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*The interaction of tone and stress in Optimality Theory**

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This paper examines the relationship between tone and prosodic positions. I show that prosodic heads prefer higher tone over lower tone, while non-heads exhibit the opposite preference. These generalisations are expressed within Optimality Theory as a family of constraints in a fixed ranking. One set regulates the relation of tone to heads: *Hd/L ≫ *Hd/M ≫ *Hd/H; the other deals with tone on non-heads: *Non-Hd/H ≫ *Non-Hd/M ≫ *Non-Hd/L. These constraints are used to account for the stress system of Ayutla Mixtec: in this language, stress is attracted to a syllable based on its tonal content, but is also influenced by the post-tonic syllable's tone. The implications of the theory for other tone–stress interactions – metrically influenced tone placement and neutralisation – are also examined.

1 Introduction

Stress systems can be divided into two types: metrical and prominence-driven. In metrical stress systems, main stress is attracted towards some edge of a prosodic word and is only ever prevented from appearing at that edge by foot-form restrictions. In contrast, prominence-driven systems allow syllables with certain properties to override edge-attraction, with stress attracted to syllables with high-sonority nuclei, long vowels, onsets or any of a number of other properties (Prince 1983, Everett & Everett 1984, Everett 1988, Hayes 1995: ch. 7, de Lacy 1997, Kenstowicz 1997, Gordon 1999).

Tone can also influence main stress placement. A particularly complex example of tone-driven stress is found in Ayutla, a Mixtec language (Pankratz & Pike 1967). Generally speaking, higher-toned syllables attract stress over lower-toned ones, a tendency complicated by conditions on the tone of post-tonic syllables, as summarised in (1) (a more complete set of data is given in (7)).

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(1) a. *Stress the leftmost H-toned syllable immediately followed by a L-toned syllable*

H'HL	[lú'lúrà]	'he is small'	(288.2)[1]
LM'HL	[lùlū'úrà]	'he is not small'	(299.1)

b. *Else stress the leftmost H-toned syllable*

'HHH	['ʃínírá]	'he understands'	(299.2)
ML'H	[kūnù'rá]	'his tobacco'	(291.1)

c. *Else stress the leftmost M-toned syllable immediately followed by a L-toned syllable*

L'ML	[tì'kātʃìʔ]	'whirlwind'	(296.2)
M'ML	[lā'ʃārà]	'his orange'	(293.1)

d. *Else stress the leftmost syllable*

'LLL	['ʃàtùì]	'my trousers'	(289.1)
'MMM	['ʃīɲūrā]	'his pineapple'	(291.1)

Tone-driven stress systems are reported in languages as genetically diverse as Golin (East New Guinea Highlands; Bunn & Bunn 1970), Serbo-Croatian (Slavic; Inkelas & Zec 1988, Zec 1999), Tibetan (Sino-Tibetan; Meredith 1990) and Vedic Sanskrit (Indo-Aryan; Kiparsky & Halle 1977).

To deal with tone-driven stress, I propose that there is a hierarchy of tone types, analogous to the sonority hierarchy. In this scale, higher tone is more prominent than lower tone.

(2) *Tonal prominence scale*

H > M > L

After Prince & Smolensky (1993), the tonal scale combines with the structural positions foot head (Hd) and foot non-head (non-Hd) to form constraints in a fixed ranking, given in (3).

(3) a. $*\text{H{\scriptsize D}}/\text{L} \gg *\text{H{\scriptsize D}}/\text{M}$

b. $*\text{N{\scriptsize ON}-H{\scriptsize D}}/\text{H} \gg *\text{N{\scriptsize ON}-H{\scriptsize D}}/\text{M}$

The constraint *Hd/L assigns a violation for each occurrence of a low-toned foot head (i.e. stressed syllable). Since it invariably outranks *Hd/M, low-toned heads are predicted to be universally less desirable than mid-toned ones. The lack of a constraint against high-toned heads ensures that this type is the least marked of all. In contrast, the constraints in (3b) militate against foot non-head syllables with higher tone, predicting that the least marked foot non-head is a low-toned one.

[1] In (1) and elsewhere the numbers of parentheses give the page and column in Pankratz & Pike (1967) from which the form is taken.

The theory of tone–stress interaction in (3) encapsulates the empirical claims that (i) there is an affinity between higher tone and heads and (ii) there is a similar attraction between lower tone and non-heads. The form of the constraints is discussed further in §2. §3 shows how the constraints produce tone-driven stress through an analysis of Ayutla's stress system.

The theory also accounts for other stress–tone interactions. §4 shows that the constraints in (3) can also motivate stress-driven tone – where tone distribution refers to metrical structure. Another effect of the constraints is stress-conditioned tone neutralisation, examined in §5.

The typological predictions of the theory are discussed in §6. §7 contains a summary.

2 A theory of tone–stress interaction

The theory presented here receives its inspiration from Prince & Smolensky's (1993) approach to the sonority hierarchy and its relation to syllable positions. Analogous to the sonority hierarchy, I propose a Tonal Prominence scale in which higher tone is more prominent that lower tone: H > M > L.[2]

The Tonal Prominence scale combines with structural scales to form constraints. While a variety of structural elements may combine with the tonal scale, as they do with other scales (Prince & Smolensky 1993, Kenstowicz 1997, de Lacy 2002), the elements that are most relevant in this article are foot heads and foot non-heads. Assuming that tone associates to moras, the foot's head is the head mora of the head syllable of the foot. Through Prince & Smolensky's (1993: ch. 8) prominence alignment, these structural elements combine with the Tonal Prominence scale to form two sets of constraints in a fixed ranking.

One set relates foot heads to tone types: *Hd/L ≫ *Hd/M. The constraints are in a universally fixed ranking, with the effect that low-toned heads always incur more significant violations than mid-toned ones. Since no constraint militates against high-toned heads, this type is the least marked.[3]

[2] It is quite possible that the Tonal Prominence scale is a total order of all possible heights, which may number as many as six (Odden 1995: 453ff). The examples I have collected only provide evidence for three tone-height distinctions in relation to stress (see §§3 and 6), so a conservative form of the hierarchy is used here. I am preceded in proposing a tonal hierarchy by Jiang-King (1996: 99), who offers the hierarchy [+upper] > [−raised]. I will show that more than a two-step tonal hierarchy is needed (see §3).

[3] This proposal is analogous to Clements' (1997) for sonority-syllable constraints. Constraints against the least marked tone-head combinations would also have an undesirable typological effect. They would allow systems in which foot heads cannot bear tone while non-heads can: *Hd/H ≫ Faith(Tone) ≫ *Non-Hd/H, where Faith(Tone) is some faithfulness constraint that preserves input tone. I know of no such system, while the opposite type of system – one where tone is only specified on heads – does exist (e.g. Yip 2001).

The non-head/tone constraints *NON-HD/H $\gg$ *NON-HD/M militate against higher-toned foot non-heads. As with the tone-head constraints, the fixed ranking of the non-head constraints produces an implicational hierarchy, with high-toned foot non-heads being least harmonic, mid-toned non-heads relatively more harmonic and low-toned non-heads the most harmonic sort. §4 will present evidence that the constraints refer specifically to foot non-heads rather than unstressed syllables.

Apart from the fixed rankings indicated in (3), the constraints' ranking is freely permutable: any *NON-HD/TONE constraint may outrank any *HD/TONE constraint and *vice versa*.

The constraints in (3) formally express the empirical claims in (4).

(4) a. Foot heads and higher tone have an affinity for each other.
b. Foot non-heads and lower tone have an affinity for each other.
c. (a) and (b) can motivate:
i. attraction of (non-)heads to tone;
ii. attraction of tone to (non-)heads;
iii. neutralisation of tone on (non-)heads.

Property (4a) is related to Goldsmith's (1987) Tone-Accent Attraction Condition, given in (5):

(5) *Tone-Accent Attraction Condition* (Goldsmith 1987)
A tone-to-grid structure is well-formed iff there is no tone-bearing syllable which has a lower level of accent than a toneless syllable.

In other words, if an unaccented syllable bears tone, all syllables with a greater level of accent must also bear tone. The Tone-Accent Attraction Condition has been used to motivate attraction of tone to foot heads (e.g. Goldsmith 1987, Bickmore 1995). In a sense, the constraints in (3a) translate Goldsmith's proposal into optimality-theoretic terms. However, they extend the proposal by allowing heads to be sensitive to several different tone heights rather than just two (or the presence *vs.* absence of tone). Other novel aspects of the present proposal are those in (4b) and (4c) – that foot non-heads also exhibit a tonal preference, and that the preferences of (4a, b) can make themselves felt in a variety of ways.

The claim in (4c) follows from a property of Optimality Theory: there is no one-to-one correspondence between triggers and repairs. The constraints in (3) are no exception – they militate against foot heads and non-heads with certain tonal properties, but they do not specify how to avoid the undesirable structures. The following sections show that conditions on tone and stress expressed by the constraints in (3) provoke a variety of responses, and that the responses are produced by different rankings of tone- and stress-related constraints. §3 shows how undesirable tone-(non-)head configurations are avoided in Ayutla Mixtec by deviating from the default prosodic structure (4c.i). §4 deals with (4c.ii), where the tone-head constraints are satisfied through tone movement. §5 shows how the tone-head constraints can trigger neutralisation of tonal contrasts in heads and non-heads (i.e. (4c.iii)).

3 Tone-driven stress: Ayutla Mixtec

The aim of this section is to present evidence for two of the major properties of the present theory: (i) that head–tone interaction is sensitive to the distinctions between (at least) high, mid and low tone and (ii) that foot non-heads prefer lower tone. In addition, I identify the rankings needed to produce tone-driven stress. One ranking is that some tone-(non-)head constraint (i.e. at least one of the constraints in (3)) must outrank constraints on stress placement. In the other ranking, constraints on tone placement must outrank the stress-placement constraints. To summarise, I will show that the ranking schema for tone-driven stress is as in (6).

(6) *Ranking scheme for tone-driven stress*

tone-placement constraints	,	tone-(non-)head constraints	≫	stress-placement constraints

The schema in (6) will be illustrated by an analysis of Ayutla Mixtec's stress system. §3.1 describes the relevant facts; §§3.2–3.5 contain the analysis and §3.6 summarises the findings.

