Tone and Prominence

Paul de Lacy
University of Massachusetts, Amherst
1999

There is a well-established relationship between tone and metrically prominent positions: metrically prominent positions attract high tone, and high toned moras attract metrical prominence. The empirical aim of this paper is to show that the converse is also true: there is an attraction between lower tone and metrically non-prominent positions. In addition, it is argued that these attractions hold at every prosodic level, from the mora to the Intonational Phrase. The theoretical aim of this paper is to provide a mechanism to account for tone-prominence interactions. Crucial to this proposal is the Designated Terminal Element of Liberman & Prince (1977). When combined with the elements of a tonal prominence scale, sets of constraints in fixed rankings are produced. Various rankings of these constraints with respect to stress- and tone-placement constraints produce the variety of attested tone-prominence interactions. To justify both the empirical and theoretical claims of this paper, the relation between tone and stress in three Mixtec dialects – Ayutla, Molinos, and Huajuapan – is examined. Conditions of adequacy on theories of prominence-driven stress are also considered.

Contents

1 Introduction 2
2 The Atomistic Theory of Tone-Prominence Interaction....3
3 Tone and Prominence in Mixtec....9
3.1 Conditions of Adequacy on a Theory of Prominence.... 9
3.2 Mixtec.... 11
3.2.1 Huajuapan (Cacaloxtepec) 12
3.2.1.1 Positive Constraints 17
3.2.1.2 Summary.... 19
3.2.2 Ayutla 20
3.2.3 Conflation in Ayutla and Huajuapan.... 23
3.2.4 Molinos 25
3.2.4.1 Default-to-Opposite Stress in Molinos.... 26
3.2.5 Summary.... 28
4 Alternatives....29
4.1 Sequential Theories.... 30
4.2 Conditions of Adequacy 31
4.3 Other Mechanisms 35
5 Typology of Processes and Levels 36
5.1 A Typology of Tone-Prominence Interactions.... 37
5.2 A Typology of Prosodic Levels 39
6 Typology of Inventories 40
6.1 Faithfulness and the Tone-Prominence Constraints 40
6.2 A Typology of Tonal Inventories.... 43
7 Typology of Prominence....47
8 Conclusions....49
References....51
Appendix – Data....57

Tone and Prominence*

Paul de Lacy
University of Massachusetts, Amherst

1999

1 Introduction

There is a special relationship between tone and metrically prominent positions: metrically prominent positions can attract high tone, and high toned moras can attract metrical prominence. The former case has been observed in many languages, where stressed positions attract tone (Liberman 1975, Selkirk 1984, 1995, Goldsmith 1987, 1988:85*ff*, 1992 Peterson 1987, Sietsema 1989, Downing 1990, Bamba 1991, Bickmore 1995, and many others). Even though the latter situation has received less attention, a significant number of cases have been reported.[1] These are exemplified by Golin (Bunn and Bunn 1970). In this language, tone placement is lexically contrastive, so words are underlyingly specified for tone. Stress (marked by a $^{+}$) falls on the rightmost high-toned syllable, and in entirely low-tone words on the final syllable:

(1)	LLL^{+}	kàw.lì.gì$^{+}$	'post'
	H^{+}LL	á$^{+}$.kò.là	'wild fig tree'
	LH^{+}L	gò.má$^{+}$.gì	'type of sweet potato'
	LLH^{+}	ò.nì.bá$^{+}$	'snake'
	HH^{+}L	sí.bá$^{+}$.gì	'sweet potato type'
	LHH^{+}	ò.gá.lá$^{+}$	'woven hat'
	HLH^{+}	én.dè.rín^{+}	'fire'
	HHH^{+}	ó.wá.ré$^{+}$	'bat'

The aim of this paper is to propose and argue for a theory of tone-prominence interaction within Optimality Theory. There are two core components of this theory. One is a tonal 'prominence scale' (Prince & Smolensky 1993), with higher tone more prominent than lower tone. The other is the notion 'DTE' (Designated Terminal Element – Liberman 1975, Liberman & Prince 1977). The DTE of a prosodic category α is a terminal prosodic node that is connected to α by an unbroken path of prosodic heads. For example, the DTE of a foot is the head mora of the head syllable of that foot. The complementary notion 'non-DTE' is also significant: every terminal node in α that is not α's DTE is a non-DTE of α.

* I owe a great deal of thanks to Lisa Selkirk and John McCarthy for their comments and guidance. I am also grateful to the following people for their comments on various manifestations of this work: Brett Hyde, Alan Prince, Keren Rice, Hubert Truckenbrodt, and Moira Yip. This work was supported by the National Science Foundation under grant SBR-9420424.

[1] Examples include Aguaruna – Payne (1990), Bambara – Woo (1969), Diuxi Mixtec – Pike & Oram (1976), Heiltsuq – Wilson (1987), Lithuanian – Blevins (1993), Ndyuka – Huttar & Huttar (1972, 1994), Serbo-Croatian – Inkelas & Zec (1988), Zec (1994), Beijing Mandarin, Tibetan – Meredith (1990), and Vedic Sanskrit – Halle & Kiparsky (1977).

The tonal prominence scale combines with DTEs (symbolized as Δ) and non-DTEs (-Δ) to form the following constraints in a fixed ranking:

(2) (i) $*\Delta_\alpha/L \gg *\Delta_\alpha/M \gg *\Delta_\alpha/H$
(ii) $*\text{-}\Delta_\alpha/H \gg *\text{-}\Delta_\alpha/M \gg *\text{-}\Delta_\alpha/L$

The first set of constraints requires DTEs to avoid lower tone. The fixed ranking means that minimal violation of these constraints can only be achieved if a DTE bears high tone. The second set of constraints require non-DTEs to be as low-toned as possible.

This proposal is dubbed the Atomistic tone-prominence theory since the constraints in (2) refer to the minimal amount of information needed to regulate the relation between tone and metrical prominence (i.e. a tone, a (non-)DTE, and the relation between them). The mechanics of the Atomistic theory are discussed in section 2.

There are a number of empirical claims embodied in these constraints:

- There is a hierarchy of tonal preference, ranging from higher tone to lower tone for DTEs, and from lower to higher tone for non-DTEs.
- The constraints are relevant at every prosodic level (i.e. α ranges over all members of the prosodic hierarchy).
- Constraints can refer to non-DTEs.

Evidence for these claims is provided in section 3 through analyzing three Mixtec stress systems. The Mixtec systems are similar to Golin's in that tone attracts stress. However, they have additional complexities: stress assignment not only refers to the tone of the potentially stressed syllable but to the tone of the following syllable as well. The richness of these systems provide a revealing test of the Atomistic theory. More importantly, they aid in identifying the essential properties of an adequate theory of tone-prominence interaction.

In section 4, alternatives to the Atomistic theory are examined. Particular attention is paid to 'sequential' theories: ones that employ constraints referring to sequences of tones. The remaining sections are devoted to the typological implications of the Atomistic theory: with regard to tone-prominence processes in section 5, inventory restrictions in section 6, and hierarchies of tonal prominence in section 7.

2 The Atomistic Theory of Tone-Prominence Interaction

It is invariably high tone that attracts or is attracted to stressed positions (Goldsmith 1987). Low toned syllables never attract stress over higher-toned ones; in fact, stressed positions avoid low tone in some cases (as in languages where low tone cannot appear in stressed positions – see section 6). So, there is a hierarchy of tonal preference: higher tones are preferred on stressed positions. In contrast, lower tone has an affinity for unstressed positions (see sections 3, 5, and 6).

There are analogous hierarchies of prosodically-conditioned preferences. One of the most frequently discussed is the sonority hierarchy (Sievers 1901, Selkirk 1984, Steriade 1988, Clements 1990). The sonority hierarchy has been shown to play an active role in a number of languages, determining syllabification (Dell & Elmedlaoui 1985, 1988, 1992, Prince & Smolensky 1993) and affecting syllable weight (Zec 1988, Kenstowicz 1996, de Lacy 1997). Prince & Smolensky (1993:67-82,129) propose that such markedness hierarchies should be formally represented as 'prominence scales' within Optimality Theory. For the sonority hierarchy, for example, there is a scale that ranks segment types in a relation of 'prominence':

(3) | vowel 〉 liquid 〉 nasal 〉 obstruent |

Such intrinsic prominence scales are combined with structural prominence scales by a process called 'prominence alignment'. The structural scale used by Prince and Smolensky is | nucleus 〉 onset | which indicates that syllable nuclei are more prominent than onsets. The results of combination are called Harmony scales:

(4) (i) { nucleus/vowel 〉 nucleus/liquid 〉 nucleus/nasal 〉 nucleus/obstruent }
(ii) { onset/obstruent 〉 onset/nasal 〉 onset/liquid 〉 onset/vowel }

An important point is that the prominence scale's ranking is reversed in combination with the less prominent structural element: *onset/obstruent* is more prominent than *onset/vowel*, while *vowel* is more prominent than *obstruent* in the sonority prominence scale. These combined scales express the notion that nuclei prefer to contain sonorous elements, while onsets prefer least sonorous segments.

The Harmony scales are converted into constraints of the form *α/β "α must not be associated to β":

(5) (i) ||*NUC/OBSTRUENT » *NUC/NASAL » *NUC/LIQUID » *NUC/VOWEL||
(ii) ||*ONS/VOWEL » *ONS/LIQUID » *ONS/NASAL » *ONS/OBSTRUENT||

Of particular importance is the fact that the ranking between constraints is fixed – there is no grammar in which they may be reversed. The impermutability of this ranking captures the absolute implicational markedness of such hierarchies: nuclei *always* prefer to contain vowels over obstruents, and never vice-versa.[2]

The effect of such constraints is exemplified in the following tableau, which presents a portion of the *NUC/α constraints. The syllable nucleus is marked in the following candidates with a superscript $^{+}$:

[2] Of course, this assumes that there are no constraints that will conflict with this hierarchy. The effect of other constraints on the tone-prominence constraints proposed here will be discussed at a number of points throughout this paper.

