 Introduction

In many languages, the position of word stress can be derived from the relative weight or prominence of the syllables in that word, a phenomenon known as weight-sensitivity (see Gordon 2006 for an overview). With respect to tone, though, the notion of weight has primarily been associated with the distribution of contour tones. In particular, Zhang (2002) observes that contour tones prefer syllables with longer duration. This paper provides evidence for a new kind of weight-sensitive tone distribution: high tone (H) on verbs in the Thetogovela dialect of Moro (Sudan: Kordofanian, Western Heiban) is sensitive to syllable weight, both in terms of onsets and codas. We argue for the specific prominence scale (C)VC > CV > V, where the relation ">" means "more prominent than." This same scale is operative in determining the position of stress in some languages with onset-sensitive stress (Gordon 2005). Overall, this paper provides evidence that privative high tone has an empirical connection with (onset-sensitive) stress, an argument that the two phenomena, while distinct, are phonologically related and may be analyzed with the same theoretical tools.

The outline of the paper is as follows. In section 2 we introduce Moro verbal morphology, where the effects of syllable weight on the position of H is most evident. In section 3 we describe the effects of syllable structure on Moro verb roots, and demonstrate that a process regulating the distribution of H familiar from Bantu languages, *tone doubling*, is weight-sensitive in Moro. In the second half of section 3, we demonstrate that H in Moro avoids syllables without onsets. In section 4 we argue against analyzing onsetless syllables as extraprosodic, the only analysis which has been presented in the extant literature for similar tonal phenomena. Finally, in section 5 we present our formal analysis of Moro H with reference to syllable weight and a prominence scale referencing onsets.

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2 Moro Verbal Morphology

In this section, we introduce Thetogovela Moro, focusing on its verbal morphology. Moro, like many distantly related Bantu languages, has a two-way high/low surface tone contrast, but only requires reference to unary H tone (Jenks & Rose 2009) in the phonology to account for H tone distribution.

Moro verbs feature extensive agglutinating morphology, with evidence for at least two subdomains, the *derivational stem* (D-stem) and the *macrostem*[2]:

(1) SM-TENSE-CL-CLAUSE-[$_{\text{Macrostem}}$OM-[$_{\text{D-stem}}$ASP-ROOT-EXT]-FV]-OM-INST-LOC

In this paper, we will be primarily concerned with the D-stem (see Downing 2000 for a similar unit in Kinande). See Jenks and Rose (2009) for more data and a more general analysis of the distribution of H tone on the Moro verb.

Extension suffixes, which follow the root within the D-stem, are derivational suffixes that usually affect the valence of the verb, including causative, passive, and applicative formatives. The final vowel (FV) marks aspect and mood:

(2) **Mood/Aspect suffixes in Moro**

a. *Perfective*	b. *Imperfective*	c. *Subordinate*
k-a-[dogaṭ]-ó	k-a-[dógáṭ]-a	ɲe-[dógáṭ]-e
CL-MAIN-[fix]-PFV	CL-MAIN-[fix]-IMPV	1SG.SM-[fix]-SUB
‘(s)he fixed’	‘(s)he is fixing’	‘…me to fix’

The perfective final vowel is underlyingly marked with H and cannot co-occur with H tone on the root. This paper is about the distribution of H tone on the root, so the focus will be imperfective verb forms.

3 Root-based H in Moro

The distribution of H on most verbs in Moro is predictable based on the length of the root and the weight of its syllables. The majority of verb roots have either one or two syllables, the first of which can be heavy (CVC), light (CV), or super-light, characterized by onsetlessness (V). The general pattern is that H occurs at the left boundary of the root and on the following mora or tone-bearing unit(TBU). We dub this pattern *tone doubling*, a name borrowed from a similar phenomenon attested in Bantu languages, e.g. CiYao (Hyman & Ngunga 1994) and Ekegusii (Bickmore 1999), among others. Heavy syllables are bimoraic, so tone doubling is confined to the heavy syllable. Onsetless, super-light syllables in root-initial

[2] SM = subject marker, CL=noun class agreement, CLAUSE = clause type, OM = object marker, ASP = aspect, EXT=extension markers, FV = final vowel (mood/aspect), INST = instrumental, LOC = locative

position do not bear H. We begin with a discussion of roots that begin with a consonant.