3.1 Description

A number of Mixtec languages have both overt stress and lexical tone.[4] Of these languages, Ayutla presents a particularly complex system of tone–stress interaction (Pankratz & Pike 1967).

Ayutla has three contrastive tones (H, M, L), and every syllable bears one and only one tone. Syllables have the shape (C)(C)V(ʔ) (Pankratz & Pike 1967: 292). Stress can fall on roots or suffixes, but never on prefixes or proclitics (Pankratz & Pike 1967: 292).[5] As suggested by the data in (1), stress is assigned in a tone-dependent fashion within the root + suffix domain. Further data supporting this generalisation is provided in (7).

(7) a. *Stress the leftmost H-toned syllable immediately followed by a L-toned syllable*

ˈHL	[ˈʃínìʔ]	'hat'	(293.1)
ˈHLL	[ˈkánìwà]	'it is very long'	(288.2)

[4] Apart from Ayutla, Mixtec languages with overt stress and lexical tone include Coatzospan (Gerfen 1996), Diuxi (Pike & Oram 1976), Huajuapan (Cacaloxtepec) (Pike & Cowan 1967), Jicaltepec (Bradley 1970), Molinos (Hunter & Pike 1969, Yip 1981) and Silacayoapan (North & Shields 1977).

[5] Following Gerfen's (1996) analysis of Coatzospan Mixtec, I assume that the root and suffixes form a Prosodic Word to the exclusion of prefixes. Since the PrWd forms the stress domain, only root + suffix combinations are considered in §3.

'HLH	['ʃínìrá]	‘his hat’	(299.2)
'HLHL	['ʃáàʃíìʔ]	‘is not eating’	(297.1)
'HLHLL	['sátàkáràrìʔ]	‘he is buying animals again’	(289.2)
L'HL	[màʔ'náì]	‘my drowsiness’	(291.1)
H'HL	[lú'lúrà]	‘he is small’	(288.2)
H'HLL	[lú'lúvàrà]	‘he is very small’	(293.2)
H'HLH	[ká'tʃíràá]	‘there is none of his cotton’	(296.2)
HH'HL	[tíká'tʃíìʔ]	‘four whirlwinds’	(296.2)
LL'HL	[sàtà'kárà]	‘he will buy more’	(292.2)
LM'HL	[lùlū'úrà]	‘he is not small’	(299.1)
LMH'HL	[vìʃīí'ráà]	‘he is not cold’	(299.1)

b. *Else stress the leftmost H-toned syllable*

'HH	['tímáʔ]	‘candle’	(288.2)
'HHH	['ʃínírá]	‘he understands’	(299.2)
'HHHH	['ʃítórírá]	‘he (animal) is watching him (man)’	(298.2)
L'H	[pà'lá]	‘brown sugar’	(288.2)
M'H	[jā'kʷáʔ]	‘is it crooked’	(291.1)
L'HH	[kà'sárá]	‘his brother-in-law’	(294.2)
M'HH	[jā'tárá]	‘is he old’	(291.1)
LL'H	[sàtà'rá]	‘he bought’	(292.2)
ML'H	[kūnù'rá]	‘his tobacco’	(291.1)
LM'H	[nùɲā'rá]	‘he will not open’	(292.1)
LLL'H	[kàʃìrì'rá]	‘he (animal) will eat him (man)’	(298.2)
LLM'H	[ʃàkùū'rá]	‘he isn’t crying’	(299.2)

c. *Else stress the leftmost M-toned syllable immediately followed by a L-toned syllable*

'ML	['nāmà]	‘wall’	(288.1)
'MLL	['tʃītʲàì]	‘my banana’	(289.1)
'MLLL	['kākā̀kàrà]	‘he will ask again’	(288.2)
L'ML	[tì'kātʃìʔ]	‘whirlwind’	(296.2)
M'ML	[lā'ʃārà]	‘his orange’	(293.1)

d. *Else stress the leftmost syllable*[6]

'LL	['kàʃìʔ]	‘to eat’	(298.2)
'LLL	['ʃàtùì]	‘my trousers’	(289.1)
'MM	['tīkū]	‘louse’	(291.1)
'MMM	['ʃīɲūrā]	‘his pineapple’	(291.1)

[6] Mid tone has a restricted distribution in Ayutla, as in many tone languages. Mid tone is prohibited (i) immediately after high tone and (ii) word-finally, and sequences of mid tone must begin in the root-initial syllable (Pankratz & Pike 1967: 297). With the restrictions on mid tone taken into account, the only words without any high-toned syllables or mid–low sequences are either entirely low- or mid-toned, as in (7d).

The primary correlates of stress in Ayutla are greater duration and higher pitch (Pankratz & Pike 1967: 289, 294). No secondary stress is reported.

Morphologically complex words show the action of the stress system. For example, the root /kàʃìʔ/ 'eat' is stressed on the initial syllable when it appears on its own: e.g. [ˈkàʃìʔ] 'to eat'. When the enclitics /rìʔ/ (3rd person (animal)) and /rá/ (3rd person (man)) are attached, though, stress falls on the high-toned syllable: [kàʃìˈráríʔ] 'he (man) will eat him (animal)', [kàʃìrìˈrá] 'he (animal) will eat him (man)' (1967: 298.2). In contrast, when the enclitics are added to the high-toned root /ʃítóʔ/ 'watch', stress remains on the initial syllable: i.e. [ˈʃítórírá] 'he (animal) is watching him (man)'. However, in [ʃítóˈrárìʔ] 'he (man) is watching him (animal)', stress falls on the penult because it initiates a HL tone sequence.

Pankratz & Pike's description of stress also receives support from two stress-dependent phonological processes: devoicing and syncope. In Ayutla, a word-initial unstressed vowel optionally devoices before voiceless consonants: e.g. [i̥ˈkááʔ] ~ [íˈkááʔ] 'is old', cf. [ˈíkà], *[ˈi̥ká] (Pankratz & Pike 1967: 289.2). Also, unstressed vowels are prone to being deleted if doing so will produce an acceptable onset (i.e. [{s, ʃ} {t, k, n}]): e.g. /sánárà/ → [sáˈnárà] → [ˈsnárà], cf. /ʃínì/ 'hat' → [ˈʃínì], *[ˈʃnì] (1967: 294.1). Pankratz & Pike observe that neither process applies to stressed vowels.

3.2 Tone-driven stress I: heads *vs.* stress

This section identifies one of the rankings necessary for tone-driven stress – involving the tone-head and stress-placement constraints. The next section will deal with the other ranking, between tone-placement and stress-placement constraints.

I begin the analysis of Ayutla by proposing that there are two separate – and relatively independent – conditions active in the language. One relates to the tone of stressed syllables, discussed in this section. The other relates to the tone of the immediately post-tonic syllable, identified as the foot non-head in §3.4.

Putting aside the post-tonic tone's influence for the moment, it is evident that stress is attracted to higher tone in Ayutla. To determine the ranking responsible for this attraction, it is first necessary to identify the constraints responsible for stress placement.

When all syllables have the same tone, stress falls on the initial syllable: e.g. [ˈʃínírá] 'he understands', [ˈʃī̃ɲūrā] 'his pineapple', [ˈʃàtùì] 'my trousers'. This fact indicates that Prosodic Words in Ayutla contain a single trochaic foot, preferably aligned with the left edge. This proposal is consistent with the fact that many other Mixtec languages also have a single left-aligned trochaic foot in every Prosodic Word (Bradley 1970, Pike & Oram 1976, North & Shields 1977, Gerfen 1996). The constraints FtBin, Trochee, Parse-σ and AllFtL – defined in (8) – capture this requirement.

(8) a. TROCHEE
Every foot is left-headed (Prince & Smolensky 1993).

b. FTBIN
Every foot is binary at the moraic or syllabic level (McCarthy & Prince 1986, 1993).

c. ALLFTL
The left edge of every foot is aligned with the left edge of some PrWd (McCarthy & Prince 1993).[7]

d. PARSE-σ
Every syllable is contained inside a foot (Prince & Smolensky 1993).

McCarthy & Prince (1993) show that the ranking ALLFTL ≫ PARSE-σ limits the number of feet per Prosodic Word to one. This ranking is employed here to rule out secondary stress.

The constraint TROCHEE ensures that feet are left-headed. There is no evidence that TROCHEE is ever violated in Ayutla, so only candidates with trochaic feet are considered below.

In contrast, ALLFTL is often violated by winning forms under the influence of the tone-head constraints. Two relevant examples are [nùɲāˈrá] 'he will not open' and [kūnùˈrá] 'his tobacco'. In these words, stress falls on the high-toned syllable despite the fact that the low- and mid-toned syllables are closer to the PrWd's left edge.

To compel avoidance of both low- and mid-toned syllables, both *HD/L and *HD/M must outrank ALLFTL. This ranking is illustrated in tableau (9) (parentheses mark foot boundaries).

(9) *Tone-driven stress: Ranking I*

/kūnùrá/	*HD/L	*HD/M	ALLFTL
☞ a. kūnù(ˈrá)			**
b. kū(ˈnùrá)	*!		*
c. (ˈkūnù)rá		*!	

While candidates (9b) and (9c) are more harmonic than (9a) in terms of left-edge alignment, they both have non-high-toned foot heads, fatally violating *HD/L and *HD/M. The tableau illustrates the general ranking needed for tone-driven stress: some tone-(non-)head constraint must outrank the constraints responsible for locating stress – in this case

[7] The constraint ALLFTL assigns a violation for every syllable that separates each foot from the left edge of the PrWd (McCarthy & Prince 1993). For example, [(tata)ta(tata)] incurs three violations – none for the first foot, and three for the second.

ALLFTL. The opposite ranking would result in no tone–stress interaction, as in candidate (9c). The same ranking correctly stresses [nùɲāˈrá].

The ranking in (9) also accounts for the fact that M-toned stressed syllables are more harmonic than L-toned ones in Ayutla. For example, stress falls on the mid-toned syllable in [ʃàkùˈūrìʔ] 'he isn't crying', avoiding the low-toned leftmost syllables even though doing so would better satisfy ALLFTL.