(6)

/sma/	*NUC/OBSTRUENT	*NUC/NASAL	*NUC/VOWEL
$s^{+}ma$	x!		
$sm^{+}a$		x!	
☞ sma^{+}			x

The tableau shows that the nucleus is identified through the effect of the *NUC/α constraints. Of the three candidates, the one that causes the lowest-ranked violation is [sma^{+}], with a vocalic nucleus.

This returns us to the present proposal. The core of the Atomistic tone-prominence theory is the following prominence scale:[3]

(7) Tonal Prominence Scale: | H 〉 M 〉 L |

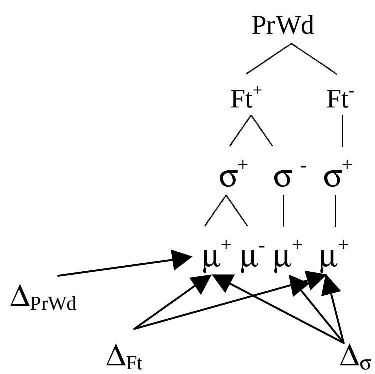
H, M, and L stand for high, mid, and low tone respectively. Only three degrees of height are shown for purely for the sake of brevity. To be more precise, the Tonal prominence scale states that higher tone is more prominent than lower tone.

Like the sonority scale, the Tonal prominence scale combines with a structural scale to form constraints. For tone, the relevant unit of structure is the 'Designated Terminal Element' (DTE), symbolized as Δ (Liberman 1975, Liberman & Prince 1977):

(8) DTE $=_{def}$ The DTE of prosodic category α (i.e. Δ_α) is the terminal prosodic node that is:
(i) a prosodic head
and (ii) is associated to α by an unbroken chain of prosodic heads.

Since a DTE crucially relies on the notion 'prosodic head' it inherits the main property of heads: for every prosodic node α there is only one DTE of α.[4] The following structure serves to clarify this definition by identifying the DTEs. The symbol $^{+}$ marks prosodic heads and $^{-}$ non-heads.

(9)



[3] For an identical hierarchy, see Jiang-King (1996, 1999).

[4] The idea that there every node contains one and only one head has persisted throughout autosegmental theory and has been embodied in the (possibly inviolable) constraint HEADEDNESS of Selkirk (1995) and Ito & Mester (1992) (see Crowhurst 1996 for differing assumptions).

As indicated, there is only one Δ_{PrWd} in this structure – the leftmost mora. This is the DTE of the PrWd since it is a head and is associated to the PrWd node by an unbroken chain of prosodic heads (i.e. the leftmost σ and Ft nodes). In comparison, there are two Δ_{Ft} – the initial and final moras. The final mora is a Δ_{Ft} since it is a head and is associated to a Ft node by a path of prosodic heads – namely the rightmost σ.

A non-DTE of α ($-\Delta_\alpha$) is every terminal node in α that is not the DTE of α. For example, every mora except the initial one in (a) is a $-\Delta_{PrWd}$. Similarly, the second and third moras are $-\Delta_{Ft}$.

Terminal nodes may be both DTEs and non-DTEs at the same time. For example, the rightmost mora is the DTE of a syllable and the DTE of a foot, but it is the non-DTE of the PrWd. Similarly, the third mora is a DTE of a syllable, but a non-DTE of a foot and a PrWd.

DTEs and non-DTEs form the structural prominence scale $| \Delta \rangle -\Delta |$. Through prominence alignment, this structural scale combines with the Tonal prominence scale to form the constraints and fixed ranking shown in (10):

(10) (i) $\| {*}\Delta_\alpha/L \gg {*}\Delta_\alpha/M \gg {*}\Delta_\alpha/H \|$
(ii) $\| {*}{-}\Delta_\alpha/H \gg {*}{-}\Delta_\alpha/M \gg {*}{-}\Delta_\alpha/L \|$

These constraints and their rankings are the expression of the Atomistic tone-prominence theory. The first set of constraints militates against lower-toned DTEs, while the second set penalizes higher-toned non-DTEs.[5]

Before considering some other aspects of the $*(-)\Delta/T$ constraints, a mention must be made of tonal underspecification – the fact that moras may be toneless (Pierrehumbert 1980, Beckman & Pierrehumbert 1986, Pierrehumbert & Beckman 1988). While the $*(-)\Delta_\alpha/T$ constraints do not specifically mention the relation between DTEs and tonelessness, they do make a variety of predictions in this regard. However, the existence of tonally unspecified moras does not, it turns out, greatly affect the generalisations and analyses presented in the following sections. Because of this, I defer discussion of tonal underspecification and its relation to the Atomistic theory until section 6.

One important aspect of these constraints resides in the identity of α: there are separate instantiations of the constraints in (10) for every possible α, where α is a member of the prosodic hierarchy {μ, σ, Ft, PrWd, MinorP, MajorP, IntonationalP, Utterance}.[6] In other words, there is a constraint set $\|{*}\Delta_{Ft}/L \gg {*}\Delta_{Ft}/M \gg {*}\Delta_{Ft}/H\|$ just as there is one $\|{*}\Delta_{PrWd}/L \gg {*}\Delta_{PrWd}/M \gg {*}\Delta_{PrWd}/H\|$.[7]

[5] Implicit in these constraints is the assumption that tone is associated to DTEs – i.e. moras. While the exact identity of Tone Bearing Units (and whether they may vary across languages) is a significant issue (see Odden 1995 for an overview), it is not of overwhelming importance in the present instance. If it were determined that tone associated to σ nodes in some language, the definition of DTE would have to be adjusted so as to refer to the syllable node. This adjustment is a trivial matter.

[6] There may also be an instantiation for 'Focus', a suggestion made to me by Hubert Truckenbrodt. Determining whether this is necessary is beyond the scope of the present work.

[7] This observation relates to whether the $*(-)\Delta_\alpha/T$ constraints are in a fixed ranking in terms of α. For this paper, it is not crucial whether the constraints are or are not in a fixed ranking in terms of α. However, if they are in a fixed ranking, it must be $\|{*}\Delta_\alpha/T_i \gg {*}\Delta_{\alpha-1}/T_i\|$ for DTEs (α is higher on the

The various instantiations of α can be used to account for cross-linguistic differences. For example, high tone is attracted to the DTE of PrWds in Zulu (Downing 1990):[8]

(11)	/ú-ku-bala/	→ ukú$^{+}$bala	'to count'
	/ú-ku-hlekisa/	→ ukuhlé$^{+}$kisa	'to amuse'
	/ú-ku-namathelisa/	→ ukunamathé$^{+}$lisa	'to make stick'

This can be explained by employing a constraint against high-toned non-DTEs (for more general discussion of this type of system, see section 5). The constraint ANCHOR-T requires underlying tone to appear in the corresponding surface position:

(12)

/úkubala/	*-Δ_{PrWd}/H	ANCHOR-T
úku^{+}bala	x!	
☞ ukú$^{+}$bala		x

It is evident from this tableau that whether high tone is attracted to the DTE of the PrWd depends on the ranking of the *Δ/T constraints with respect to a 'blocking' constraint like ANCHOR-T. If *-Δ_{PrWd}/H was ranked below ANCHOR-T its effect would be nullified and tone would remain in its underlying position.

Digo is similar to Zulu in that tone is attracted to a stressed position (Kisseberth 1984, Goldsmith 1988:85, Lubowicz 1997). The difference is that tone is attracted to the DTE of a Phonological Phrase (PPh), not a PrWd. This is shown in the forms below. In (a) the word *akagura* forms a single PrWd. This is indicated by { } brackets. It also forms a PPh on its own, indicated by [ ] brackets. The DTE of the Phonological Phrase is indicated by $^{++}$. In (b), *akagura* again forms a PrWd. However, it is not alone in the PPh: it appears with *nguwo*, which forms a separate PrWd and heads the PPh. As shown in (b), high tone is attracted past the DTE of the initial PrWd to the PPh's DTE:[9]

(13)	a. á-ka-gur-a	→ [{akagurá$^{++}$}]	'he has bought'
	b. á-ka-gur-a nguwo	→ [{akagura^{+}}{nguwó$^{++}$}]	'he has bought clothes'

As shown, the underlying H ends up on the final syllable of the PPh. This can be explained by employing a constraint analogous to the one used for Zulu, but this time referring to the PPh:

---

prosodic hierarchy than α-1), and $\|*\text{-}\Delta_{\alpha}/T_i$ » $*\text{-}\Delta_{\alpha+1}/T_i\|$ for non-DTEs. If the reverse rankings were fixed, the constraints would only be effective at the lowest level of the prosodic hierarchy.

[8] More specifically, if there is a high tone in a noun, infinitive, or verb, it is attracted to the antepenultimate syllable. A similar case is found in Chizigula (Kenstowicz and Kisseberth 1990), although tone is attracted to the penult in this language.

[9] The final high tone is "actually pronounced as a Rise-Fall pattern over the last two syllables" (Goldsmith 1988: 85). Despite this, Goldsmith (1988) and Kisseberth (1984) treat the final syllable as the head of the PPh. I follow their analysis here without comment.

(14)

/ákagura nguwo/	*-Δ_{PPh}/H	ANCHOR-T
(a) [{ákagura^{+}}{nguwo^{++}}]	x!	
(b) [{akagurá$^{+}$}{nguwo^{++}}]	x!	x x x
☞ (c) [{akagura^{+}}{nguwó$^{++}$}]		x x x x x

As is evident from the tableau, ANCHOR-T is a violable constraint: the further an tone appears from its corresponding underlying position, the more violations of ANCHOR-T are incurred (here, one per TBU). Reference to the PPh is necessary here. If only DTEs of the PrWd could be mentioned the high tone would fall on the closest Δ_{PrWd}, producing the ungrammatical candidate (b): **akagurá nguwo*.