3.1 Consonant-initial verb roots with light syllables

Almost all verb roots with two light syllables, of the shape CVCVC, surface with H tone on both root syllables (syllable boundaries are marked with dots):

(3) **Bisyllabic roots with light syllables: HH-L**

		3rd Imperfective CL-MAIN-ROOT-IMPV	*3rd Imperfective Passive* CL-MAIN-ROOT-PASS-IMPV	*Gloss*
HH-L	a.	k-a-t̪á.və́.ð-a	k-ʌ-t̪ʌ́.və́.ʧ-ən-iə	'spit'
	b.	k-a-k^{w}ə́.ɾé.ð-a	k-ʌ-kú.ɾî.ð-ən-iə	'scratch'
	c.	k-a-və́.lé.ð-a	k-ʌ-və́.lî.ð-ən-iə	'pull'
	d.	k-a-dó.gá.t̪-a	k-ʌ-dú.gʌ́.ʧ-ən-iə	'fix'

The first column represents imperfective verb forms. The final suffix /-a/, which marks the imperfective and is underlyingly unmarked for H tone, never surfaces with H when attached to bisyllabic verb roots. The second column represents the passive forms of the verbs in the first column. The passive suffix is also underlyingly unmarked for H and surfaces with low tone when attached to bisyllabic roots. Note that the passive triggers high-vowel harmony on the root and palatalization of a final dental stop (3a,d).[3]

Monosyllabic verb roots with the shape CVC surface with one of two tone melodies. These melodies are not predictable from any segmental properties of the verb root, and we assume the difference is lexical; note that (4a) and (4d) form a near-minimal pair. The pattern in (4a-c), where tone spreads to following suffix, is more common, comprising approximately 80% of the relevant verb roots.

(4) **Monosyllabic roots with light syllables**

		3rd Imperfective CL-MAIN-ROOT-IMPV	*3rd Imperfective Passive* CL-MAIN-ROOT-PASS-IMPV	*Gloss*
H-H	a.	k-a-wá.ð-á	k-ʌ-wʌ́.ð-ə́n-iə	'poke'
	b.	k-a-wá.t̪-á	k-ʌ-wʌ́.ʧ-ə́n-iə	'sew'
	c.	k-a-boá.ɲ-á	k-ʌ-buʌ́.ɲ-ə́n-iə	'like', want'
H-L	d.	k-a-vá.ð-a	k-ʌ-vʌ́.ð-ə́n-iə	'shave'

Unlike bisyllabic roots, in monosyllabic roots, H spreads to the imperfective suffix in (4a-c). This vowel constitutes the second mora for tone doubling, even if

[3] The form in (3d) contains an applicative suffix -t̪ in the passive form, which replaces the final /ð/, and undergoes palatalization. Vowel height harmony raises /e a o/ to [i ʌ/iə u] respectively.

outside the root. In the passive, the H appears on the following vowel in both classes, neutralizing the distinction present in active verb forms. The fact that H appears on the passive or imperfective suffixes only with monosyllabic verbs and not with bisyllabic indicates that it has spread from the root, not that the passive and imperfective suffixes are underlyingly marked for H.

Between the bisyllabic and monosyllabic verb forms, then, two generalizations emerge. First, H is associated with the initial root syllable, and second, in most verbs forms, that H spreads a single syllable to the right.

3.2 Consonant-initial verb roots with heavy syllables

While verbs with light syllables exhibit tone doubling, verbs with an initial heavy syllable do not. Bisyllabic verb roots with an initial heavy syllable surface with a HL melody on the root, while H in heavy monosyllabic roots never spreads to the final vowel or passive extension suffix. H can spread to the coda of the heavy syllable only if the coda is a tone-bearing segment, as is the case for /r/ (5e). Some of these roots (5c,g) contain high vowels which trigger vowel height harmony.