(10) *Preference for mid- over low-toned heads*

/ʃàkùūrìʔ/	*HD/L	*HD/M	ALLFTL
a. (ˈʃàkù)ūrìʔ	*!		
b. ʃà(ˈkùū)rìʔ	*!		*
☞ c. ʃàkù(ˈūrìʔ)		*	**

While all candidates violate some tone-head constraint in tableau (10), candidates (a) and (b) violate the most highly ranked of the set: *HD/L. Only candidate (c) is left, despite having a mid-toned stressed syllable.

While the tone-(non-)head constraints often force candidates to violate ALLFTL, ALLFTL can be decisive. When the tone-head constraints fail to identify a unique winner, ALLFTL favours the candidate with stress on the leftmost syllable. The emergent effect of ALLFTL is clearest in words with identical tones. For example, the tone-head constraints do not determine a unique winner for the input /ʃīɲūrā/ 'his pineapple' – every candidate will incur the same number of violations of *HD/M: i.e. [(ˈʃīɲū)rā], *[ʃī(ɲūrā)]. Since *HD/M is indecisive in this competition, ALLFTL assigns the crucial violation to favour the candidate with the leftmost foot [(ˈʃīɲū)rā].

In short, tableaux (9) and (10) illustrate an essential part of the ranking for tone-driven stress: some tone-(non-)head constraint – here ALLFTL – must outrank constraints on stress placement; the opposite ranking would favour the initial-stressed candidates, effectively rendering stress insensitive to tone.

The tableaux also show that separate constraints against low- and mid-toned heads are necessary – the constraints are essential in producing a hierarchy of tonal preference, with low-toned heads most vigorously avoided, followed by mid-toned ones.

3.3 Tone-driven stress II: tone *vs.* stress

While it is necessary to have some tone-head constraint outrank stress-placement constraints to produce tone-driven stress, it is not sufficient. The other essential ranking relates to constraints on tone placement: they must at least outrank the stress-placement constraints.

The constraint responsible for tone distribution in Ayutla is IDENT(T), a constraint that preserves input tone specifications (after McCarthy & Prince 1995).

(11) IDENT(T)

If mora *x* bears tone T in the input, then the output correspondent of *x* bears T.

The need for IDENT(T) to outrank stress-placement constraints is shown in tableau (12), with the form [sàtàˈrá] 'he bought'.

(12) *Tone-driven stress: Ranking II*

/sàtàrá/	IDENT(T)	*HD/L	ALLFTL
a. (ˈsàtà)rá		*!	
☞ b. sàtà(ˈrá)			**
c. (ˈsátà)rá	*!		

Candidate (a) fatally violates *HD/L by having a low-toned head. Both (b) and (c) avoid *HD/L – (b) by moving the foot and (c) by changing the initial syllable's tone from low to high. By altering the input tone, (c) fatally violates IDENT(T). The ranking between IDENT(T) and ALLFTL is therefore crucial; if (c) were the winner the Ayutla system would not have tone-driven stress, but rather stress-conditioned tone neutralisation (see §5).

It is important to point out that it is not necessary for *HD/L to outrank IDENT(T) (or *vice versa*) to produce tone-driven stress. As tableau (12) shows, the tone-driven stress candidate (b) would win under either ranking. The ranking of these two constraint types does prove significant for tone neutralisation, though: in Ayutla, IDENT(T) must outrank both *HD/L and *HD/M; otherwise every word would surface with a high-toned foot head. This point is illustrated in tableau (13):

(13) *Anti-neutralisation ranking*

/kàʃìʔ/	IDENT(T)	*HD/L
☞ a. (ˈkàʃìʔ)		*
b. (ˈkāʃìʔ)	*!	
c. (ˈkáʃìʔ)	*!	

The low tones of the input /kàʃìʔ/ are faithfully preserved in the winning candidate (a) despite the influence of *HD/L (cf. (b, c)). For a case that differs from Ayutla primarily in this ranking, see §5.

To summarise, this and the preceding section have shown that two rankings are needed to produce tone-driven stress. One is that some tone-head constraint(s) must outrank a stress-placement constraint; in Ayutla both *HD/L and *HD/M outrank ALLFTL. The other ranking ensures that violations of the tone-head constraints are avoided by tone-driven stress rather than neutralisation: constraints on tone placement must outrank the stress constraints; this is achieved in Ayutla by having IDENT(T) outrank ALLFTL.

3.4 Tone and non-heads

This section presents evidence for constraints that refer to the tonal preferences of foot non-heads. The evidence comes from the fact that Ayutla's stress is sensitive to the immediately post-tonic syllable's tone. Since Ayutla has trochaic feet, the immediately post-tonic syllable can be identified as the non-head syllable of a foot. Reference to the foot non-head's tone is crucial, as shown by the form [lú('lúrà)] 'he is small'. If the non-head's tone were unimportant, stress should fall on the leftmost syllable with high tone since doing so would minimise violations of ALLFTL: i.e. *[('lúlú)rà].

To produce sensitivity to foot non-heads, I employ the constraints in (3b). The effect of these constraints is seen in competing forms such as *[('lúlú)rà] and [lú('lúrà)], illustrated in tableau (14).

(14) *The foot non-head constraints*

/lúlúrà/	*NON-HD/H	ALLFTL
a. ('lúlú)rà	*!	
☞ b. lú('lúrà)		*

Forms such as [lā('ʃārà)] 'his orange' show the need for the ranking *NON-HD/M over ALLFTL: the sole tonal difference between this form and its competitor *[('lāʃā)rà] is that the latter violates *NON-HD/M.[8]

It is crucial that the present constraints refer to the non-head of a foot, as opposed to unstressed syllables. If the constraints referred to unstressed syllables, they would be unable to distinguish between (14a) and (14b) since both have one high-toned and one low-toned unstressed syllable. A constraint against unstressed high-toned syllables would assign both candidates one violation – for the second syllable [lú] in (14a) and for the first [lú] in (14b). The decision would then be passed to the lower-ranked ALLFTL, thereby incorrectly favouring (14a).

Again, ALLFTL is decisive when there are two equally harmonic feet in a word. For example, /sátàkáràrìʔ/ 'he is buying animals again' has two σ́σ̀ sequences, and therefore two candidates with equally harmonic feet: [('sátà)káràrìʔ] and *[sátà('kárà)rìʔ]. Since both equally satisfy the tone-head and tone-non-head constraints, ALLFTL will assign the decisive violation, eliminating the latter candidate.

In short, constraints on the tonal preference of foot non-heads are necessary in Ayutla. Notably, low-toned non-heads are the most desirable, as predicted by the present theory. Other cases where tone on foot non-heads influences stress are presented in §6.

[8] Like the *HD/Tone constraints, IDENT(T) must outrank *NON-HD/H in Ayutla, otherwise tones of foot non-heads would be neutralised.

3.5 Post-tonic tone and foot binarity

To complete the analysis, it is necessary to establish the ranking of FtBin. This constraint's ranking is essential in producing sensitivity to the foot non-head's tone: unless FtBin forces feet to be disyllabic, the non-head constraints can be satisfied by reducing foot size. For example, while a candidate such as *[(ˈlúlú)rà] is ruled out by *Non-Hd/H, the form *[(ˈlú)lúrà] is not – this form does not contain a foot non-head, so *Non-Hd/H is vacuously satisfied. In order to eliminate *[(ˈlú)lúrà] while retaining the attested [lú(ˈlúrà)], FtBin must outrank AllFtL, as shown in tableau (15).

(15) FtBin: *Ranking I*

/lúlúrà/	*Non-Hd/H	FtBin	AllFtL
a. (ˈlúlú)rà	*!		
b. (ˈlú)lúrà		*!	
☞ c. lú(ˈlúrà)			*

While FtBin outranks AllFtL, it is not undominated, as shown by the fact that it can be violated by winning forms: e.g. [pà(ˈlá)] 'brown sugar', [kūnù(ˈrá)] 'his tobacco'. The latter form shows that degenerate high-toned feet are more harmonic than a disyllabic (ˈσ̄σ̀) foot (cf. *[(ˈkūnù)rá]). The generalisation here is that the desire to have a high-toned foot head outweighs the need for foot binarity. Having *Hd/M outrank FtBin accounts for this fact.

(16) FtBin: *Ranking II*

/kūnùrá/	*Hd/M	FtBin	AllFtL
a. (ˈkūnù)rá	*!		
☞ b. kūnù(ˈrá)		*	**

To summarise, conditions on foot binarity in Ayutla are subordinate to the requirements of the tone-head constraints, yet can still have a visible effect.[9]

I conclude this analysis by identifying which rankings are indeterminable. One is the ranking between FtBin and the non-head constraints. A conflict does arise between these constraints in a form such as /ʃínírá/ 'he understands': FtBin favours the candidate [(ˈʃíní)rá] while *Non-Hd/H favours [(ˈʃí)nírá]. Unfortunately, the phonetic realisation of

[9] Support for this approach comes from Ayutla's relative Huajuapan (Cacaloxtepec) (Pike & Cowan 1967). Huajuapan's stress system is almost the same as Ayutla's, except for the fact that MLH words have stress on the initial syllable: e.g. [(ˈn-ā̃-nĩ̀-)ní] 'your (sg adult) brother'. The difference between Ayutla and Huajuapan can be straightforwardly described in the present theory: while *Hd/M outranks FtBin in Ayutla, the opposite ranking obtains in Huajuapan (de Lacy 1999).

both candidates is the same, so there is no straightforward way to determine which of these two is the winner. I do not know of any phonological processes in Ayutla which help distinguish the two.

Similarly, there is no direct way to tell whether the tone-head constraints outrank the tone-non-head constraints. The difficulty in determining the ranking relates to the fact that degenerate feet can be used to avoid violations of the tone-non-head constraints. For example, a form with the tonal shape MLHH produces candidates that conflict on the tone-head and tone-non-head constraints: *[('ML)HH] only violates *Hd/M while *[ML('HH)] only violates *Non-Hd/H. However, the candidate [ML('H)H] violates neither – it only violates the low-ranked FtBin, so is guaranteed to win in any case.