Having introduced the *Δ_{α}/T constraints, it remains to illustrate their effect in attracting stress to tone. The example employed here is Golin. As mentioned in section 1, stress in Golin is attracted to the rightmost high-toned syllable, else to the rightmost syllable. The tendency to stress the rightmost syllable can be expressed as the constraint ALIGN(σ^{+}, R, PrWd, R), which requires a stressed syllable to appear at the right edge of a PrWd (McCarthy & Prince 1993). In the following discussion, and in the rest of this paper, this constraint will abbreviated as ALIGN-σ^{+}-R.

In order to introduce tonal sensitivity some *Δ_{α}/T constraints must outrank ALIGN (Walker 1996, de Lacy 1997). The relevant constraint for Golin is one that prohibits a DTE of a PrWd from bearing low tone: *Δ_{PrWd}/L. The following tableau shows this constraint in action:

(15) Tone-Dependent Stress in Golin

		*Δ_{PrWd}/L	ALIGN-σ^{+}-R	*Δ_{PrWd}/H
1.	/gòmágì/	*Δ_{PrWd}/L	ALIGN-σ^{+}-R	*Δ_{PrWd}/H
	gò$^{+}$mágì	x!	x x	
☞	gòmá$^{+}$gì		x	x
	gòmágì$^{+}$	x!		
2.	/síbágì/	*Δ_{PrWd}/L	ALIGN-σ^{+}-R	*Δ_{PrWd}/H
	sí$^{+}$bágì		x x!	x
☞	síbá$^{+}$gì		x	x
	síbágì$^{+}$	x!		

The first form – /gòmágì/ – shows how the constraints conspire to attract stress to a high-toned syllable. The constraint *Δ_{PrWd}/L prohibits stress from falling on low-toned syllables, hence stress is forced to appear on a high-toned one. Since there is only one such syllable in /gòmágì/, the place of stress is entirely determined by *Δ_{PrWd}/L. In comparison, there are two high-toned syllables in /síbágì/, so *Δ_{PrWd}/L only eliminates the possibility of stress falling on the rightmost syllable [gì]. Whether stress falls on the initial or peninitial syllable falls is determined by a lower-ranked constraint – ALIGN-σ^{+}-R. Since this prefers rightmost stress, the candidate [síbá$^{+}$gì] wins.

This illustration shows how the *(-)Δ_{α}/T constraints can influence stress placement: stress is attracted to tone if the ranking ||*Tone Constraints*, *(-)Δ_{α}/T » *Stress*

Constraints|| obtains. *Tone Constraints* refer to constraints on tone-placement, including faithfulness to underlying tone; *Stress Constraints* refer to constraints on stress placement, such as ALIGN-σ^+-R. In comparison, stress-dependent tone – as in Zulu and Digo – is achieved by the ranking ||*Stress Constraints*, $*(-)\Delta_\alpha/T$ » *Tone Constraints*||. Another permutation produces languages without tone-stress interaction: ||*Stress Constraints*, *Tone Constraints* » $*(-)\Delta_\alpha/T$ ||. In this sort of language, stress placement and tone placement proceed independently. The effect of permuting the ranking of the $*(-)\Delta_\alpha/T$ constraints with tone- and stress-related constraints will be discussed further in sections 5 and 6. Of most importance for the following section will be the tone-dependent stress ranking.

The aim of the remainder of this paper will be to justify the form of the tone-prominence constraints and their empirical implications. The constraints embody three main empirical claims:

- Higher tone and DTEs mutually attract each other.
- Lower tone and non-DTEs mutually attract each other.
- Constraints can refer to non-DTEs.

In section 3, the claim that there is a hierarchy of tonal preference based on height will be justified and reference to non-DTEs will also be shown to be necessary. Evidence will also be given that the form of these constraints is correct: arguments that the constraints must be negative than positive (e.g. $\Delta \rightarrow H$ "DTEs must bear high tone") will be presented.

3 Tone and Prominence in Mixtec

The purpose of this section is to provide evidence for the $*(-)\Delta_\alpha/T$ constraints. To achieve this aim, the stress systems of three Mixtec languages – Ayutla (Pankratz & Pike 1967), Huajuapan (Pike & Cowan 1967), and Molinos (Hunter & Pike 1969) – will be analyzed. In these systems, stress placement is dependent on tone.

Before proceeding to examine these languages, though, it is necessary to consider some of the necessary conditions on a theory of tone-prominence interaction – conditions which will prove to be significant in testing the adequacy of any such theory. This is the subject of section 3.1. The analysis of the Mixtec systems will commence in section 3.2.

3.1 Conditions of Adequacy on a Theory of Prominence

Systems where stress placement depends on tone are a subcase of a broader phenomenon – prominence-driven stress (Hayes 1995:270-295, Kenstowicz 1996, de Lacy 1997, Gordon 1997). In prominence-driven stress systems, the placement of primary stress is not simply a side-effect of footing. Instead, main stress seeks out a syllable that has certain properties (e.g. long vowels, diphthongs, onsets, high-sonority nuclei).

An example is found in the Polynesian language Maori (Biggs 1961, Hohepa 1967, Bauer 1981, 1993, de Lacy 1997). In Maori, stress falls in the following manner:

(16) Stress the leftmost long vowel,
e.g. ku.ri:$^{+}$ ‘dog’, tau.a:$^{+}$ ‘ridge’, tu:$^{+}$.i: ‘parson bird’
Else the leftmost diphthong,
e.g. te.kau^{+} ‘ten’, tai^{+}.tei ‘Thursday’
Else the leftmost syllable.
e.g. pa^{+}.ke ‘obstinate’, ta^{+}.ŋa.ta ‘man’

Maori exemplifies the problems faced by a theory of prominence-driven stress. The problems can be stated as ‘conditions of adequacy’ – conditions that every theory of prominence must meet. There are three such conditions: (1) Categorization – distinguishing the correct number and types of elements, (2) Relative Harmony – producing the correct hierarchy of types, and (3) Conflation – allowing categories to be combined in some systems and distinct in others.

An adequate theory of prominence must be rich enough to differentiate attested categories – the Categorization condition. For example, a theory that only allows reference to mono-moraic *vs* bi-moraic syllables is simply inadequate in the three-weight system of Maori. Such a theory must be able to (at least) differentiate long vowels, diphthongs, and mono-moraic syllables. This problem also arises in the more specific realm of tone-dependent stress systems. From Golin, it is evident that an adequate theory must at least distinguish between high-toned and low-toned syllables. In considering Mixtec, the conditions will be shown to be more complex: mid-toned syllables must be recognized as a separate type.

Another condition – the Harmony condition – refers to the hierarchical relations between different categories. In Maori, for example, stressed long vowels are more harmonic than stressed diphthongs, and stressed diphthongs are more harmonic than stressed (C)V syllables. In fact, cross-linguistically long vowels are *always* more harmonic than diphthongs (see discussion in de Lacy 1997). Such universal harmonic rankings must be captured by an adequate theory of prominence.

Equally as important are variable harmonic rankings: where a category A is more harmonic than category B in one language, but B is more harmonic than A in another. One example is the difference between CVC and CVG (G is the first half of a geminate) syllables. In many languages, stress is attracted to CVG syllables but not to CVC syllables (see examples in Hayes 1989). However, the opposite situation obtains in other languages: CVC syllables attract stress, while CVG syllables do not (e.g. Tashlhiyt Berber metrics – François Dell p.c., Ngalakan – Baker 1997). Moreover, CVG and CVC syllables are combined into a single category in some languages, as opposed to a more prominent category (e.g. Malayalam, Selkup – Tranel 1991, Leti – Elizabeth Hume p.c.). In short, an adequate theory of prominence must not set up a fixed harmonic ranking between CVC and CVG syllables – it must be allowed to be variable.[10]

Finally, an adequate theory must be flexible enough to allow categories to be conflated into a single category – the Conflation condition. For example, suppose a

[10] This example depends on the assumption that the representation of geminates is consistent in all these cases (for differing views see Hayes 1989 and Selkirk 1991). Some cases of harmonic variability may be ascribed to differing representations. However, it is unlikely that all such cases can be treated representationally (see de Lacy 1997 for other examples, and the analyses of the Mixtec languages below).

theory is constructed that differentiates long vowels, diphthongs, and mono-moraic syllables. While this would adequately account for Maori, it raises a potential problem: what if the theory *always* differentiated these categories? Such a theory would always prefer a stressed long vowel over a stressed diphthong, and a stressed diphthong would always be preferable to a stressed short vowel.

This theory would face insurmountable difficulties when faced with a stress system that only differentiated bi-moraic and mono-moraic syllables (e.g. Samoan – Churchward 1951). In such systems, long vowels and diphthongs are treated alike: neither attracts stress over the other. Faced with a form which contained both a long vowel and a diphthong, the theory would wrongly predict that the long vowel would always end up stressed. An adequate theory must be flexible enough to group certain categories together and treat them as alike in one language, while also being able to differentiate them in another.

The same problem comes up in tone-dependent stress. It was noted above that high-, mid-, and low-toned syllables must be recognized as different categories by an adequate theory. However, not all tone-dependent stress systems differentiate between these categories. In Huajuapan Mixtec, for example, it will be shown (in section 3.2) that high- and mid-toned syllables are conflated into one category in some circumstances, while mid- and low-toned syllables are grouped together in other situations.

In short, while the Categorization condition requires a theory to differentiate all possible categories, the Conflation condition demands that the theory be flexible enough for categories to be grouped together and treated alike in different grammars. Add in the fact that some categories are in a fixed hierarchical ranking while others are variably ranked and these conditions of adequacy provide a stringent test for theories of tone and prominence interaction.

Another issue is more theory-specific: how such conditions can be expressed in Optimality Theory. Cross-linguistic differences are expressed in OT as variation in constraint ranking. Therefore, differences in category conflation must be the result of ranking permutation. This will be shown to pose a strong condition of adequacy on tone-prominence constraints (see section 4).

Having identified the necessary properties of an adequate theory of prominence, it remains to see whether the Atomistic theory meets these conditions. This is the aim of the following sections.