(5) **Roots with heavy first syllables**

		3rd Imperfective	*3rd Imperfective Passive*	
		CL-MAIN-ROOT-IMPV	CL-MAIN-ROOT-PASS-IMPV	*Gloss*
HL-L	a.	k-a-m^{w}án.dəð-iə	kʌ-m^{w}ʌ́n.dəð-ən-iə	‘ask’
	b.	k-a-wə́n.da̰t-a	kʌ-wə́n.datʃ-ən-iə	‘see’
	c.	k-ʌ-vʌ́n.də^{j}tʃ-iə	kʌ- vʌ́n.də^{j}tʃ-ən-iə	‘hold’
	d.	k-a-lálləɲ-a	n/a	‘run’
H-L	e.	k-a-wáɾ̀.ð-a	kʌ-wʌ́ɾ̀.ð-ən-iə	‘write’
	f.	k-a-lán.d̰-a	kʌ-lʌ́n.ʤ-ən-iə	‘close’
	g.	k-ʌ-tún.d-ʌ	n/a	‘cough’

While tone doubling spans two light syllables giving a HH pattern, tone is confined to a single heavy syllable, giving a HL pattern.[4] This demonstrates that tone doubling must be defined relative to syllable weight or size.

Some analyses account for tone doubling with a rule or constraint requiring binary tone association (Hyman & Ngunga 1994, Odden 1998, Bickmore 1999), while others use a constraint penalizing single H associations, but constrain spreading to apply minimally (Cassimjee and Kisseberth 1998). Finally, binarity is a property of metrical feet, and tone distribution within foot boundaries has been proposed for Kera (Pearce 2006), Sukuma (Bradshaw 1998), Lamba (Bickmore 2003; deLacy 2002), Yabem (Hansson 2004) and Bambara (Leben 2003; Weidman and Rose 2006).

[4] There are no verb roots with heavy syllables occupying the second syllable of the verb root. This may be due to long verb roots being derived historically from lexicalized extension suffixes.

We adopt the foot-based analysis for Moro. Tone aligns with the boundaries of binary moraic feet: (CV.CV.) or (CVC.)[5]. Even if a moraic coda cannot bear H tone, the foot boundary prevents spreading to a following vowel. An analysis without feet would have to address why tone cannot spread to another mora if the immediately following one is not a tone-bearing unit. In addition, the foot-based analysis structurally unifies the behavior of CV.CV and CVC syllable sequences.

3.3 Vowel-initial verb roots

To this point, H has been associated with the initial syllable of verb roots. This pattern is not found when the verb root begins with a light-syllable vowel; these syllables do not host H.[6] Bisyllabic roots of this type have H on their second syllable, with a LH melody. Spreading does not extend to the syllable after the root, including in the passive (6a-c). Vowel-initial monosyllabic roots surface with all-low tone (6d-f). Yet H does appear on the passive extension suffix of these roots. Thus, passive monosyllabic V-initial roots pattern like bisyllabic V-initial roots in terms of their tone pattern:

(6) **Vowel-initial verb roots**

		3rd Imperfective	*3rd Imperf. Passive*	
		CL-ROOT-IMPV	CL-ROOT-PASS-IMPV	*Gloss*
V.CV.C	a.	k-o.gə́t̪-a	k-u.gə́tʃ-ən-iə	‘jump’
	b.	k-ʌ.wú̪t̪-ʌ	k-ʌ.wútʃ-ən-iə	‘drop’
	c.	k-a.bátʃ-a	k-ʌ.bʌ́tʃ-ən-iə	‘lift’
V.C	d.	k-oa.ð-a	k-uʌ.ð-ə́n-iə	‘mill’
	e.	k-oa.r-a	k-uʌ.r-ə́n-iə	‘badmouth’
	f.	k-a.l-a	k-ʌ.l-ə́n-iə	‘slice’

The ban on vowel-initial roots hosting a high tone is not alleviated by the presence of an onset, the subject noun class agreement marker /k-/. We show in section 3.4 that onsets can license tone on the vowel-initial root, but only when they are contained within the derivational stem.