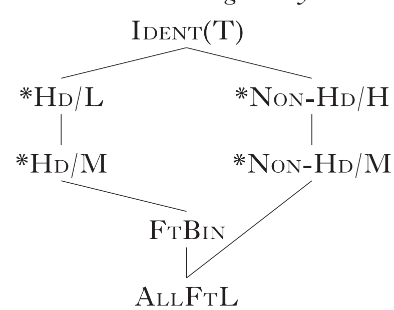
The only way to establish the ranking between the tone-head and tone-non-head constraints is to determine the FtBin and tone-non-head ranking. If FtBin outranks *Non-Hd/H, then by transitivity *Hd/M outranks *Non-Hd/H (see tableau (16)). Such a ranking has no undesirable effects: since all tone-head constraints outrank FtBin high-toned syllables will always attract the stress even if doing so creates a degenerate foot.

3.6 Summary

To summarise, Ayutla provides support for two of the main properties of the present theory. One is that there is a hierarchy of tonal preference: heads prefer high tone, then mid, then low. The hierarchy is evident in the forms [kūnù('rá)] and [ʃàkù('ūrì)], as explained in §3.2. The other is that non-heads of feet also have a tonal preference, accounting for the stress in [lú('lúrà)] (cf. *[('lúlú)rà]).

The Ayutla analysis also illustrated the two rankings necessary for tone-driven stress. To aid in the exposition, the ranking in Ayutla is summarised in (17).

(17) *Constraint ranking in Ayutla*



One essential ranking is that some tone-(non-)head constraint must outrank a stress-placement constraint. Ayutla is remarkable in that all tone-head and tone-non-head constraints outrank the relevant stress constraint(s) (i.e. ALLFTL); other languages may have fewer active tone-head constraints, a point discussed in §6.

The other crucial ranking is that tone-placement constraints must outrank stress-placement constraints. For Ayutla, this ranking involves the tone-preservation constraint IDENT(T) and ALLFTL. This ranking is crucial in determining the language's response to the tone-head constraints. The next section will show that the opposite ranking produces a different repair – stress-driven tone.

4 Stress-driven tone: Lamba

The aim of this section is to show the theory presented in §2 accounts for metrically sensitive tone distribution. Two rankings are crucial in such systems. One is that some tone-head constraint must outrank constraints on tone placement or preservation. The other is that constraints on stress placement must outrank the tone-placement/preservation constraints. The ranking schema is given in (18).

(18) *Ranking scheme for metrically sensitive tone*

stress-placement constraints	,	tone-(non-)head constraints	≫	tone-placement constraints

The schema in (18) is illustrated through an analysis of tone distribution in the Bantu language Lamba. §4.1 contains the relevant facts. An analysis is provided in §§4.2 and 4.3, and a summary in §4.4.

4.1 Description

Bickmore (1995) presents a detailed description and analysis of Lamba's tone distribution. I adopt Bickmore's analysis in its essentials here, but recast it in optimality-theoretic terms using the constraints in (3).

If a Lamba word contains no input high tone, it surfaces as entirely low-toned (19a). However, if some morpheme has a high tone in the input – whether it be a root (19b.i) or affix (19b.ii) – a high tone appears on the surface. Following convention, only high tones are indicated in the transcriptions in this section.

(19) a. *No input H tone*

i.	[u-ku-fut-a]	'to pay'	(310)
ii.	[u-ku-kom-a]	'to hurt'	(310)
iii.	[u-ku-mu-kom-a]	'to hurt him/her'	(310)

b. *Input H tone*

i.	/tu-chi-léemb-a/	→ [tuchiléemba]	'we still write'	(311)
ii.	/tá-tu-ka-kom-a/	→ [tatukákoma]	'we will not hurt'	(310)

If one or more morphemes have an underlying high tone, the high tone appears in a predictable surface position. High tone falls on the leftmost mora of a certain class of prefixes, called 'attractor' prefixes (20a), and on every other mora up to the root (20b). If there are no attractor prefixes, the high tone falls on the root-initial mora (19b.i). The leftmost attractor prefix is marked with a preceding curly brace in the examples below.

(20) a. /u-ku-léemb-a/ → [u{kúleemba]
'to write' (310)
/tu-a-chi-mu-léemb-el-a/ → [twachi{múleembela]
'we just wrote to him' (315)
/u-ku-mu-léemb-el-a/ → [u{kúmuleembela]
'to write to him/her' (310)
/u-ku-mu-bútush-a/ → [u{kúmubutusha]
'to chase him' (325)
/tu-la-léemb-a/ → [tu{láleemba]
'we write' (311)
/tá-tu-ka-kom-a/ → [tatu{kákoma]
'we will not hurt' (310)
/tá-tu-le-kom-a/ → [tatu{lékoma]
'we are not hurting' (316)

b. /tá-tu-luku-mu-kom-a/ → [tatu{lúkumúkoma]
'we are not hurting him' (319)
/tu-ka-luku-mu-léemb-a/ → [tu{kálukúmuleemba]
'we will be writing to him' (321)
/tá-tu-ka-luku-mu-léemb-el-a/ → [tatu{kálukúmuleembela]
'we will not be writing to him' (311)

The examples show that the underlying position of high tones is irrelevant for surface tone distribution: all high tones end up on the leftmost attractor prefix's first mora and on every other mora up to the root. It makes no difference if there is only one underlying high tone and two surface positions that require high tone: the underlying H splits in two in such situations, as in the first form in (20b).

4.2 Metrically driven tone

I adopt Bickmore's proposal that the surface distribution of tone depends on metrical structure. Specifically, the stress domain is parsed into trochaic feet, and high tones are required to appear on foot heads.[10]

The stress domain (SD) starts with the leftmost attractor prefix; in words without attractors, the left edge of the SD coincides with the root's

[10] There is some disagreement between Doke (1938) and Bickmore (1995); Doke describes an audible stress on the penult. Here I follow Bickmore's data and description, which are based on his fieldwork.

left edge.[11] The right edge of the SD also aims to be as close to the root-initial syllable as possible. An example foot parse is [tatu{('kalu)('kumu)} leemba] – the SD extends from the leftmost attractor morpheme *ka* to the left edge of the root, and contains two feet. High tones fall on all foot heads.[12]

This section concentrates on identifying the ranking needed to produce foot-sensitive tone distribution. §4.3 presents details of tone splitting and coalescence.

Foot structure is controlled by the same foot-related constraints used in the analysis of Ayutla (see (8)). Again, TROCHEE is never violated by winning candidates – all feet are left-headed. Feet are also always disyllabic, so FTBIN is likewise unviolated. Unlike Ayutla, PARSE-σ outranks ALLFTL, ensuring a fully footed Stress Domain.

The foot-related constraints are never violated in Lamba. Instead, tone-placement constraints are the ones to yield to the pressure of the tone-head constraints. The two tone-placement constraints of present interest are IDENT-ASSOC and DEP(T), defined in (21).

(21) a. IDENT-ASSOC
If there is an association between *x* and tone T in the input, then there is an association between *x′* and T′ in the output, where *x′* and T′ are the correspondents of *x* and T respectively (after Myers 1997: 863).

b. DEP(T)
Every tone in the output has some input correspondent (Myers 1997: 852, 859).

The constraint IDENT-ASSOC preserves input tone associations, thereby prohibiting tone movement. It is frequently violated in Lamba under the influence of *HD/L, as shown in tableau (22) for /u-ku-mu-pám-a/ 'to beat him/her'.

(22) *Stress-driven tone: Ranking I*

/u-ku-mu-pám-a/	*HD/L	IDENT-ASSOC
a. u{('kumu)}páma	*!	
☞ b. u{('kúmu)}pama		*

[11] Bickmore (1995: 325) observes that the stress domain is not equivalent to any morphological domain, although – as a reviewer points out – it closely resembles the 'macrostem' (as used in e.g. Hyman & Ngunga 1994; cf. Myers 1987). The stress domain may be a phonological constituent (cf. Bickmore 1995: 325), but I will not explicitly identify which one, as this issue is tangential to the point of this analysis.

[12] Following McCarthy & Prince (1993) and Selkirk (1995), the stress domain is formed through the action of alignment constraints. The constraint ALIGN(SD-L, Rt-L) requires the left edge of the SD to coincide with the root's left edge, a constraint overridden by the requirement that attractor prefixes be contained inside a SD (see Selkirk 1995 for relevant discussion). The other constraint is ALIGN(SD-R, Rt-L), which requires the right edge of the SD to be as close to the root's left edge as possible; this constraint is violated when there is too little space – i.e. when there are no attractor prefixes: e.g. [tuchi{(léemba)}] 'we still write'; any other SD parse would violate FTBIN.

Candidate (a) preserves the underlying high tone's position, but in doing so fatally violates the tone-head constraint *HD/L. Candidate (b) satisfies *HD/L only at the expense of being unfaithful to the high tone's input position.

Tableau (22) illustrates one of the two rankings necessary for metrically conditioned tone placement: some tone-head constraint must outrank constraints on tone placement. The other ranking relates to the stress- and tone-placement constraints. In Lamba, the relevant stress constraint is ALLFTL – it conflicts with IDENT-ASSOC, as shown in tableau (23) for /u-ku-pám-a/ 'to beat'.

(23) *Stress-driven tone: Ranking II*

/u-ku-pám-a/	ALLFTL	IDENT-ASSOC
a. u{ku('páma)}	*!	
☞ b. u{('kúpa)ma}		*

Candidate (a) exhibits tone-driven stress, with the foot head attracted to the high-toned syllable; this candidate is ruled out by the footing constraint ALLFTL. The winner is therefore (b), where the high tone moves from its input position.

A remarkable aspect of Lamba's tone system is the extent to which underlying tone will alter in order to avoid low-toned foot heads. Not only will tones move, they will even split so that foot heads can end up with high tones. A relevant example is /tá-tu-luku-mu-kom-a/ 'we are not hurting him'. Since there are two foot heads in the surface form but only one input high tone, the high tone splits in two: [tatu{('lúku)('múko)}ma].[13] In the output form just cited, the input high tone has two output correspondents – one over [lu] and the other over [mu]. Tone splitting violates the constraint INTEGRITY(T), defined in (24) (after McCarthy & Prince 1995).

(24) INTEGRITY(T)

Every input tone has only one output correspondent.

The tone-head constraint *HD/L must outrank INTEGRITY(T), otherwise splitting would not take place. The opposite ranking would favour the failed form *[tatu{('lúku)('muko)}ma]. Tableau (25) illustrates this ranking.