3.2 Mixtec

A number of Mixtec languages exhibit tone and overt stress (Coatzospan – Gerfen 1996, Diuxi – Pike & Oram 1976, Jicaltepec – Bradley 1970, Silacayoapan – North & Shields 1977), and there are reportedly many undocumented cases (Barbara Hollenbach p.c.). Three Mixtec languages – Ayutla (Pankratz & Pike 1967), Huajuapan (Pike & Cowan 1967), and Molinos (Hunter & Pike 1969) – are of present interest since they exhibit tone-dependent stress.[11] The aim of this section is to analyze each system in detail, providing an account in terms of the *(-)Δ_α/T constraints.

The stress system of Huajuapan is the first to be examined since it is the most straightforward, at least in descriptive terms. This is followed by analyses of Ayutla and Molinos.

3.2.1 Huajuapan (Cacaloxtepec)

The prosody of Huajuapan has been analyzed by Pike & Cowan (1967). P&C observe that there are three tones in this language (H, M, and L), and every vowel bears one and only one tone.[12] Syllables have the shape (C)(C)V, and all possible tone sequences are attested. Primary stress falls on either the root or its suffixes, and never on prefixes.[13] There are no secondary stresses.

Huajuapan's stress system is described by P&C (p.17) as follows (only representative examples are given here for reasons of brevity. For a fuller list, see Appendix 1):

(17) (i) Stress the leftmost syllable which is followed by a syllable with a lower tone.

HH^{+}L:	sáđí$^{+}$nà̜	'he/she/they (known) are closing it'
MM^{+}L:	nì̜-sō̜^{ʔ}nī̜$^{+}$nà̜	'he/she/they (known) tied it'
H^{+}ML:	kó̜$^{+}$nā̜à̜	'a wide thing'
M^{+}LH:	ñā̜$^{+}$nì̜ní̜	'your (sg, adult) brother'

(ii) Otherwise stress the leftmost syllable.

H^{+}HH:	sá$^{+}$đíní̜	'you (sg, adult) are not closing (it)'
M^{+}MM:	nì̜-kē$^{+}$ʔē^{n}dō	'you (pl) teased (someone)'
L^{+}LL:	sò$^{+}$ʔò^{n}dò 'will notify'	
L^{+}MM:	šì$^{+}$tōsō	'our (incl.) bed'
L^{+}LH:	đù$^{+}$kùní̜	'your (sg, adult) niece'

---

[11] The primary correlate of stress in these languages is duration and higher pitch (Pankratz & Pike 1967:289.c1,294.c2, Hunter & Pike 1969:25, Pike & Cowan 1967:6). There is also phonological evidence for metrical prominence: in Ayutla, an unstressed vowel in an onsetless syllable optionally devoices before voiceless consonants: e.g. [í̥ká$^{+}$àʔ] 'is old' (PP 289.c2). Also, an unstressed vowel may delete if doing so will produce an acceptable onset (i.e. [{s,š}{t,k,n}]): e.g. /sánárà/ → [sná$^{+}$rà]. Both of these processes do not apply to stressed vowels (e.g. [ū$^{+}$.šà], *[ū̥$^{+}$.šà] and [šà$^{+}$kù], *[škù$^{+}$]). The works on Huajuapan and Molinos do not present similar cases where reference to stress in segmental processes is crucial – this is unsurprising considering their focus on tonal processes. Two processes that potentially offer proof are nasal harmony and glottalisation: these have been shown to make crucial reference to stress in other Mixtec languages (e.g. Jicaltepec – Bradley 1970, Coatzospan – Gerfen 1996), and may also do so in Ayutla, Molinos, and Huajuapan. This is an issue for further study, though.

[12] Evidence that every vowel bears a tone in Huajuapan (and Ayutla and Molinos) is found in a variety of tone sandhi processes. See the original works for details.

[13] This indicates that the root and suffixes form a PrWd, excluding prefixes. Such a PrWd structure is very common (Nespor & Vogel 1986). A PrWd boundary is indicated in the data by '-' as in [nì̜-sō̜^{ʔ}nī̜$^{+}$nà] 'he/she/they (known) tied it'.

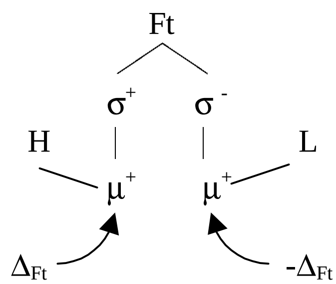
So, σ́σ̀, σ́σ̄, and σ̄σ̀ sequences (abbreviated henceforth to HL, HM, ML) are sought out, and stress falls on the first syllable of such sequences. If there are no such sequences, stress falls on the initial syllable of the PrWd.

This description refers to sequences of tone in order to place stress, not to single tones as in Golin. Because of this, it may seem that constraints that refer directly to tone sequences are needed. However, the analysis below will show that an atomistic theory – one with constraints that refer only to single tones – can account for the facts. Sequential theories will be discussed in detail in section 4.

There are a number of components of this system that need explanation. One of the most striking differences between Huajuapan's system and – for example – Golin, is that context matters here: stress does not simply seek out the highest-toned syllable, but rather a syllable *followed* by a lower-toned syllable.

The key to understanding such a condition, I propose, is foot structure: every PrWd contains a trochaic foot.[14] Clause (i) of the algorithm can be reformulated as "form the leftmost best foot". 'Best' is definable in terms of tones: the 'best' foot is one whose DTE contains a higher tone (H or M), and whose non-DTE contains a lower tone. A representation of a HL foot is given below with its DTE and non-DTE indicated.

(18)



In the rest of this paper, such feet will be abbreviated as $T^{+}T$, where T is a tone and $^{+}$ indicates that the mora it is attached to is the DTE of a foot. For example, the foot in (18) is $H^{+}L$.

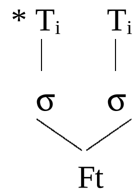
These facts can now be considered with respect to the Categorization condition: an adequate theory of tone-prominence interaction must be able to distinguish 'falling tone' feet (i.e. $H^{+}L$, $H^{+}M$, $M^{+}L$) from all other feet. To satisfy the Harmony condition, falling tone feet must be preferred over all others. In OT terms, to say that a structure A is 'preferred' over another structure B means that A satisfies constraints better than B. The challenge, then, is to show that $H^{+}L/H^{+}M/M^{+}L$ feet are more harmonic in terms of constraints than all other feet (i.e. $H^{+}H$, $M^{+}H$, $M^{+}M$, $L^{+}H$, $L^{+}M$, $L^{+}L$).

The $*(-)\Delta_{\alpha}/T$ constraints play a central role in categorizing and establishing the hierarchy of foot types. Since the level at which tonal interactions are significant is the foot level, the constraints $*(-)\Delta_{Ft}/T$ will be employed. An additional constraint needs to be introduced at this point – the OCP, relativized to the foot domain (Leben 1973, Goldsmith

[14] In fact, most other (described) Mixtec languages also have trochaic feet.

1976, McCarthy 1986, Yip 1988, Myers 1997). OCP_{Ft} bans adjacent identical tones within the foot:[15]

(19) OCP_{Ft}: Syllables in the same foot may not bear the same tone.[16]



The following table shows that the non-falling tone sequences in a foot ($H^{+}H$, $M^{+}H$, $M^{+}M$, $L^{+}H$, $L^{+}M$, $L^{+}L$) incur constraint-violations while the falling sequences do not:

(20)

Constraint	Violated by
$*\Delta_{Ft}/L$	$L^{+}L$, $L^{+}M$, $L^{+}H$
$*\text{-}\Delta_{Ft}/H$	$L^{+}H$, $M^{+}H$, $H^{+}H$
OCP_{Ft}	$L^{+}L$, $M^{+}M$, $H^{+}H$

As shown, all 'non-falling' feet ($H^{+}H$, $M^{+}H$, $M^{+}M$, $L^{+}H$, $L^{+}M$, $L^{+}L$) violate at least one of the constraints stated above. Crucially, though, the feet HL, HM, and ML do not violate any of the constraints. In OT terms, $H^{+}L$, $H^{+}M$, and $M^{+}L$ feet 'harmonically bound' the other sorts.

This is not to say that $H^{+}L$, $H^{+}M$, and $M^{+}L$ do not violate any constraints at all: they all violate (at least) $*\Delta/H$ and $*\text{-}\Delta/L$. However, it will be shown in the analysis below that the effects of the constraints they violate are blocked by constraints on the location of DTEs. This blocking effect was shown in section 2 in the analyses of Zulu and Digo.

The OCP plays a crucial role in this analysis: it rules out $M^{+}M$ feet. If $*\Delta/M$ was used instead, this would incorrectly eliminate $M^{+}L$ feet; if $*\text{-}\Delta/M$ was used, $H^{+}M$ would be incorrectly penalized. The need for the OCP by no means diminishes the value of the tone-prominence constraints. In fact, given the existence of the OCP (as argued for in numerous works), it is to be expected that it interact with tone-prominence constraints. In the present situation, the OCP complements the Atomistic constraints. This is a desirable result; it would be less desirable if a tone-prominence theory clashed with the OCP, producing unattested patterns. It would also be somewhat undesirable if the effects of the OCP and tone-prominence constraints overlapped considerably, producing redundancy.

The following constraints on prosodic form are also needed:

[15] The effect of the OCP with respect to tone has been demonstrated in a large number of works, at virtually every prosodic level (see the works cited in the text above). Because of this, I will not spend any time justifying its existence.

[16] This does not rule out a foot with two syllables that *share* the same tone. I assume that tone sharing is not permitted in Huajuapan, Ayutla and Molinos Mixtec. Sharing is prohibited by the constraint NOSPREADTONE (Tranel 1996, Zoll 1997, Myers 1997, and many others).

(21) FTBIN(σ) "Feet must be disyllabic" (P&S 1993, M&P 1993)
ALIGN-σ^+-L "Δ_{PrWd} must be leftmost in the PrWd" (M&P 1993)
FTFORM=TROCHEE "Feet are left-headed" (P&S 1993)

FTBIN(σ) requires feet to contain two syllables and FTFORM=TROCHEE requires the head of the foot to be leftmost. These constraints are undominated in Huajuapan since feet are always disyllabic and left-headed. ALIGN-σ^+-L expresses the tendency for stress to fall on the leftmost syllable possible.