The distribution of H in (6), particularly on bisyllabic roots, provides another argument for the foot-based analysis of tone doubling. If tone doubling were construed as H tone spreading to a following mora or TBU, the unattested pattern *kʌbʌ́tʃə́niə ‘s/he is being lifted’ would be expected. However, if a bimoraic foot is left-aligned with the root, we would not predict spreading, either to the imperfective final vowel or to the extension suffix due to the foot boundary falling before these suffixes: k(ʌbʌ́)tʃəniə.

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[5] It is also possible to define feet using rimal timing positions instead of moras. See section 5 for a discussion of syllable positions and H tone.

[6] There are a few exceptions that have a HL pattern – see Jenks & Rose (2009) for details.

Below, we summarize the different patterns characteristic of H tone from this section. Except for the case of monosyllabic light verbs which have two tone patterns, the tone melody is predictable from root length and syllable structure.

(7)	σσ	σ–σ (non-final)	σ–σ (final)
Roots that begin with CV syllables:	HH	H-H	H-H
			H-L
Roots that begin with CVC syllables:	HL	H-L	H-L
Roots that begin with V syllables:	LH	L-H	L-L

Before we proceed to an analysis of these facts, we will discuss the behavior of vowel-initial roots in more detail.

3.4 Licensing H on vowel-initial roots

In (6), a subject noun class agreement marker /k-/ did not license H tone on the initial root vowel. However, the prefix /v-/, which only occurs in the imperfective, does license H on initial root vowels. The semantics of this prefix are unclear — it is sometimes associated with a progressive interpretation. Its appearance is also phonologically restricted: it only appears on vowel-initial roots without a round vowel or labial consonant — an apparent case of a [LABIAL] coocurrence restriction.[7] When /v-/ occurs, H appears on the initial root vowel and spreads:

(8) **Vowel-initial verb roots with /-v/ prefix**

		3rd Imperfective CL-MAIN-**v**-ROOT-IMPV	*Gloss*
HH	a.	kʌ-(**v**-ə́lí)ð-ʌ	'buy'
	b.	kʌ-(**v**-ʌ́gə́)r-iə	'read'
	c.	ka-(**v**-álə́)ŋ-a	'sing'
H-H	d.	ka-(**v**-áj-á)	'die'
	e.	ka-(**v**-ár-á)	'cry'
	f.	kʌ-(**v**-íd-iə́)	'fall down'

The presence of H with tone doubling — the regular pattern for consonant-initial roots (4)-(5) — is significant in light of the exceptional tone melodies associated with vowel-initial verb roots (6). The H that we see on the initial syllable of these roots appears to be licensed by the prefix.

There is evidence that the /v-/ prefix is not directly associated with the H appearing on the initial root syllable, but licenses it indirectly by acting as an onset for the vowel-initial root. Prefixes with H tone that also abut the verb root trigger H tone deletion. For example, object prefixes are underlyingly associated with H, and trigger loss of H on the root due to an OCP constraint:

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[7] There are some roots that may occur both with and without /v-/: kʌ-v-ʌ́g-iə́ / k-ʌg-iə 'put.'

(9) /k-a-ɲé-ləvətʃ-a/ → [kaɲé ləvətʃa]
CL-MAIN-**1SGOM**-hide-IMPV ‘s/he is about to hide me’

When the object prefixes attach to vowel-initial roots, the vowel in the prefix deletes due to a regular hiatus process. The H associated with the prefix does not appear on the root but instead appears on the preceding vowel:

(10) /k-a-ɲé-abátʃ-a/ → [káɲabatʃa]
CL-MAIN-1SGOM-lift-IMPV ‘s/he is about to lift me’

If H were associated with the /v-/ prefix in (7), its presence on the root would be surprising in light of (9) and (10). An analysis where the prefix provides an onset for the root, licensing H on the initial syllable, does not encounter such a problem. What is the difference between the /k-/ and the /v-/ prefixes in terms of H licensing? The key distinction appears to be their position in the verbal morphological template. While the subject marker is at the left edge of the verb outside the macrostem, /v-/ occurs close to the root in the derivational stem. The H tone distribution is therefore sensitive to the D-stem boundary.