(25) *Tone splitting*

/tá-tu-luku-mu-kom-a/	*HD/L	INTEG(T)
a. tátu{('luku)('muko)}ma	*!*	
b. tatu{('lúku)('muko)}ma	*!	
☞ c. tatu{('lúku)('múko)}ma		*

[13] Bickmore treats cases with a single input high tone and two high-toned output syllables as involving a single high tone linked to non-contiguous moras. Assuming that low tone is specified in output forms, the gapped representation can be adopted in this analysis, otherwise the No-Crossing Constraint would be violated (Goldsmith 1976).

The faithful candidate (a) violates *Hᴅ/L, because both foot heads have low tone. Candidate (b) shows that tone movement alone does not suffice to satisfy *Hᴅ/L. Instead, candidate (c) wins: in this form, the input H tone has split in two, with one output correspondent appearing on [lu] and the other on [mu].

Evidence that the tone distribution in [tatu{(ˈlúku)(ˈmúko)}ma] comes about through tone splitting and not epenthesis comes from underlying low-toned words. For example, the output of /u-ku-fut-a/ 'to pay' is [u{(ˈkufu)ta}], not *[u{(ˈkúfu)ta}]. Since the output is not high-toned, it must be the case that epenthesis of high tones is banned in Lamba. Such a prohibition is produced by ranking Dᴇᴘ(T) above *Hᴅ/L, a ranking illustrated in tableau (26). Candidate (a) fails because a high tone is inserted in the output.

(26) *Ban on tone epenthesis*

/u-ku-fut-a/	Dᴇᴘ(T)	*Hᴅ/L
☞ a. u{(ˈkufu)ta}		*
b. u{(ˈkúfu)ta}	*!	

To summarise, there are two crucial rankings in metrically driven tone systems. One involves the tone-head constraints of (3a) and tone-placement constraints – in Lamba *Hᴅ/L and Iᴅᴇɴᴛ-Assᴏᴄ respectively (tableau (22)). The other involves stress-placement constraints and tone-placement constraints – AʟʟFᴛL and Iᴅᴇɴᴛ-Assᴏᴄ (tableau (23)).

4.3 Avoidance of high tone in non-heads

The preceding section dealt with the generalisation that all foot heads surface with high tone when one is present underlyingly. This section completes the Lamba analysis by discussing a further generalisation: that no unstressed syllable bears a high tone on the surface.[14]

The effect of this generalisation can be seen in the fact that tone moves rather than spreads: e.g. /u-ku-pám-a/ → [u{(ˈkúpa)ma}], *[u{(ˈkúpá)ma}] – the unattested form is ruled out because it has a high-toned non-foot head [pá].

To deal with high-tone avoidance, I employ a constraint against unstressed high-toned syllables: *Uɴsᴛʀᴇssᴇᴅ/H. This constraint is a

[14] Bickmore identifies two idiosyncratic morphemes that apparently violate this restriction. The Relative prefix retains its input H tone on the surface but allows it to spread to foot heads (1995: 317). Similarly, the suffix /-ákal/ retains its high tone, but does not allow its tone to spread (1995: 322). These idiosyncrasies can be produced by morpheme-specific faithfulness constraints. For the Relative, there is a specific Iᴅᴇɴᴛ-Assᴏᴄ constraint; for the prefix, both Iᴅᴇɴᴛ-Assᴏᴄ and Iɴᴛᴇɢʀɪᴛʏ(T) hold.

straightforward extension of the present theory; as pointed out in §2, the tonal scale can combine with any structural scale (also see de Lacy 1999). The present constraint is like the foot non-head constraints in favouring low tone. It differs in that it refers to all unstressed syllables, not just those in feet.

To force tone movement instead of spreading, *Unstressed/H must outrank Ident-Assoc, as shown in tableau (27). The opposite ranking would favour a candidate in which high tone spread from its input position to the foot head (as found in Ndebele; Downing 1990).

(27) *Eliminating tone spread*

/u-ku-pám-a/	*Unstressed/H	Ident-Assoc
a. u{(ˈkúpá)ma	*!	
☞ b. u{(ˈkúpa)ma		*

A constraint against unstressed high-toned syllables is needed rather than one against spread tone because of cases involving tonal coalescence. From the input /tá-tu-ka-le-léemb-a/, the output *[tátu{(kále)}leemba] must be ruled out. In this form, only one input high tone has moved; the other remains faithful to its input position. The constraint *Hd/L is ineffective in ruling out the failed candidate since every foot head (i.e. [ka]) is high-toned. Rather, the only problem with this candidate is that it has a high-toned unstressed syllable. Therefore, *Unstressed/H must outrank a faithfulness constraint that bans coalescence – i.e. Uniformity(T) (after McCarthy & Prince 1995).

4.4 Summary

This section has shown that two rankings are needed to produce metrically sensitive tone placement. One is that some tone-(non-)head constraint must outrank tone-placement constraints. In Lamba, this requirement is met by having the constraint *Hd/L outrank the tone-faithfulness constraints, especially Ident-Assoc. Lamba is somewhat remarkable in the extent of *Hd/L's dominance over tone faithfulness: *Hd/L outranks almost every tone-faithfulness constraint except for Dep(T). The effect of *Hd/L's dominance in the ranking is that almost any means is employed to produce a candidate with high-toned heads: tone movement, splitting and fusion. The only method not employed is epenthesis (cf. §5).

The other crucial ranking is that stress-placement constraints must outrank the tone-placement constraints. In Lamba, this ranking involves AllFtL and the tone-faithfulness constraints.

5 Stress-conditioned tone neutralisation

The aim of this section is to show how the present theory accounts for cases where tone neutralises in foot heads and non-heads. Such neutralisation is yet another possible response to the tone-(non-)head constraints, and is independent of tone-stress attraction. I will show that neutralisation comes about when tone-head constraints outrank constraints on the preservation of tone height, such as IDENT(T).

An example of metrically sensitive tone neutralisation is found in the language game Ngóɓòóɓò (Bamba 1991). In Ngóɓòóɓò trochaic feet are constructed from left to right on words from the source language, Mahou. Regardless of input tonal specifications, heads of feet are assigned high tone and non-heads surface with low tone, producing (ˈσ́σ̀) feet throughout the word.

Neutralisation in Optimality Theory is produced when a markedness constraint outranks relevant faithfulness constraints. For metrically sensitive tone neutralisation, the relevant markedness constraints are the tone-head ones. In Ngóɓòóɓò, both *HD/L and *NON-HD/H outrank the tone-faithfulness constraint OO-IDENT(T), which relates the output of the native grammar to the language game's output. The ranking is illustrated in tableau (28).

(28) *Metrically conditioned tone neutralisation*

/ŋgóɓóòɓò/	*HD/L	*NON-HD/H	OO-IDENT(T)
a. (ˈŋgóɓó)(ˈòɓò)	*!	*	
b. (ˈŋgóɓò)(ˈòɓò)	*!		*
c. (ˈŋgóɓó)(ˈóɓò)		*!	*
☞ d. (ˈŋgóɓò)(ˈóɓò)			**

The dominance of the tone-(non-)head constraints in Ngóɓòóɓò ensures that the input tone is entirely ignored in the language game, as shown by candidates (a)–(c), which all fatally retain some vestige of the input tone specification. Only a candidate that ignores input tone entirely and has high-toned heads and low-toned non-heads can win (d).

In constraint terms, Ngóɓòóɓò and Lamba differ primarily in the ranking of specific tone-faithfulness constraints. In Ngóɓòóɓò – as in all metrically conditioned tone neutralisations – tone-(non-)head constraints outrank faithfulness constraints that preserve tone height (IDENT(T)). In contrast, tones do not alter in Lamba: underlying highs do not change to lows, nor lows to highs. Instead, tones move, split and coalesce to accommodate the tone-head constraints – produced by ranking the tone-head constraints above faithfulness constraints that regulate tone position and consistency (e.g. IDENT-ASSOC, INTEGRITY(T)).

A similar restriction is found in the northern Min language Fuqing (Jiang-King 1996: §3.3.2). In this language, foot heads can only bear H or M tone (e.g. [síŋ] 'spirit', [sīŋ] 'ante'), but never low tone. In contrast, foot non-heads may only bear a low tone (e.g. [ŋíɛ̀] 'art'). The ranking for Fuqing is essentially the same as the one in Ngóɓòóɓò, except that faithfulness on the input–output dimension is relevant here, rather than output–output faithfulness. The main difference between the systems is that Fuqing provides evidence for the ranking of the constraints against mid tone. The faithfulness constraint IO-IDENT(T) must outrank *HD/M in order to preserve mid tone on heads, while *NON-HD/M must outrank IO-IDENT(T) to force neutralisation of mid-toned non-heads.

5.1 Neutralisation and tone–stress interaction

Metrically sensitive tone neutralisation is independent of tone-driven stress and stress-driven tone. This is due to the fact that the ranking between IDENT(T) and the tone-head constraints is not crucial in either tone-driven stress or stress-driven tone systems.

Lithuanian presents a relevant case: it has both tone-driven stress and tone neutralisation. Stress falls on the leftmost high-toned syllable (Leskein 1919, Senn 1966, Kiparsky & Halle 1977, Halle & Kiparsky 1981, Halle & Vergnaud 1987: 190–203, Blevins 1993, Hayes 1995: 278). As with Ayutla, such a system is produced by ranking both *HD/L and IDENT(T) over ALLFTL (tableau (12)).

However, unlike the tone-driven stress systems discussed so far, every word surfaces with a high-toned syllable. Even underlying low-toned words surface with a high tone: e.g. /prà-nèʃù/ → [ˈpránèʃù], *[ˈprànèʃù] ‘I announce’ (Blevins 1993: 244). Such stress-sensitive neutralisation is produced when *HD/L outranks IDENT(T), illustrated in tableau (29) (cf. tableau (13)).

(29) *Neutralisation of tone on heads*

/prà-nèʃù/	*HD/L	IDENT(T)
a. ˈprànèʃù	*!	
☞ b. ˈpránèʃù		*

Tableau (30) shows that the *HD/L ≫ IDENT(T) ranking still allows tone-driven stress: /prà-dúrtè/ ‘to pierce through’ surfaces as [pràˈdúrtè], not *[ˈprádúrtè].