The following tableau demonstrates these constraints at work. FTBIN and FTFORM=TROCHEE are not included for the sake of brevity; since they are so high-ranked, only candidates with disyllabic left-headed feet could possibly win, so only these are considered. ALIGN-σ^+-L is ranked below the tone-prominence constraints mentioned in (20) above, so allowing their effect to be manifested in the stress system. All other constraints (*Δ_{Ft}/M, *Δ_{Ft}/H, *-Δ_{Ft}/M and *-Δ_{Ft}/H) are ranked below ALIGN, so ensuring their inactivity.

Candidates are presented as tones symbols only for the sake of brevity; for example, LHL is a candidate with a low-toned initial syllable, a high-toned second syllable, and a low-toned final syllable. Foot boundaries are marked by ( ), and the head of the foot is marked by a $^+$.

(22)

1. /HHL/	*Δ_{Ft}/L	*-Δ_{Ft}/H	OCP$_{FT}$	ALIGN-σ^+-L
(H$^+$H)L		x!	x	
☞ H(H$^+$L)				x
2. /LMHL/	*Δ_{Ft}/L	*-Δ_{Ft}/H	OCP$_{FT}$	ALIGN-σ^+-L
(L$^+$M)HL	x!			
L(M$^+$H)L		x!		x
☞ LM(H$^+$L)				x x
3. /HLHL/	*Δ_{Ft}/L	*-Δ_{Ft}/H	OCP$_{FT}$	ALIGN-σ^+-L
☞ (H$^+$L)HL				
H(L$^+$H)L	x!	x		
HL(H$^+$L)				x x!

Example (1) shows that falling-tone feet, exemplified by H$^+$L, are more harmonic than level-tone feet. Example (2) shows that rising sequences are less harmonic than falling ones: the foot (H$^+$L) does not violate any constraints, while the rising feet (L$^+$M) and (M$^+$H) do. Example (3) shows that the leftmost most harmonic foot wins. This example shows that the low-ranked ALIGN-σ^+-L can be active, just in case there are two or more candidates which have equally harmonic feet.

This analysis shows that the Categorization condition is met for Huajuapan: H$^+$L, H$^+$M, and M$^+$L feet are distinguished from all other types. The Harmony condition is also met: H$^+$L/H$^+$M/M$^+$L feet are more harmonic than other foot types.

The Conflation condition is also met. In Huajuapan H$^+$L, H$^+$M, and M$^+$L feet are treated as identical: there is no preference for one type over the other. The following tableau shows that the present proposals correctly conflate these categories. If HL was always preferred over M^+L it should always attract stress away from it, so producing *[ML(H^+L)], not the attested [(M^+L)HL]. As shown, it does not: the leftmost falling sequence attracts stress, regardless of the exact tonal nature of the fall.

(23)

		$*\Delta_{Ft}/L$	$*\text{-}\Delta_{Ft}/H$	OCP_{FT}	ALIGN-σ^+-L
	1. /HLML/	$*\Delta_{Ft}/L$	$*\text{-}\Delta_{Ft}/H$	OCP_{FT}	ALIGN-σ^+-L
☞	a. (H^+L)ML				
	b. HL(M^+L)				x x!
	2. /MLHL/	$*\Delta_{Ft}/L$	$*\text{-}\Delta_{Ft}/H$	OCP_{FT}	ALIGN-σ^+-L
☞	a. (M^+L)HL				
	b. M^+L(H^+L)				x x!

The reason that these foot types are conflated is due to the fact that any constraint that could tell them apart, such as $*\Delta_{Ft}/M$, is ranked below ALIGN-σ^+-L.

A comment must be made on the constraints used here. The tone-prominence constraints refer to (non-)DTEs of feet. This is not crucial in the case of $*\Delta/T$ because the DTE of the foot is also the DTE of the PrWd, since there is only one foot per PrWd; the constraint $*\Delta_{PrWd}/L$ could equally have been used. Foot-reference is crucial in the case of the non-DTE constraint, though. If this referred to the PrWd instead, incorrect results emerge.

This was already seen (in an informal manner) in the description of the stress system: it is only the tone of the syllable that *immediately* follows the stressed syllable that matters, not the tonal properties of the rest of the form. By employing feet, this captures the fact that the environment for tone placement is local. Reference beyond the foot domain is not only irrelevant, but harmful. This is shown in the following tableau with the form MMH; since there are no falling sequences in this form, stress should default to the initial syllable; however, it is incorrectly predicted to fall on the penult, as shown by the 💣 symbol:

(24)

	1. /MMH/	$*\Delta_{Ft}/L$	$*\text{-}\Delta_{PrWd}/H$	OCP_{FT}	ALIGN-σ^+-L
	a. (M^+M)H		x	x!	
💣	b. M(M^+H)		x		x

Candidate (b) harmonically bounds candidate (a) since it incurs a subset of (a)'s violations (ignoring the low-ranked ALIGN-σ^+-L). This means that under every possible ranking permutation, (b) will be incorrectly preferred over (a). The failure here is the inability of $*\text{-}\Delta_{PrWd}/H$ to distinguish between the H that is in a foot in (b), and not in a foot in (a). This problem is avoided if $*\text{-}\Delta_{\underline{Ft}}/H$ is employed: since neither candidate harmonically bounds the other, the problem can be resolved by ranking:

(25)

1. /MMH/	$*\Delta_{Ft}/L$	$*\text{-}\Delta_{Ft}/H$	OCP_{FT}	ALIGN-σ^{+}-L
☞ a. $(M^{+}M)H$			x	
b. $M(M^{+}H)$		x!		x

In candidate (a), the H is not in a foot, and hence does not belong to the non-DTE of a foot, so avoiding the violation of $*\Delta_{Ft}/L$. The significance of the ranking of these constraints is further discussed in section 3.2.3.

3.2.1.1 Positive Constraints

At this point, an alternative to the Atomistic constraints can be considered: instead of negative constraints, positive constraints could be used (de Lacy 1997:§3.1.6). An example of a positive constraint is $\Delta_\alpha \rightarrow H$ "DTEs of α must be associated to a high tone." The positive constraints needed to supplant the corresponding negative constraints are listed in (26):[17]

(26) (I) $\| \Delta_\alpha \rightarrow H \gg \Delta_\alpha \rightarrow M \gg \Delta_\alpha \rightarrow L \|$

(II) $\| \text{-}\Delta_\alpha \rightarrow L \gg \text{-}\Delta_\alpha \rightarrow M \gg \text{-}\Delta_\alpha \rightarrow H \|$

While these positive constraints can produce many of the same results as their negative counterparts, they differ in terms of the conflation of categories. To illustrate this, let us attempt to analyse Huajuapan with them.

In Huajuapan, $(H^{+}L)$, $(H^{+}M)$ and $(M^{+}L)$ feet equally attract stress. As in the analysis in the preceding section, the analysis can be divided into separate components. The first point is that H- and M-tones attract stress equally. This immediately seems to pose a problem for the positive constraints: if the constraints $\Delta_{PrWd} \rightarrow H$ and $\Delta_{PrWd} \rightarrow M$ are used, overdifferentiation results. This is shown in the following tableau. The form /MLHL/ should be output as $[(M^{+}L)HL]$ since M^{+} and H^{+} are treated identically:

(27)

/MLHL/	$\Delta_{PrWd} \rightarrow H$	$\Delta_{PrWd} \rightarrow M$	ALIGN-σ^{+}-L
$(M^{+}L)HL$	x!		
💣 $ML(H^{+}L)$			x x

However, this result can be avoided by using the constraint $\text{-}\Delta_{PrWd} \rightarrow L$. With this in place of the $\Delta \rightarrow T$ constraints, the correct conflation is achieved:

(28)

---

[17] Two extra series of constraints can be added here: $\| H \rightarrow \Delta_\alpha \gg M \rightarrow \Delta_\alpha \gg L \rightarrow \Delta_\alpha \|$ and $\| L \rightarrow \text{-}\Delta_\alpha \gg M \rightarrow \text{-}\Delta_\alpha \gg H \rightarrow \text{-}\Delta_\alpha \|$. These are different from the constraints in (26) in terms of quantification: $H \rightarrow \Delta$ requires *every* high tone in a form to associate to some DTE, while $\Delta \rightarrow H$ requires *some* high tone to associate with a DTE.

/MLHL/	$-\Delta_{PrWd}\rightarrow L$	ALIGN-σ^{+}-L
☞ (M^{+}L)HL	x	
ML(H^{+}L)	x	x x!
M(L^{+}H)L	x x!	x

More difficult problems arise in the conflation of feet in terms of their non-DTEs. As in the previous section, the OCP is needed to ban (M^{+}M) feet. To account for the fact that (M^{+}H) feet are banned, though, constraints that refer to the non-DTEs of feet are needed. This is shown in the following tableau:

(29)

/MHL/	$-\Delta_{PrWd}\rightarrow L$	$\mathbf{-\Delta_{Ft}\rightarrow L}$	ALIGN-σ^{+}-L
☞ (M^{+}H)L	x	x!	
M(H^{+}L)	x		x

Without the constraint $-\Delta_{Ft}\rightarrow L$, stress would incorrectly fall on the initial syllable. $-\Delta_{Ft}\rightarrow L$ is not the only non-DTE constraint needed, though. $-\Delta_{Ft}\rightarrow M$ is also necessary:

(30)

/MHM/	$-\Delta_{PrWd}\rightarrow L$	$-\Delta_{Ft}\rightarrow L$	$-\Delta_{Ft}\rightarrow M$	ALIGN-σ^{+}-L
(M^{+}H)M	x x	x	x!	
☞ M(H^{+}M)	x x	x		x

Without $-\Delta_{Ft}\rightarrow M$, (M^{+}H) would be treated as more harmonic than (H^{+}M).