4 Onsetless Syllables and Extraprosodicity

Onsetless syllables show exceptional behavior in several languages (Downing 1998). One well-known example is diminutive/frequentative reduplication in Timugon Murut, in which the initial syllable is copied unless it is an initial onsetless syllable, in which case the second syllable is copied as an infix, e.g. *tulu?* → ***tu**-tulu?* ‘point at’ vs. *abalan* → *a-**ba**-balan* ‘often bathes’ (Prentice 1971). McCarthy and Prince (1993) analyze this as resulting from the constraint ONSET, which requires syllables to have onsets. The initial vowel is skipped in order to copy a syllable with an onset to avoid a violation of ONSET, resulting in a less than perfectly aligned prefix, an infix.

Downing (1998) proposes a reanalysis of Timugon Murut and several other languages based on data which shows that onsetless syllables are also avoided in reduplication word-internally, and are avoided in phonological processes besides reduplication, such as stress assignment. She proposes an analysis of these data where morphological structure is misaligned with the prosodic structure to which phonological processes are sensitive. The exceptional behavior of onsetless syllables results from their exclusion from the prosodic domains to which phonological processes are sensitive.

Cases in which tone is sensitive to onsetlessness are particularly relevant, and have been reported in CiYao (Ngunga 2000) Kikerewe (Odden 1995), Kikuria (Mwita 2008), Yoruba (Orie 2000), and Zinza (Odden 2006). In Kikerewe, high tone is positioned to avoid onsetless syllables at the prosodic word edge. In (11a),

the consonant-initial subject prefix is high-toned and tone doubling spreads H tone onto the next syllable. In (11b), the subject prefix is vowel-initial and cannot bear H tone. Instead, the H tone appears on the following affix and spreads onto the verb root:

(11) **Conditional, low-toned verbs in Kikerewe** (Odden 1995)

a. *Consonant-initial subject prefix*

bá-ká-luunduma	'if they growl'
tú-ká-luunduma	'if we growl'

b. *Vowel-initial subject prefix*

o-ká-lúúnduma	'if you (sg.) growl'
a-ká-lúúnduma	'if he growls'

To account for these and other data, Downing (1998) proposes that the constraint ONSET is conjoined with a constraint aligning tone with the leftmost position in a prosodic domain. This conjunction excludes the onsetless syllable from the prosodic word, and H is accordingly positioned on the C-initial syllable. Odden (2006) analyzes similar data in Zinza, arguing that onsetless syllables are excluded from the prosodic word and unparsed into syllable structure altogether.

While most accounts of the exceptional behavior of onsetless syllables have used some version of extraprosodicity, such an analysis is problematic for Moro. First, consider the HL tone pattern characteristic of bisyllabic roots with onsetless initial syllables. The lack of tone doubling in verb roots with onsetless, light syllables is unexpected if the initial syllable is extraprosodic:

(12) a. k-(ʌ.bʌ́)ʧ-ən-iə
b. *k-ʌ.(bʌ́ʧ-ə́)n-iə

The unattested pattern in (12b), with tone doubling, would result from an analysis of the initial syllable as extraprosodic, as in Kikerewe. If the initial onsetless syllable is included in foot structure, it would be included in larger phonological constituents as well in accordance with the prosodic hierarchy.