(30) *Tone-driven stress in Lithuanian*

/prà-dúrtè/	*HD/L	IDENT(T)	ALLFTL
a. (ˈpràdúr)tè	*!		
b. (ˈprádúr)tè		*!	
☞ c. prà(ˈdúrtè)			*

Since the faithful candidate (a) has a low-toned head, it is ruled out by *HD/L. Both candidates (b) and (c) satisfy *HD/L: (b) by changing the tone on the initial syllable and (c) by deviating from the default foot position (i.e. leftmost). Since IDENT(T) outranks ALLFTL in this ranking, it is more harmonic to move the foot rather than alter input tone. In other words, *HD/L in Lithuanian is preferably repaired by deviating from the default prosodic structure; only when foot movement will not solve the problem – as for /prà-nèʃù/ – will Lithuanian resort to tone neutralisation.

As a brief note on an apparent alternative, positional faithfulness constraints – constraints that promote preservation in a restricted environment – cannot supplant the tone-prominence constraints (Casali 1997, Beckman 1998). Positional faithfulness constraints do the opposite to what is needed in Lithuanian – they maintain contrast in heads. In order to reduce contrast in heads, it is necessary to invoke a markedness constraint that specifically refer to heads and their tonal content. I hasten to add that the existence of tone-prominence constraints does not imply that positional faithfulness constraints do not exist; as shown by Yip (2001), there is evidence for both kinds of constraint.

Again, the present theory predicts that neutralisation will always proceed in a certain way: if two tones are neutralised in a stressed position, the output will be the higher tone. For example, there can be no language in which a high tone is neutralised to low specifically on a stressed syllable. Such a process would require a markedness constraint that favours low-toned stressed syllables over high-toned ones; no such constraint exists in the present theory.

6 Typology

The aim of §§4 and 5 was to identify the rankings that produce the various responses to the tone-(non-)head constraints. These rankings are summarised in (31).

(31) a. *Tone-driven stress*
tone-placement constraints, tone-head constraint(s) $\gg$ stress constraints

b. *Stress-driven tone*
stress constraints, tone-head constraint(s) $\gg$ tone-placement constraints

c. *Stress-conditioned neutralisation*
tone-head constraint(s) $\gg$ tone-faithfulness constraints

d. *No tone–stress interaction*
stress constraints, tone-placement constraints $\gg$ tone-head constraints

The one ranking not so far discussed is type (d): if both stress- and tone-placement constraints outrank the tone-head constraints, tone and stress will not influence each other. Such a system is found in Angaatiha (Huisman & Lloyd 1981), Hopi (Jeanne 1982), Saramaccan (Rountree 1972), Eastern Popoloca (Kalstrom & Pike 1968) and Tlacoyalco Popoloca (Stark & Machin 1977).

The aim of this section is to identify the subtypes of the phenomena listed in (31). §6.1 deals with tone-driven stress, showing that the present theory places significant restrictions on the tone types that may attract heads and non-heads. §6.2 focuses on the typology of stress-driven tone systems.

6.1 Tone-driven stress

By allowing relatively free constraint ranking, Optimality Theory predicts a spectrum of tone-driven stress systems, differing in the extent of tonal influence. At one extreme are systems in which tone plays no role at all, while at the other are systems in which tone is the primary factor in determining stress placement. Between the two extremes are languages in which tone conditions are subordinate to other footing requirements. I will deal with the latter two types in turn.

(32) lists a number of languages in which tone is the primary factor in determining the position of stress, as in Ayutla. The categories in the list express the general character of the stress systems; the sources cited should be consulted for details.[15]

(32) a. *Stress the leftmost high-toned syllable, else the leftmost syllable*

Cubeo	Morse & Maxwell (1999: 6)
Ijo	Williamson (1965: 26)
Kpelle	Welmers (1962: 86)
Lithuanian	Blevins (1993)
Serbo-Croatian (Neo-Štovakian)	Inkelas & Zec (1988), Zec (1999)
Vedic Sanskrit	Kiparsky & Halle (1977)

b. *Stress the rightmost high-toned syllable, else the rightmost syllable*

Golin	Bunn & Bunn (1970), Bunn (1974)
Masset Haida	Enrico (1991: 111ff)

c. *Every word has just one high-toned syllable, and stress falls on it*

Aguaruna	Payne (1990: 166)
Barasano	Stolte & Stolte (1971: 91)
Hixkaryana	Derbyshire (1985: 180–181), Hayes (1995: 207)

15 Two cases do not easily fit into categories in (32). For Bambara, Woo (1969: 32–36) describes stress in compound nominals as falling on the last high-toned syllable in the first sequence of high tones. There is some controversy surrounding this case, though (Sietsema 1989). Similarly, Kraft & Kirk-Greene (1973: 18) report that stress in Hausa falls on the high tones, but high-toned syllables that immediately precede a low tone bear greater stress than others.

As shown in §3, tone-driven stress comes about when some tone-(non-) head constraint and tone-preservation/preservation constraints outrank stress constraints. In the cases in (32), the tone-head constraints outrank all foot-related constraints, ensuring that tonal conditions have primacy in stress placement.

One thing that the languages in (32) have in common is that all the cases involve attraction of stress to a high-toned syllable. There is no language in which stress seeks out a low-toned syllable, ignoring high-toned ones that are closer to the default edge. This fact follows from the present theory: in order to have a language where stress avoids high-toned syllables, there would have to be some constraint that assigns a violation to high-toned syllables but not to low-toned ones. The present theory has no such constraint, thereby predicting the impossibility of such a system.

6.1.1 *Tone as a secondary influence on stress.* Since the tone-head constraints are violable and can be freely ranked with respect to other constraints, the statement that stress is never attracted to lower-toned syllables over higher-toned ones must be tempered slightly. Specifically, stress will not fall on a high-toned syllable if doing so would violate some foot-related constraint F, where F outranked all relevant tone-head constraints. In such a case, stress may appear to avoid a high-toned syllable for a low-toned one.

A relevant case is found in Tibetan noun stress (Meredith 1990: 85ff). The primary factor for stress placement is moraic content: stress falls on the heaviest of the first two syllables in a word (1990: 88). If both syllables have the same weight and same tone, then stress falls on the leftmost one: e.g. [ˈthúːcáː] 'iron banner fixture'. However, if the two syllables have the same weight and different tones, the high-toned syllable takes the stress: e.g. [pùˈsú] 'nursery' (1990: 92), [rèːˈséː] 'cotton robe' (1990: 91). The primacy of weight is seen in words with a low-toned heavy syllable and a high-toned light syllable – the heavy syllable takes the stress: e.g. [ˈphȍːmí] 'Tibetan' (1990: 90).

Since moraic content is the primary factor for stress in Tibetan, a constraint requiring bimoraic syllables to be stressed (i.e. WEIGHT-TO-STRESS – Prince 1990) must outrank stress-placement constraints (e.g. ALIGN (ˈσ-L)). Since stress avoids low-toned syllables of the same weight, *HD/L must outrank the stress constraints as well.

The ranking between WEIGHT-TO-STRESS and *HD/L is also determinable: the former must outrank the latter, so ensuring that weight considerations are primary in this system. The need for this ranking is illustrated in tableau (33).

(33) *Tone-driven stress in Tibetan*

/phȍːmí/	WEIGHT-TO-STRESS	*HD/L
☞ a. ˈphȍːmí		*
b. phȍːˈmí	*!	

It is because of tone's subordinate role to weight in Tibetan that there are words in which low-toned syllables are stressed while high-toned ones are not. However, in all cases where stress falls on low-toned syllables, the alternative is ruled out because stress on the high-toned syllable would violate the constraint WEIGHT-TO-STRESS. Despite the special case when weight is at issue, it is still evident that – putting weight aside – Tibetan prefers high-toned syllables over low-toned ones.

Similar cases include Ndyuka (Huttar & Huttar 1972: 6, 1994) and Iraqw (Mous 1993). In both these languages, stress first seeks out a bimoraic syllable. Only if there are no heavy syllables does stress fall on the leftmost high-toned syllable.

In short, although tonal considerations can be secondary or even entirely obscured in a stress system, the prediction of the present theory is that in no language will stress avoid a high-toned syllable because of its tone quality. If stress does avoid a high-toned syllable, some non-tone-head constraint forces it to do so.

6.1.2 *Foot non-heads.* The present theory predicts that if the foot non-head's tone is relevant in a stress system, the foot with the lowest-toned non-head will be preferred. The prediction stems from the fact that there is no ranking of the constraints that favours a candidate with a higher-toned foot non-head over one with a lower-toned non-head.

Apart from Ayutla, evidence for the relevance of foot non-heads in tone-driven stress is found in two other Mixtec languages – Huajuapan (Cacaloxtepec) (Pike & Cowan 1967) and Molinos (Hunter & Pike 1969). Both systems are similar to Ayutla's: stress seeks out high- and mid-toned syllables that are immediately followed by syllables with lower tones (de Lacy 1999).

A non-Mixtec language that exhibits a preference for low-toned foot non-heads is Beijing Mandarin (Meredith 1990: 133ff). Syllables are bimoraic, so each is able to form a foot on its own. The most desirable foot is one with a high-toned head. Of feet with mid-toned heads, though, ones with a high-toned non-head are least desirable: e.g. [(ˈyāà)chīí] 'teeth', [jīán(ˈchāà)] 'to investigate', *[(ˈjīán)chāà] (1990: 135).

It is important to emphasise that the present theory does not predict that the foot non-head's tone will always be significant. If the *NON-HD/T constraints are ranked below stress-placement constraints, they will have no influence on stress placement. Such a case is found in Golin (Bunn & Bunn 1970). In this language, stress falls on the rightmost high-toned syllable: e.g. [ògáˈlá] 'woven hat', [síˈbágì] 'type of sweet potato', [ˈákòlà] 'wild fig tree'. The form [éndèˈrín] 'fire' shows that the post-tonic tone is irrelevant; if it were significant, stress would fall on the initial syllable instead. Similarly, the form [ògáˈlá] shows that the pre-tonic tone is irrelevant.