However, this produces an undesirable result: now (H^{+}L) and (H^{+}M) sequences cannot be conflated. This is shown in the following tableau.

(31)

/HMHL/	$-\Delta_{PrWd}\rightarrow L$	$-\Delta_{Ft}\rightarrow L$	$-\Delta_{Ft}\rightarrow M$	ALIGN-σ^{+}-L
(H^{+}M)HL	x x	x!		
☞ HM(H^{+}L)	x x		x	x

Since (H^{+}L) and (H^{+}M) are treated the same, stress should fall on (H^{+}M) since it is leftmost foot in the word. However, $-\Delta_{Ft}\rightarrow L$ prefers feet with low-toned non-DTEs over all other sorts. Similarly, this system cannot conflate (M^{+}L) with (H^{+}M) sequences.

In short, the positive constraints wrongly predict that low-toned non-DTEs are *always* preferable to mid-toned ones and that these categories cannot be conflated.[18] No other positive constraints can rectify this situation.

[18] This depends on the assumption that H/M/L are primitive units. If tones are taken to be sets of features (e.g. [+/-upper] and [+/-lower]) then H = [+upper, -lower], M = [-upper, -lower], L=[-upper, +lower] (see Yip 1995 for an overview). If $-\Delta\rightarrow$[-upper] is used, this will correctly refer to σ̀ and σ̄ as a group. I will not pursue the use of tone features and positive constraints here, partially due to the fact that there are many different theories of tone features. Whether the points made in this section apply broadly to specific combinations of positive constraints and tone features depends on the tone features employed. I leave this issue open for further research.

This result deserves some discussion. In the theory advocated in this paper, a category is defined by constraints and constraint ranking. Crucial to this are two sorts of constraints: (i) the categorisation. constraints (i.e. the tone-prominence constraints), and (ii) the blocking constraint. The blocking constraint used in the tableaux above is ALIGN-σ^+-L. As shown above and in previous sections, it nullifies the effect of every categorisation constraint ranked below it. In short, the full constraint ranking can be summarized as ||'Active' Categorisation Constraints » Blocking Constraint » 'Inactive' Categorisation Constraints||. Active Categorisation constraints are those tone-prominence constraints which cause categories to be visibly differentiated.

It is a result of this system that two categories are conflated if they incur the same violations of active categorisation constraints. For example, in the ranking ||*Δ/L » ALIGN-σ^+-L » *Δ/M » *Δ/H||, *Δ/L is an active categorisation constraint since it outranks the blocker ALIGN. The categories M^+ and H^+ are conflated since they violate the active *Δ/L equally.

Fixed rankings present an added complexity. Due to the implicational nature of fixed rankings, if a constraint in a fixed ranking is active every other constraint that outranks it will also be active. For example, *Δ/L outranks *Δ/M in a fixed ranking. Hence, if *Δ/M is active – i.e. outranks the blocking constraint – *Δ/L will also be active. This result means that fixed rankings restrict category conflation.

Such a restriction is evident in the case of positive constraints above. In this system, there is crucial conflation between L- and M-toned non-DTEs. Since there is a distinction between L^- and M^- on the one hand and H^- on the other, -Δ→M must outrank the blocker. If not, M^- would conflate with H^-. This necessary ranking ensures the active status of -Δ→L, since -Δ→L is in a fixed ranking with -Δ→M. However, two categories can only be conflated if they satisfy all active constraints equally. With -Δ→L and -Δ→M ranked above the blocking constraint, L^- and M^- incur different violations so preventing their conflation.

In short, the failure of the positive constraints to produce the correct conflation results from the proposal that category conflation arises from constraint ranking, and from the fixed rankings needed for the tone-prominence constraints (see section 4 for further discussion of this point).

3.2.1.2 Summary

To complete this section, it is worthwhile to consider the empirical aims of the Atomistic theory, and how they relate to Huajuapan. As stated in section 2, the Atomistic theory proposes that *higher* tone has an affinity with DTEs, not simply *high* tone. This is shown in the Huajuapan system: the higher tones H and M attract DTEs, not the high tone alone.

The Huajuapan system also shows that reference to non-DTEs is crucial. As shown here, the constraint *-Δ_{Ft}/H plays a crucial role in Huajuapan. Without it, it would be impossible to distinguish between MH and falling sequences. This is shown in the following tableau, with *-Δ_{Ft}/H removed from the constraint system:

(32)

/MHL/	$*\Delta_{Ft}$/L	OCP_{FT}	ALIGN-σ^{+}-L
💣 a. (M^{+}H)L			
b. M(H^{+}L)			x!

In this example, the stress should have fallen on the second syllable: [M(H^{+}L)]. Without the $*\text{-}\Delta_{Ft}$/H constraints, there is no way to exclude the M^{+}H foot type.

The analysis presented here shows than an atomistic theory – one that has constraints referring to single tones alone – can adequately explain phenomena that seem to make reference to tone sequences. The final point is that the $*(\text{-})\Delta_{\alpha}$/T constraints hold at every level of the prosodic hierarchy. This has been shown to a limited extent in this analysis. At the least, reference to the Ft level has been shown to be essential. Further discussion of this issue can be found in section 5.

3.2.2 Ayutla

The phonology of Ayutla has been described by Pankratz & Pike (1967). Like Huajuapan, there are three tones (H,M,L), and every syllable bears one and only one tone. Syllables are (C)(C)V in shape. While Ayutla's stress system is similar to Huajuapan's in many respects, there are a few revealing differences:[19]

(33) (i) Stress the leftmost H-toned syllable followed by a L-toned syllable:[20]

HHH^{+}L:	[tíkátʃí$^{+}$ìʔ]	'whirlwinds'	296.column 2
H^{+}LHL:	[ʃá$^{+}$.à.ʃí.ìʔ]	'is not eating'	297.c1
LMHH^{+}L:	[vìʃíírá$^{+}$à]	'he is not cold'	299.c1

(ii) Else stress the leftmost H-toned syllable:

H^{+}HH:	[ʃí$^{+}$núrá]	'his pineapple'	291.c1
MLH^{+}	[kūnùrá$^{+}$]	'his tobacco'	291.c1.
LH^{+}H:	[sùt^{y}á$^{+}$í]	'I will swim'	291.c1
LMH^{+}:	[sùt^{y}āí$^{+}$]	'I will not swim'	291.c1

(iii) Else stress the leftmost M-toned syllable followed by an L-toned syllable:

MM^{+}L:	[lāʃā$^{+}$rà]	'his orange'	293.c1

(iv) Else stress the leftmost syllable:

M^{+}MM:	[ʃī$^{+}$ñūrā]	'his pineapple'	292.c1
L^{+}LL:	[ʃà$^{+}$tùì]	'my trousers'	289.c1

Ayutla's system is similar to Huajuapan's in that it employs a trochaic foot and aligns stress with the left edge of the PrWd. Again, broadly speaking, falling sequences (HL,

[19] The stress description given here differs slightly from the summary given by PP (p.293.c1). PP rank ML sequences above H toned syllables. However, the data they list clearly show the opposite ranking: H syllables attract stress away from ML sequences as in [kūnùrá$^{+}$]. A distinction between H and HL is still necessary, though, as shown by the form HHH^{+}L.

[20] There are no HM sequences in Ayutla.

ML) are preferred over every other sort. At this point, though, the systems diverge. While Huajuapan conflates HL and ML feet, Ayutla distinguishes them.

This point raises a number of issues. With regard to the Categorization condition, Ayutla shows that an adequate theory must distinguish HL from ML feet; it is not enough to simply distinguish 'falling' from 'non-falling' tone sequences.

The Harmony condition is also relevant here: an adequate theory must show that HL is more harmonic than ML. Moreover, it seems safe to conjecture that this harmonic ranking is fixed – HL will always be more harmonic than ML (see section 5 for further discussion).

The Conflation condition poses a stringent test on any tone-prominence theory: the theory must be flexible enough to conflate HL and ML in Huajuapan, but to distinguish them in Ayutla.

The following tableau shows that the Atomistic theory meets these conditions in a rather minimal way: by ranking $*\Delta_{Ft}/M$ above ALIGN-σ^{+}-L (compare this with tableau 23).

(34)

1.	/HLML/	$*\Delta_{Ft}/L$	OCP$_{FT}$	$*\text{-}\Delta_{Ft}/H$	$*\Delta_{Ft}/M$	ALIGN-σ^{+}-L
☞	a) $(H^{+}L)ML$					
	b) $HL(M^{+}L)$				x!	x x
2.	/MLHL/	$*\Delta_{Ft}/L$	OCP$_{FT}$	$*\text{-}\Delta_{Ft}/H$	$*\Delta_{Ft}/M$	ALIGN-σ^{+}-L
	a) $(M^{+}L)HL$				x!	
☞	b) $M^{+}L(H^{+}L)$					x x

The crucial example is (2). If ML and HL were conflated, stress should fall on the leftmost falling sequence: i.e. $(M^{+}L)$. As shown, though, $*\Delta_{Ft}/M$ is violated by $(M^{+}L)$, so rendering it less harmonic than $(H^{+}L)$. This analysis shows that the Atomistic theory is powerful enough to make a distinction between HL and ML, yet flexible enough to allow conflation of these types. Furthermore, the analysis produces a fixed harmony ranking between HL and ML: there is no ranking permutation which will result in ML being more harmonic than HL. Hence, the theory only permits the possibility that HL and ML will be conflated (e.g. Huajuapan), or that HL will be more harmonic than ML (e.g. Ayutla); ML can never be more harmonic than HL.

Ayutla differs from Huajuapan in another respect: if an HL sequence cannot be found, the leftmost H is sought out. Only if there is no H does an ML sequence attract stress.

This can be reformulated in a more precise manner with respect to feet. It is evident from examples such as [kūnùrá$^{+}$] 'his tobacco' that the foot in this form is degenerate – i.e. only consists of one syllable: [kūnù(rá$^{+}$)] (assuming that left-headedness is inviolable). Hence, this aspect of the stress system can be reformulated as "Form a degenerate foot with a high-toned syllable."