Another argument against the extraprosodic status of onsetless syllables in Moro comes from reduplication. Durative or iterative aspect in Moro is signaled by a heavy syllable high-toned reduplicative prefix which copies the first segment of the root, be it a vowel or a consonant:

(13) a. **CáC- reduplicant with C-initial roots**

k-a-d̪áṭ-**ṭ̪avəð**-a	's/he's spitting'
k-a-gák-**kəreð**-a	's/he's scratching'

b. **ɤ́kk reduplicant with V-initial roots**

k-ókk-**ogəṭ**-a	‘s/he’s jumping’
k-ákk-**al**-a	‘s/he’s slicing’

Durative/iterative reduplication copies the first consonant of consonant-initial roots into a CáC template (with predictable voicing changes associated with gemination). If the root is V-initial, the template is ɤ́kk and the first vowel is copied. The fact that reduplication copies either the initial consonant or the initial vowel would be problematic for an analysis where the initial vowel’s resistance to H was due to extraprosodicity; while H assignment would be sensitive to prosodic structure, the analysis would be forced to stipulate that reduplication is not. This is surprising in light of the fact that some of the best-known cases of exceptional behavior with respect to onsetless syllables involve reduplication.

A final argument against an extraprosodic analysis of the Moro data comes from the tone patterns of *heavy* onsetless syllables. Roots with initial VC syllables consistently surface with H:

(14) **Vowel-initial verb roots with heavy syllables**

		3rd Imperfective	*3rd Imperfective Passive*	
		CL-MAIN-ROOT-IMPV	CL-MAIN-ROOT-PASS-IMPV	*Gloss*
H-L	a.	k-ɤ́nd-iə	k-ɤ́nd-ən-iə	‘catch’
HL	b.	k-ónḍəṭ-a	n/a	‘dry (int.)’

As with other heavy syllables, H fails to spread to the following syllable due to the weight-sensitivity of tone doubling. To capture this fact, an extraprosodicity analysis would be forced to analyze light onsetless syllables V as extraprosodic but not heavy VC syllables. Yet most analysis of extraprosodicity (e.g. Downing 1998, Orie 2000) capitalize only on the fact that onsetless syllables violate the constraint ONSET. This predicts that heavy and light onsetless syllables will behave the same. This is clearly true for several cases of exceptional onsetless behavior. In the Timugon Murut cases cited earlier in this section, initial syllables are avoided for reduplication even when heavy, eg. om-**po**-podon ‘always flatter.’ This demonstrates that heaviness and onsetlessness are separate issues in Timugot Murut. The fact that heaviness, or the presence of a coda, outweighs onsetlessness in Moro suggests that the effects of onsetlessness on H tone realization and syllable weight are related. Thus, extraprosodicity is not a good fit for the Moro data. In the following section we present an analysis of the exceptionality of Moro onsetless syllables for H tone realization in terms of syllable weight or size.

5 Prominence scale and H tone

In the previous sections, we showed that the distribution of H tone in Moro is sensitive to the weight or size of the syllable along a scale. Heavy syllables serve

as the domain for tone doubling (section 3.2) while light onsetless syllables are exceptional because they resist bearing H tone. Putting these facts together, they provide evidence for the following weight hierarchy for Moro:

(15) (C)VC > CV > V

This hierarchy for H tone distribution parallels one observed for stress placement in several languages that show sensitivity to both onsets and codas, namely Mbabaram (Dixon 1981, Goedemans 1998, Gordon 2005) and Manam (Lichtenberk 1983, Buckley 1998, Gordon 2005). These languages also resemble Moro in that rime-based heaviness outweighs onsetlessness (Gordon 2005).

Gordon calculates the effect of onsets and longer rimes using perceptual energy, a function of both intensity and time. Translating this concept into a formal model, the presence of onsets and codas is indicated with skeletal slots. Within Optimality Theory, he proposes constraints penalizing certain syllables from being in positions of prominence. A constraint penalizing prominence on syllables without onsets outranks one penalizing prominence on syllables with onsets. A Rime constraint requires syllables with branching rimes to be stressed.

(16) **Onset constraints**:
*PROM $[Ø[X]_{RIME}]_{\sigma}$ >> *PROM $[X[X]_{RIME}]_{\sigma}$

Rime constraint:
PROM $[(X)[XX]_{RIME}]_{\sigma}$

Prominence is defined as a perceptual property of syllables. High pitch has a natural connection with increased prominence; many languages with stress and tone prefer to stress syllables bearing H tone (de Lacy 2002). As for the connection to perceptual energy, Gordon (2006:192) observes that high tone in Hausa corresponds directly with greater intensity. Thus, it is not surprising that the realization of H tone itself might be sensitive to weight- or prominence-based distinctions.