I conclude with the observation that in order for the present theory's typological predictions to hold, not only must the constraints proposed here exist in CON, but there can be no constraints that favour low-toned stressed syllables over high-toned ones. So, constraints such as ALIGN(ˈσ-L), aligning low tones with stressed syllables, must also be excluded. Similarly, constraints that assign fewer violations to higher-toned foot non-heads than low-toned ones must also be banned.

Less obviously, certain constraints on foot-internal tone combinations must be prohibited. For example, a constraint such as OCP_{Ft} bans sequences of identical tones within a foot: e.g. *(σ́σ́), *(σ̀σ̀). Such a constraint subverts the predictions of the present theory in that it favours the foot type (ˈσ̀σ́) over (ˈσ́σ́) and (ˈσ̀σ̀). If a constraint like OCP_{Ft} existed, we could expect a language in which stress fell on the leftmost syllable followed by one of a different tone, regardless of the types of tones involved. In known cases where the foot non-head's tone is significant, it is never simply a matter of having different tones in a foot; stress is always related to tone height, as predicted by the present theory.

6.2 Stress-driven tone

The present theory makes typological predictions for stress-driven tone that are similar to those for tone-driven stress. Again, the extent to which metrical structure is the primary factor in determining the distribution of tone depends on the relative ranking of the tone-head constraints and constraints that regulate tone placement.

In Lamba (§4), metrical structure is the primary factor in determining tone distribution – every foot head requires a high tone and tones will move or split to satisfy this requirement, grossly violating the tone-faithfulness constraints if necessary. Many other languages have been analysed as having metrically driven tone (Liberman 1975, Goldsmith 1987, Sietsema 1989, Downing 1990, Bamba 1991 and many others). Examples include Ci-Ruri (Massamba 1984, Goldsmith 1988: 85), Slave (Rice 1987), the Chimaraba dialect of Makonde (Odden 1990) and a number of Nguni languages (Downing 1990). The primacy of metrical structure in tone placement comes about when stress constraints outrank all tone-placement constraints.

In all the cases just cited, it is high tone that moves to positions of metrical prominence. This fact follows from the present theory since no constraint favours low-toned foot heads over high-toned ones. However, I hasten to add that there are systems in which stress seems to be attracted to low tone, avoiding high tone. In fact, the present theory does not exclude such systems; but it does predict that stress placement in such languages is not directed by tonal considerations, but by incidental influences.

For example, tone is attracted to the antepenultimate syllable in Zulu: e.g. /ú-ku-bala/ → [ukúbala] 'to count', /ú-ku-namathelisa/ → [ukuna-mathélisa] 'to make stick'. Downing (1990) argues that the high tone is attracted to the head of a trochaic foot, built near the right edge of the PrWd, but avoiding the final syllable. However, when the high tone originates on the antepenult, it surfaces on the penult: e.g. /úkulwa/ → [ukúlwa] 'to fight', *[úkulwa]; /u-ya-báhleka/ → [uyabahléka] 'you laugh at them'. Downing argues that this is due to a process of tone flop, requiring a tone to appear at least one mora to the right of its input position. In present terms, the flop-inducing constraint would outrank the tone-head constraint *HD/L, so that the attraction of high tone to foot heads would be overridden in just this situation. So, although high tone appears on a foot non-head in words with underlying antepenultimate highs, this fact is due to the overriding influence of tone-placement constraints and does not invalidate the predictions of the present theory.

To generalise, the present theory predicts that if a metrically prominent position attracts low tone and ignores intervening high tones, the constraint that favours such an output will do so for incidental reasons and not because of the tonal properties of the head.

6.2.1 *Low-toned heads.* In some languages the tone-head constraints are entirely obscured by tone-placement constraints. In these languages, the tone-head constraints may be ignored, resulting in low-toned heads and high-toned non-heads. These 'tone-placement' constraints most commonly relate to tone faithfulness or morpheme alignment.

For example, Bruce (1977) distinguishes two tonal accents in the Stockholm variety of Swedish. In Pierrehumbert's (1980) notation, one has the shape HL*, where the low tone associates to the stressed syllable and the other is H*L, with the high tone attracted to stress. Since these tone shapes are contrastive, it is clearly impossible to see such tones as completely phonologically motivated: they must either form an independent tonal morpheme in themselves, or at least be part of the underlying representation of the word. Assuming they are part of the word's underlying form, an appropriate analysis would aim to preserve the stressed syllable's tone: i.e. ˈσ-IDENT(T), after Beckman (1998). With this constraint outranking *HD/L, an underlying L tone will surface faithfully on the head syllable.[16]

So, although some words in Stockholm Swedish surface with a low-toned foot head and a high-toned foot non-head, this tone structure is due to constraints on faithfulness and tone distribution (i.e. the OCP). Riad (1996) provides an analysis of several Scandinavian accent systems without employing any markedness constraints that promote low-toned foot heads.

Morpheme-subcategorisation constraints may also outrank the tone-head constraints, resulting in low-toned heads. Such cases are common in intonation, where morphemes composed entirely of tones subcategorise for stressed syllables. For example, Hayes & Lahiri (1991: 66) identify an

[16] Following Riad (1996), the fact that the phrase accent is the opposite of the head's tone can be accounted for by the OCP. With the OCP outranking IDENT(T), the phrase accent will be L if the stressed syllable's tone is H, and H if the pitch accent is L. The OCP must outrank *NON-HD/H, otherwise the H of the L*H accent will be prevented from surfacing.

intonation contour used in 'polite offerings' in Bengali as L*H %, with a low tone appearing on the stressed syllable and a high tone at the boundary of the intonation phrase. The fact that the low tone of this morpheme surfaces on a head is due to the fact that the morpheme subcategorises for a stressed syllable, just as some reduplicative morphemes prefix to stressed syllables (e.g. Samoan; McCarthy & Prince 1993). The motivation for the L of the 'polite offering' morpheme to appear on a stressed syllable is a constraint that requires alignment of the morpheme with a stressed position; there is no need for a markedness constraint that specifically promotes low-toned stressed syllables.[17]

To summarise, the theory presented in §2 allows for a spectrum of metrically influenced tone systems. If the tone-head constraints outrank the majority of tone-placement/preservation constraints, the influence of heads and non-heads on tone will show through clearly. On the other hand, if the tone-head constraints are outranked by tone-related constraints, the interaction of metrical structure and tone will be obscured in certain environments (as in Zulu), or even eliminated. The present theory predicts that while low tone may seek out heads and high tone non-heads, such cases are motivated by constraints on faithfulness or morpheme subcategorisation requirements; markedness constraints never explicitly promote low-toned heads over high-toned ones.

7 Conclusions

The aim of this article was to provide evidence for the set of constraints in (3) and their fixed ranking, repeated in (34).

(34) a. *Hd/L ≫ *Hd/M
b. *Non-Hd/H ≫ *Non-Hd/M

The constraints in (34) encapsulate the proposals that:

(35) a. There is a hierarchy of tonal preferences, based on height: H > M > L.
b. Foot heads and higher tone have an affinity for each other.
c. Foot non-heads and lower tone have an affinity for each other.
d. (b) and (c) can motivate:
i. attraction of tone to (non-)heads (i.e. stress-driven tone);
ii. attraction of (non-)heads to tone (i.e. tone-driven stress);
iii. neutralisation of tone on (non-)heads (i.e. stress-conditioned neutralisation).

[17] One final case relates to languages where the only tone is a low tone. In such languages, low tone could be attracted to stressed syllables by a constraint that requires stressed syllables to bear tone (Yip 2001). The present theory does not ban such a system: the theory only prohibits systems in which (i) low tone is attracted to stressed syllables *and* (ii) high tones are ignored.

§3 presented evidence for the first three predictions. The stress system of Ayutla requires constraints that favour high-toned foot heads over mid- and low-toned ones, and mid-toned heads over low-toned ones. The constraints in (34a), along with their fixed ranking, adequately accounted for Ayutla's tone-head interactions. They explained why stress avoids both low and mid tone for the high-toned final syllable in words such as [nùɲā'rá] 'he will not open' and [kūnù'rá] 'his tobacco'. Similarly, they accounted for the preference of stressed mid-toned syllables over low-toned ones in [tì'kātʃìʔ] 'whirlwind'.

Ayutla's stress system also showed that high tone is preferred in foot heads while lower tone is favoured in foot non-heads. In terms of the head and non-head constraints in (34), the most harmonic foot is one with a high-toned head and a low-toned non-head: ('σ́σ̀). Ayutla's stress system provided support for this prediction in that it aims to realise this foot type above all others. This point is illustrated by the word [vìʃīí('ráà)] 'he is not cold', where the foot forms over the only HL tone sequence, ignoring alternatives such as *[vìʃī('írá)à] and *[vì('ʃīí)ráà].

Evidence that the tone-head constraints can be used to motivate a variety of processes was presented in §§3–5. This property follows from the relatively free constraint ranking allowed in Optimality Theory. The tone-(non-)head constraints only rule out candidates with ill-formed tone-(non-)head configurations; the repair is determined by the ranking of other faithfulness, tone-placement and stress-placement constraints. In short, by claiming that stress-driven tone, tone-driven stress and stress-conditioned tone neutralisation are triggered by the same markedness constraints, the theory predicts that they must share certain characteristics – namely, the predilection of heads for higher tone, and *vice versa*, and the attraction of non-heads to lower tone, and *vice versa*.

I conclude with the observation that tone-driven stress is still an understudied phenomenon. While several cases have been discussed in this article, no doubt many more are yet to be discovered. To some extent, then, the empirical generalisations made about the phenomenon are provisional; their validity awaits the determination of future research.

REFERENCES

Bamba, Mossa (1991). *De l'interaction entre tons et accent*. PhD dissertation, UQAM.

Beckman, Jill (1998). *Positional faithfulness*. PhD dissertation, University of Massachusetts, Amherst. Published 1999, New York: Garland.

Beckman, Jill, Laura Walsh Dickey & Suzanne Urbanczyk (eds.) (1995). *Papers in Optimality Theory*. Amherst: GLSA.

Bickmore, Lee (1995). Tone and stress in Lamba. *Phonology* **12**. 307–341.

Blevins, Juliette (1993). A tonal analysis of Lithuanian nominal accent. *Lg* **69**. 237–273.