So, the hierarchy of foot types in Ayutla is as follows: | $(H^{+}L) > (H^{+}) > (M^{+}L) >$ all others|. In other words, a disyllabic HL foot is preferred over a degenerate H-toned foot, which is in turn preferred over a disyllabic ML foot.

Before considering how to analyze these facts, it is worthwhile to note that this raises a significant issue for the Harmony condition. While Ayutla treats (H^+) as more harmonic than (M^+L), Huajuapan treats (M^+L) as more harmonic than (H^+). This means that an adequate theory must allow a variable harmonic ranking to obtain between (H^+) and (M^+L). This stands in contrast to the ranking of H^+L and M^+L, which is in all likelihood fixed universally.

In the present theory, variability results from permuting the ranking of two conflicting constraints. In other words, (H^+) must violate some constraint that (M^+L) does not, and vice-versa, *and* those constraints must be permutable – i.e. not in a fixed ranking. The conflicting constraints are easily identified: (1) unlike (M^+L), (H^+) violates FTBIN since it only contains one syllable, (2) unlike (H^+), (M^+L) violates $*\Delta_{Ft}/M$. Therefore, in Huajuapan, FTBIN outranks $*\Delta_{Ft}/M$, while in Ayutla the ranking is reversed. This is illustrated in the following pairs of tableaux with the form MLH. In Huajuapan, since ML is more harmonic than H, stress falls on the initial syllable; in Ayutla, since H is more harmonic than ML, it falls on the final syllable:

(35)

	Huajuapan /MLH/	FTBIN	$*\Delta_{FT}/M$
☞	(M^+L)H		x
	ML(H^+)	x!	
	Ayutla /MLH/	$*\Delta_{FT}/M$	FTBIN
	(M^+L)H	x!	
☞	ML(H^+)		x

The following tableau shows the full constraint ranking in Ayutla, with examples pertinent to the degenerate (H) foot:

(36)

1.	/LHH/	$*\text{-}\Delta_{Ft}/H$	OCP	$*\Delta_{Ft}/L$	$*\Delta_{Ft}/M$	FTBIN	ALIGN-σ^+-L
	(L^+H)H			x!			
	L(H^+H)	x!	x				x
☞	L(H^+)H					x	x
2.	/LMH/	$*\text{-}\Delta_{Ft}/H$	OCP	$*\Delta_{Ft}/L$	$*\Delta_{Ft}/M$	FTBIN	ALIGN-σ^+-L
	(L^+M)H			x!			
	L(M^+H)	x!			x		x
	L(M^+)H				x!	x	x
☞	LM(H^+)					x	x x
3.	/MLH/	$*\text{-}\Delta_{Ft}/H$	OCP	$*\Delta_{Ft}/L$	$*\Delta_{Ft}/M$	FTBIN	ALIGN-σ^+-L
	(M^+L)H				x!		
	M(L^+H)	x!		x			x
☞	ML(H^+)					x	x x

To summarize the main points in this section, a comparison of Ayutla's and Huajuapan's stress systems highlights the relevance of the Categorization, Harmony, and Conflation conditions. While a theory of tone-prominence interaction must be rich enough to distinguish between (H^+L), (M^+L), and (H^+) feet it must also be flexible enough to conflate these categories in a variety of ways. The Harmony problem presented significant issues: an adequate theory must have the power to have a fixed harmonic ranking of $|(H^+L) > (M^+L)|$, but at the same time it must be flexible enough to allow $|(M^+L) > (H^+)|$ in one system and the opposite ranking in another.

3.2.3 Conflation in Ayutla and Huajuapan

So far, the issue of conflation has only been considered in relation to the 'heavy' categories of feet – H^+L, H^+M, and M^+L. Most attention was paid to the fact that H^+L, H^+M, and M^+L were treated equally in Huajuapan, but that H^+L was more harmonic than M^+L in Ayutla. The Conflation problem arises equally for the 'non-prominent' foot types, though. It is equally important that a theory of tone-prominence interaction conflates such foot types as (L^+L) with (L^+M), for example, since these foot types are treated equally in all three of the Mixtec languages under discussion. The question, then, is whether the Atomistic theory adequately conflates all 'level' and 'rising' foot types (i.e. H^+H, M^+H, M^+M, L^+H, L^+M, L^+L).

For Ayutla, this issue does not arise. Because Ayutla treats (H^+), (H^+L), and (M^+L) feet as prominent, only tone sequences without these sequences are of interest. In all possible three-tone sequences, this only leaves LLL, LLM, LMM, and MMM. Two independent restrictions on tone sequences in Ayutla further narrow this down (PP p.291-2):

- Sequences of more than one M tone must begin in the initial syllable, so MML is well-formed, but *LMM is not.
  This eliminates LMM.
- M is neutralized to L between L and a word-final boundary: M → L/ L_#.
  This eliminates LLM.

With these sequences eliminated, only LLL and MMM remain. The correct stress is achieved on these forms with the current ranking:

(37)

1.	/LLL/	$*\text{-}\Delta_{Ft}/H$	OCP	$*\Delta_{Ft}/L$	$*\Delta_{Ft}/M$	FTBIN	ALIGN-σ^{+}-L
	$(L^{+}L)L$		x!	x			
	$L(L^{+})L$			x		x	x!
☞	$(L^{+})LL$			x		x	
2.	/MMM/	$*\text{-}\Delta_{Ft}/H$	OCP	$*\Delta_{Ft}/L$	$*\Delta_{Ft}/M$	FTBIN	ALIGN-σ^{+}-L
	$(M^{+}M)M$		x!		x		
	$M(M^{+})M$				x	x	x!
☞	$(M^{+})MM$				x	x	

Stress defaults to the leftmost syllable in these forms since every possible foot is identical in terms of tonal properties. This means that the low-ranked ALIGN-σ^{+}-L is crucial in these cases, correctly ensuring default initial stress.

The more interesting case is Huajuapan. In this system, forms without HL, HM, or ML should all have default stress on the initial syllable. For almost all three-tone sequences, the correct results are obtained given the ranking in tableau (35) below. One form in which the correct results are not achieved is LLM.[21] The following tableau shows that $L(L^{+}M)$ harmonically bounds $(L^{+}L)M$ (the ranking below has been established in previous sections):

(38)

	/LLM/	FTBIN	$*\text{-}\Delta/H$	OCP_{FT}	$*\Delta/L$	ALIGN-σ^{+}-L
	a. $(L^{+}L)M$			x!	x	
💣	b. $L(L^{+}M)$				x	x

This form poses a particular problem. Not only does it show that the ranking does not achieve the correct results, it shows that there is *no* possible ranking which will work. This is because the ungrammatical candidate (b) harmonically bounds the attested candidate (a) (ignoring ALIGN-σ^{+}-L, which is ranked too low to be of any use in resolving this problem). In this tableau, the only way to avoid this result would be to rank ALIGN-σ^{+}-L above the OCP. This is impossible, though, since ranking the OCP below ALIGN would incorrectly conflate $(M^{+}M)$ feet with falling tone feet.

This result leads to the conclusion that there must be another constraint at play here. This constraint must at least outrank the OCP and penalize $L(L^{+}M)$ while preferring $(L^{+}L)M$. I propose the following:

(39) ALIGN($\grave{\sigma}^{+}$, L, PrWd, L) “Align a low-toned stressed syllable with the left edge of a PrWd.”

With this constraint, the correct results are achieved:

---

[21] It is unlikely that Huajuapan has the same restriction as Ayutla – prohibiting M tones finally. Although no LLM form was found in the data, LM and HLM forms are attested: nà̰$^{+}$ñā̰ ‘he/she/they (known) tied her/them’, kó̰ò̰ñō̰ ‘you (sg, child) want’.

(40)

/LLM/	ALIGN-$\grave{\sigma}^+$-L	*Δ/L	OCP$_{FT}$
☞ a. (L$^+$L)M		x	x
b. L(L$^+$M)	x!	x	

Of course, this solution raises as many questions as it answers. In particular, what is the justification for this constraint? Showing that this constraint is present in the Mixtec languages is the subject of the next section. It will be demonstrated that this constraint is visibly active in the final Mixtec language to be discussed in this paper – Molinos. In fact, this constraint achieves not only the correct conflation, but accounts for the direction of stress assignment in Molinos'.

3.2.4 Molinos[22]

Molinos is the last Mixtec language to be discussed here (Hunter & Pike 1969). Molinos shares aspects of both Ayutla and Huajuapan, with a unique difference. Like the other Mixtec languages, Molinos contrasts three tones (H,M,L) and every vowel has a single tone. Its stress system is as follows (HP 25):[23]

(41) (i) Stress the rightmost H-toned syllable followed by a M- or L-toned syllable.

MH$^+$MML:	[kāndí$^+$hādēʒà]	'he will obey God'	25
MHMH$^+$L:	[sīkútʃīsá̹$^+$tì]	'I will bathe the animal'	25

(ii) else stress the rightmost M-toned syllable followed by an L-toned syllable.

MLM$^+$L:	[k^{w}īnìdē$^+$tì]	'he will see the animal'	25

(iii) else stress the leftmost syllable:

L$^+$LL:	[tì$^+$ndòkò]	'avacado seed'	25
L$^+$MH:	[kì$^+$vīsá]	'I will enter'	25

Molinos is like Huajuapan in that it absolutely requires disyllabic feet. Like Ayutla, (H$^+$L) and (H$^+$M) are conflated, and are more harmonic than (M$^+$L). These aspects of the Molinos system can be explained in the same manner as Huajuapan's and Ayutla's: (1) FTBIN is undominated, and (2) *Δ_{Ft}/M outranks ALIGN-σ^+.