To pursue our analysis, we adapt the constraints in (16) to tone by translating "prominence" as high tone.

(17) *[Ø[ý]] >> *[c[ý]] >> *[(c) [ýc]]

A constraint penalizes H on an onsetless light syllable is ranked above those prohibiting H on onsetful syllables. H tone on syllables without codas is dispreferred relative to those with. The *[(c)[ýc]] constraint is formulated as a negative constraint instead of the positively formulated rime constraint in (16) which requires syllables with branching rimes to be stressed. Although we used the concept of a mora to define foot structure in section 3, moras reference rimal

weight, and are not useful for distinguishing onsetless from onsetful light syllables, as both would be monomoraic. Although Topintzi (2006) has proposed that onsets can be moraic in some languages, this would not solve the issue for Moro. First, it would group VC and CV syllables together as bimoraic, and second, Topintzi's theory only allows non-geminate voiceless onsets to be moraic. We therefore use syllable positions to define our tone-bearing constraints in (17) in a similar manner to Gordon (2005). The net effect of this constraint ranking, though, is similar to WEIGHT-TO-TONE (Lee 2005)

The remaining ingredients of our analysis are constraints which produce the distribution of tone on verbs that we observed in section 3.1-3.2. First, we assume that a constraint requiring feet to be binary is present and undominated. Second, because we concluded that tone doubling is best analyzed as resulting from tone being constrained by an independent prosodic foot, we use a constraint that aligns a binary moraic foot with the left edge of the root (18a). Third, a constraint aligning the left edge of the H tone domain with a TBU at the left edge of the foot, and a corresponding constraint for the right edge, together produce binary spreading (18b,c). Because every verb root in the imperfective occurs with H (unless weight-based considerations prevent it), we posit a constraint which requires H on D-stems, obviating the need to have input H tone (18d). Finally, the constraint in (18e) prevents H tone from appearing on the word final vowel.

(18) a. ALIGN(FT,L,RT,L) Align a foot with the left edge of the root.
b. ALIGN(H,L,FT,L) Align H tone domain with TBU at left edge of foot
c. ALIGN(H,R,FT,R) Align H tone domain with TBU at right edge of foot
d. DSTEM-H A H tone must appear on the D-stem.
e. NON-FINALITY The final TBU of a prosodic word must not be H

It will be crucial for our analysis below that the alignment constraints in (18) are only penalized by misaligned tones or feet, not by the absence of them altogether.

First consider consonant initial forms. The winning candidate has a high tone aligned on both tone-bearing units in the foot, thereby satisfying ALIGN(H)-L and ALIGN(H)-R. Failure to realize tone at all incurs a violation of DSTEMH.

(19) **CV open syllables — H tone doubling**

/k-a-vəleð-a/	DSTEM-H	AL(H)-L	AL(H)-R	*cv́
☞ a. ka(və́lé)ða				**
b. ka(və́le)ða			*!	*
c. ka(vəlé)ða		*!		*
d. ka(vəle)ða	*!			

Short roots operate in the same manner, with H tone spreading onto the final imperfective vowel. Those CVC roots without H spread as discussed in (4)

provide an argument for NON-FINALITY ranked above AL(H)-R for those roots only. The ranking is switched for the more common roots that do show spreading.

(20) **CVC roots — H tone doubling and non-finality**

/k-a-vað-a/	DSTEM-H	AL(H)-L	NON-FINAL	AL(H)-R	*cv́
☞ a. ka(váða)				*	*
b. ka(váðá)			*!		**

For bisyllabic roots with a heavy syllable, we assume iterative foot construction in (21), but this is not crucial. The ranking of *cv́ >> *cv́c ensures that H emerges on the initial syllable with no spreading whether the following syllables form a second foot or not. We assume that the nasal does not count as a TBU for H tone and therefore ALIGN(H)-R is satisfied.