Bradley, C. Henry (1970). *A linguistic sketch of Jicaltepec Mixtec*. Norman: Summer Institute of Linguistics.

Bruce, Gösta (1977). *Swedish word accents in sentence perspective*. Lund: CWK Gleerup.

Bunn, Gordon (1974). *Golin grammar*. Ukarumpa, Papua New Guinea: Summer Institute of Linguistics.
Bunn, Gordon & Ruth Bunn (1970). Golin phonology. In S. A. Wurm (ed.) *Papers in New Guinea linguistics*. No. 11. Canberra: Australian National University. 1–7.
Casali, Roderic (1997). *Resolving hiatus*. PhD dissertation, UCLA.
Clements, G. N. (1997). Berber syllabification: derivations or constraints? In Iggy Roca (ed.) *Derivations and constraints in phonology*. Oxford: Clarendon Press. 289–330.
de Lacy, Paul (1997). *Prosodic categorisation*. MA thesis, University of Auckland. Available as ROA-236 from the Rutgers Optimality Archive.
de Lacy, Paul (1999). Tone and prominence. Ms, University of Massachusetts, Amherst. Available as ROA-333 from the Rutgers Optimality Archive.
de Lacy, Paul (2002). *The formal expression of scales*. PhD dissertation, University of Massachusetts, Amherst.
Derbyshire, Desmond C. (1985). *Hixkaryana and linguistic typology*. Dallas: Summer Institute of Linguistics & University of Texas at Arlington.
Doke, Clement M. (1938). *Textbook of Lamba grammar*. Johannesburg: Witwatersrand University Press.
Downing, Laura J. (1990). Local and metrical tone shift in Nguni. *Studies in African Linguistics* **21**. 261–317.
Enrico, John (1991). *The lexical phonology of Masset Haida*. Fairbanks: Alaska Native Language Center.
Everett, Daniel & Keren Everett (1984). On the relevance of syllable onsets to stress placement. *LI* **15**. 705–711.
Everett, Daniel (1988). On metrical constituent structure in Pirahã phonology. *NLLT* **6**. 207–246.
Gerfen, Henry (1996). *Topics in the phonology and phonetics of Coatzospan Mixtec*. PhD dissertation, University of Arizona.
Goldsmith, John (1976). *Autosegmental phonology*. PhD dissertation, MIT. Published 1979, New York: Garland.
Goldsmith, John (1987). Tone and accent, and getting the two together. *BLS* **13**. 88–104.
Goldsmith, John (1988). Prosodic trends in the Bantu languages. In Harry van der Hulst & Norval Smith (eds.) *Autosegmental studies on pitch accent*. Dordrecht: Foris. 81–93.
Gordon, Matthew (1999). *Stress and other weight-sensitive phenomena: phonetics, phonology, and typology*. PhD dissertation, UCLA.
Grimes, Joseph E. (ed.) (1972). *Languages of the Guianas*. Norman: Summer Institute of Linguistics.
Halle, Morris & Paul Kiparsky (1981). Review of Paul Garde (1976). *Histoire de l'accentuation slave*. *Lg* **57**. 150–181.
Halle, Morris & Jean-Roger Vergnaud (1987). *An essay on stress*. Cambridge, Mass.: MIT Press.
Hayes, Bruce (1995). *Metrical stress theory: principles and case studies*. Chicago: University of Chicago Press.
Hayes, Bruce & Aditi Lahiri (1991). Bengali intonational phonology. *NLLT* **9**. 47–96.
Huisman, Ronald & Joy Lloyd (1981). Angaatiha tone, stress, and length. In Phyllis M. Healey (ed.) *Angan languages are different: four phonologies*. Huntington Beach: Summer Institute of Linguistics. 63–82.
Hunter, Georgia G. & Eunice V. Pike (1969). The phonology and tone sandhi of Molinos Mixtec. *Linguistics* **47**. 24–40.
Huttar, George L. & Mary L. Huttar (1972). Notes on Djuka phonology. In Grimes (1972). 1–11.

Huttar, George L. & Mary L. Huttar (1994). *Ndyuka*. London & New York: Routledge.

Hyman, Larry & Armindo Ngunga (1994). On the non-universality of tonal association 'conventions': evidence from Ciyao. *Phonology* **11**. 25–68.

Inkelas, Sharon & Draga Zec (1988). Serbo-Croatian pitch accent: the interaction of tone, stress, and intonation. *Lg* **64**. 227–248.

Jeanne, LaVerne Masayesva (1982). Some phonological rules of Hopi. *IJAL* **48**. 245–270.

Jiang-King, Ping (1996). *An optimality account of tone–vowel interaction in Northern Min*. PhD dissertation, University of British Columbia. Also available as ROA-266 from the Rutgers Optimality Archive.

Kalstrom, Marjorie R. & Eunice V. Pike (1968). Stress in the phonological system of Eastern Popoloca. *Phonetica* **18**. 16–30.

Kenstowicz, Michael (1997). Quality-sensitive stress. *Rivista di Linguistica* **9**. 157–188.

Kiparsky, Paul & Morris Halle (1977). Towards a reconstruction of the Indo-European accent. In Larry Hyman (ed.) *Studies in stress and accent*. Los Angeles: Department of Linguistics, University of South California. 209–238.

Kraft, Charles H. & A. H. M. Kirk-Greene (1973). *Hausa*. London: Hodder & Stoughton.

Leskein, August (1919). *Litauisches Lesebuch*. Heidelberg: Carl Winter.

Liberman, Mark (1975). *The intonational system of English*. PhD dissertation, MIT. Published 1979, New York: Garland.

McCarthy, John & Alan Prince (1986). *Prosodic morphology*. Ms, University of Massachusetts, Amherst & Brandeis University.

McCarthy, John & Alan Prince (1993). Generalized alignment. *Yearbook of Morphology 1993*. 79–153.

McCarthy, John & Alan Prince (1995). Faithfulness and reduplicative identity. In Beckman *et al*. (1995). 249–384.

Massamba, David (1984). Tone in Ci-Ruri. In G. N. Clements & John Goldsmith (eds.) *Autosegmental studies in Bantu tone*. Dordrecht: Foris. 235–254.

Meredith, Scott (1990). *Issues in the phonology of prominence*. PhD dissertation, MIT.

Merrifield, William (ed.) (1977). *Studies in Otomanguean phonology*. Dallas & Arlington: Summer Institute of Linguistics & University of Texas.

Morse, Nancy L. & Michael B. Maxwell (1999). *Cubeo grammar*. Dallas & Arlington: Summer Institute of Linguistics & University of Texas.

Mous, Maarten (1993). *A grammar of Iraqw*. Hamburg: Buske.

Myers, Scott (1987). *Tone and the structure of words in Shona*. PhD dissertation, University of Massachusetts, Amherst. Published 1987, Amherst: GLSA.

Myers, Scott (1997). OCP effects in Optimality Theory. *NLLT* **15**. 847–892.

North, Joanne & Jäna Shields (1977). Silacayoapan Mixtec phonology. In Merrifield (1977). 21–33.

Odden, David (1990). Tone in the Makonde dialects: Chimaraba. *Studies in African Linguistics* **21**. 61–105.

Odden, David (1995). Tone: African languages. In John Goldsmith (ed.) *The handbook of phonological theory*. Cambridge, Mass. & Oxford: Blackwell. 444–475.

Pankratz, Leo & Eunice V. Pike (1967). Phonology and morphotonemics of Ayutla Mixtec. *IJAL* **33**. 287–299.

Payne, David (1990). Accent in Aguaruna. In Doris L. Payne (ed.) *Amazonian linguistics: studies in lowland South American languages*. Austin: University of Texas Press. 161–184.

Pierrehumbert, Janet (1980). *The phonetics and phonology of English intonation*. PhD dissertation, MIT.

Pike, Eunice & John H. Cowan (1967). Huajuapan Mixtec phonology and morphophonemics. *Anthropological Linguistics* **9:5**. 1–15.

Pike, Eunice & Joy Oram (1976). Stress and tone in the phonology of Diuxi Mixtec. *Phonetica* **33**. 321–333.

Prince, Alan (1983). Relating to the grid. *LI* **14**. 19–100.

Prince, Alan (1990). Quantitative consequences of rhythmic organization. *CLS* **26:2**. 355–398.

Prince, Alan & Paul Smolensky (1993). *Optimality Theory: constraint interaction in generative grammar*. Ms, Rutgers University & University of Colorado, Boulder.

Riad, Thomas (1996). Remarks on the Scandinavian tone accent typology. In Patrik Bye, Ove Lorentz & Curt Rice (eds.) *Papers from the 2nd Workshop on Comparative Germanic Phonology*. Norway: University of Tromsø. 129–156.

Rice, Keren (1987). Metrical structure in a tone language: the foot in Slave (Athapaskan). *CLS* **23:2**. 239–252.

Rountree, S. Catherine (1972). The phonological structure of stems in Saramaccan. In Grimes (1972). 22–27.

Selkirk, Elisabeth (1995). The prosodic structure of function words. In Beckman *et al*. (1995). 439–469.

Senn, Alfred (1966). *Handbuch der litauischen Sprache*. Heidelberg: Carl Winter.

Sietsema, Brian (1989). *Metrical dependencies in tone assignment*. PhD dissertation, MIT.

Stark, Sharon & Polly Machin (1977). Stress and tone in Tlacoyalco Popoloca. In Merrifield (1977). 69–92.

Stolte, Joel & Nancy Stolte (1971). A description of Northern Barasano phonology. *Linguistics* **75**. 86–92.

Welmers, William E. (1962). The phonology of Kpelle. *Journal of African Languages* **1**. 69–93.

Williamson, Kay (1965). *A grammar of the Kolokuma dialect of Ịjọ*. Cambridge: Cambridge University Press.

Woo, Nancy (1969). *Prosody and phonology*. PhD dissertation, MIT.

Yip, Moira (1981). The interaction of tone and stress in Molinos Mixtec. Ms, MIT.

Yip, Moira (2001). The complex interaction of tone and prominence. *NELS* **31**. 531–545.

Zec, Draga (1999). Footed tones and tonal feet: rhythmic constituency in a pitch-accent language. *Phonology* **16**. 225–264.