(21) *(***C)VC closed syllable — single H tone follows from *cv́ > *(c)v́c**

/k-a-wəndaṭ-a/	DSTEM-H	AL(H)-L	AL(H)-R	*cv́	*(c)v́c
a. ka(wə́n)(dáṭa)			*!	*	*
☞ b. ka(wə́n)(daṭa)					*
c. ka(wən)(dáṭá)				**!	
d. ka(wən)(daṭa)	*!				

For vowel-initial roots, although ALIGN(H)-L requires H at the left edge of the foot, *v́ militates against this outcome, motivating the ranking *v́ >> ALIGN(H)-L. It is crucial for the interpretation of *v́ that the initial consonant /k-/, which appears outside the D-stem (and the macrostem), is not included.[8] In (22c), H is spread across the foot boundary, violating ALIGN(H)-R in addition to incurring another *cv́ violation.[9] Lastly, DSTEM-H must also be ranked above ALIGN(H)-L, as otherwise the candidate with no output H would be preferred due to its satisfaction of the alignment and prominence constraints. (D-stem boundaries are marked with brackets)

[8] This can be achieved by indexing the constraints to operate within the D-stem or by building the word up in a cyclic fashion, requiring a version of OT that incorporates levels.

[9] As suggested to us by Rachel Walker, an alternate analysis would be to use a more general right word edge alignment constraint combined with CRISPEDGE, which would prevent H tone domains crossing foot boundaries. See Jenks & Rose (2009) for an exploration of this type of analysis.

(22) **V-initial VCVC root — *v́, DSTEM-H >> AL(H)-L**

/k-a-ogə̰t-a/	*v́	DSTEM-H	AL(H)-L	AL(H)-R	*cv́
a. k([ógə́)t̰]a	*!				*
☞ b. k([ogə́)t̰]a			*		*
c. k([ogə́)t̰]á			*!	*!	**
d. k([ogə)t̰]a		*!			

The fact that outputs without H satisfy alignment constraints is crucial for monosyllabic forms with onsetless syllables, which we turn to next. There, the only syllable within the D-stem is onsetless. The ranking from (22), correctly predicts that these forms emerge with with no surface H tone. Note that H on the imperfective final vowel would not satisfy DSTEMH. Therefore, it is better to realize no H tone at all, as in candidate (23d):

(23) **V-initial VC root — no H**

/k-a-oað-a/	*v́	DSTEM-H	AL(H)-L	AL(H)-R	*cv́
a. k([oáð]á)	*				*!
b. k([oáð]a)	*			*!	
c. k([oað]á)		*	*!		*
☞ d. k([oað]a)		*			

Yet because it is within the D-stem, H tone emerges on the passive suffix when it occurs. This is the same outcome as in the bisyllabic V-initial forms in (22):

(24) **V-initial VC root with passive suffix**

/k-a-oað-ən-a/	*v́	DSTEM-H	AL(H)-L	AL(H)-R	*cv́
a. k([úʌð-ə́)n]iə	*!				*
☞ b. k([uʌð-ə́)n]iə			*		*
c. k([uʌð-ə́)n]iə́			*!	*!	**
d. k([uʌð-ə)n]iə		*!			

The basic tone patterns of Moro verbs are derived by ranking prominence constraints relative to constraints regulating the position of H within feet

6 Conclusion

H tone distribution in Moro verb stems is largely predictable based on the size of syllables, with both the presence of codas and onsets affecting tone distribution. Moro exhibits tone doubling, which we analyze as foot-bounded spreading of H. Tone doubling does not occur in two cases: when the root begins with a heavy syllable where the coda cannot bear tone, giving a HL pattern, and with root-initial onsetless light syllables, producing the opposite LH pattern. We relate this effect to a hierarchical prominence scale similar to one proposed for stress: (C)VC > CV > V. We also argued that an extraprosodicity analysis fails to account for the avoidance of H tone on onsetless syllables in Moro for a variety of reasons. The Moro data contributes to the typological study of tonal systems. The analysis presented here makes connections between H and the formal constraints of stress systems, with reference to syllable size/weight and foot structure.

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