The difference that sets Molinos apart from Huajuapan and Ayutla is the nature of its stress system: whereas Huajuapan and Ayutla are default-to-same systems, Molinos is default-to-opposite. In other words, in Huajuapan and Ayutla, stress falls on the *leftmost* most harmonic foot, otherwise defaults to the *leftmost* syllable, while in Molinos, in comparison, stress falls on the *rightmost* most harmonic foot, and otherwise defaults to

[22] Thanks to Moira Yip for originally bringing this to my attention. To my knowledge, Yip (1981) is the only other formal (autosegmental) analysis of this system.
[23] This description is a slight simplification of HP's formulation (p. 25). The nature of the simplification has to do with MMM and HHH sequences, a point which will be discussed below.

the *leftmost* syllable. The purpose of the following section is to account for the default-to-opposite aspect of Molinos' stress system.

3.2.4.1 Default-to-Opposite Stress in Molinos

As noted in the previous section, Molinos has a default-to-opposite stress system: prominent feet are aligned to the right edge of the word, otherwise stress falls on the leftmost syllable.

Walker (1996) and Zoll (1997) have presented a general approach to dealing with default-to-opposite stress systems. To illustrate their approach, take a more common default-to-opposite system: the rightmost bimoraic syllable is stressed, and in the absence of bimoraic syllables, the leftmost syllable (e.g. Huasteco – Larson & Pike 1949, Kuuku-Yaʔu – Thompson 1976). Zoll and Walker propose that there are two ALIGN constraint in such a system. The higher-ranked ALIGN is very specific, and refers to highly marked structure. In the present example, this marked structure is a stressed mono-moraic syllable. So, the constraint used here is ALIGN-σ_μ^+-L "A stressed mono-moraic syllable must appear at the left edge of a PrWd." This outranks a very general alignment constraint: ALIGN-σ^+-R "A stressed syllable must appear at the right edge of a PrWd." In tandem with a constraint requiring that bi-moraic syllables be stressed (WT-TO-STRESS), the correct results are obtained. This is illustrated in the following tableau. [ta:] is a bi-moraic syllable, and [ki] is mono-moraic.

(42)

1.	/kita:kita:ki/	ALIGN-σ_μ^+-L	WT-TO-STRESS	ALIGN-σ^+-R
	ki$^+$ta:kita:ki		x x!	x x x x
	kita:$^+$kita:ki		x	x x x!
	kita:ki$^+$ta:ki	x x!	x x	x x
☞	kita:kita:$^+$ki		x	x
2.	/kikiki/	ALIGN-σ_μ^+-L	WT-TO-STRESS	ALIGN-σ^+-R
☞	ki$^+$kiki			x x
	kiki$^+$ki	x!		x
	kikiki$^+$	x x!		

The same strategy can be used to account for Huajuapan. Again, there must be a constraint specifically aligning a highly-marked stressed syllable with the left edge. Unlike the system illustrated in tableau (39), though, the relevant weight distinction in Huajuapan is not between mono- and bi-moraic syllables but between syllable types based on tone. According to the tone-prominence constraints, the most marked DTE is one with a low tone (recall that *Δ/L outranks all other types). Since the specific ALIGN constraint refers to the most marked sort of syllable, it must be ALIGN-$\grave{\sigma}^+$-L "Align a stressed low-toned syllable to the left of a PrWd."

The general constraint schema proposed by Zoll and Walker can now be filled in with the constraints relevant to Molinos: || ALIGN-$\grave{\sigma}^+$-L » *(-)Δ/T, OCP » ALIGN-σ^+-R||. In this system, the tone-prominence constraints *(-)Δ/T and the OCP take the place of WT-TO-STRESS. The following tableau illustrates these constraints at work in a variety of forms. The first shows that the rightmost most prominent foot is stressed, while the others show the default case.

(43)

1.	/HLHL/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
	(H^{+}L)HL						x x x!
	H(L^{+}H)L	x!	x		x		
☞	HL(H^{+}L)						x
2.	/LLL/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
☞	(L^{+}L)L			x	x		x x
	L(L^{+}L)	x!		x	x		x
3.	/LMH/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
☞	(L^{+}M)H				x		x x
	L(M^{+}H)		x!			x	x

There are a few recalcitrant cases. Two consist entirely of M or H syllables. These are shown in the tableau below:

(44)

1.	/MMM/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
	(M^{+}M)M			x		x	x x!
☞	M(M^{+}M)			x		x	x
2.	/HHH/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
	(H^{+}H)H		x	x			x x!
☞	H(H^{+}H)		x	x			x

As shown, stress is predicted to fall on the penult in such forms. At first, this seems to be contrary to the description that stress defaults to the initial syllable. However, HP take special note of these forms. They observe that their stress pattern is different from the default initial stress in other forms, and in fact claim that “all syllables are equally stressed” (p.25):

(45) HHH: [kó$^{+}$ní$^{+}$ní$^{+}$] ‘your turkey-hen’ 25
MMM: [kē$^{+}$tē$^{+}$dē$^{+}$] ‘he will dig’ 25

However this statement is to be construed, it effectively means that it is impossible to know where the Δ_{PrWd} is in such forms.[24] The present proposal predicts it will be the penult syllable; whether this is the correct placement is a subject for future research.

Of all other three- and four-syllable forms, only PrWds with the shape LLMM and MMMH pose a potential problem ('potential' as they are not attested in the data). These are shown in the tableau below:

(46)

1.	/LLMM/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
	(L^{+}L)MM			x	x!		x x x
	L(L^{+}M)M	x!			x		x x
☞	LL(M^{+}M)			x		x	x
2.	/MMMH/	ALIGN-$\grave{\sigma}^{+}$-L	*-Δ/H	OCP-T_{FT}	*Δ/L	*Δ/M	ALIGN-σ^{+}-R
	(M^{+}M)MH			x		x	x x x!
☞	M(M^{+}M)H			x		x	x x
	MM(M^{+}H)		x!			x	x

As shown, the constraints fail to prefer the candidate with initial stress in these forms. There is no easy way to circumvent this problem. If a constraint such as ALIGN-$\bar{\sigma}^{+}$-L was employed, attracting a mid-toned stressed syllable to the left edge, difficulties would arise in forms such as [MLML], where stress would be incorrectly predicted to fall on the first M-toned syllable, not the second. There is little more to say about these forms except for the fact that they were not present in the data. I leave these as unresolved problems; in any case, they hardly constitute conclusive evidence for or against the current approach.

The benefit of the present proposal is that it draws a close parallel between Huajuapan and Molinos. The *only* difference between the two languages is in the lowest-ranked ALIGN constraint: in Huajuapan it is ALIGN-σ^{+}-L, while in Molinos it is ALIGN-σ^{+}-R. As pointed out in previous sections, it would be surprising if two closely related systems employed vastly divergent constraints. The fact that such a minimal change is needed to account for a descriptively minimal difference lends credence to the present approach.

3.2.5 Summary

In section 3.1, it was suggested that phonological systems that are minimally different in descriptive terms could be reasonably expected to receive minimally different explanations. While not a rigorously quantifiable heuristic, it seems to be a reasonable post-hoc test of the plausibility of analyses. It is notable, then, that the explanations offered for the minimally different Mixtec languages require minimal changes in constraint ranking.

The 'parameters' along which the languages vary are few. In terms of different categories, while Huajuapan conflates the categories HL, HM, and ML, Huajuapan and

[24] By 'equal stress', I assume that the percept of stress (duration) is confounded in these forms. Since stress is cumulative (Hayes 1995), it is unlikely that each syllable in such forms is a DTE.

Molinos distinguish HL and HM from ML. This was explained by ranking $*\Delta_{Ft}/M$ below ALIGN-σ^+ in Huajuapan, and reversing the ranking for the other two languages. The languages also varied in terms of whether FTBIN was ranked high or low: the former was the case for Huajuapan and Molinos, and the latter for Ayutla. The final difference was in the direction of the ALIGN-σ^+ constraint. For Huajuapan and Ayutla, the constraint attracted stressed syllables to the left, and for Molinos to the right.

The focus throughout this section has been on whether the Atomistic theory meets the conditions of adequacy on Categorization, Harmony, and Conflation. While this has been shown to be the case in terms of the Mixtec systems, there are other ways to determine the plausibility of a theory. One way is to determine whether there are better (empirically and/or conceptually) alternative theories. This is the subject of the next section. The other way is to examine the predictions the theory makes in other areas. This is the subject of sections 5, 6, and 7.

4 Alternatives

There are a number of ways to evaluate a theory. The most tangible is empirical adequacy – whether the theory correctly explains the attested facts. However, if several theories prove equally empirically adequate, other criteria must be invoked to decide between them. Such criteria relate to the form of the theory employed and its conceptual economy. The aim of this section is to consider a number of alternatives to the Atomistic theory to determine whether they are both empirically and conceptually adequate. Despite the narrow set of data focussed on here (i.e. the Mixtec languages) it will be shown that a large number of theories are empirically inadequate – they fail the conditions of Categorization, Conflation, or Harmonic Ranking.

Some of the alternatives entertained are by necessity constructed solely for the purposes of this discussion. This is due to the fact that (as far as I am aware) there is no other theory of tone-stress interaction that is powerful enough to deal with the Mixtec facts.[25] Because of this, I will not present a specific alternative theory in detail and then argue against it. Instead, the aim is to consider general *types* of alternative theories and identify their necessary properties. Then, it is a matter of determining whether those properties are compatible with the Conflation, Categorization, and Harmony conditions.

The class of theories that are the primary focus of section 4.1 are 'sequential'– theories that crucially refer to sequences of tones. Mechanisms that can produce constraints on sequences of elements, such as Local Conjunction (Smolensky 1993, 1995) and more complex operations on constraints (Hewitt & Crowhurst 1995), are discussed in section 4.2.

---

[25] By no means do I wish to imply that the subject of tone and stress interactions has not been given thoughtful and careful attention by a large number of researchers. However, most proposals have been limited in scope to single languages, to a single level of the prosodic hierarchy, and/or to languages with only two tonal oppositions (exceptions include Jiang-King 1996 and Anttila and Bodomo 1996).

4.1 Sequential Theories

The theory proposed in this paper is 'atomistic' since the constraints employed refer to the minimal amount of phonological material needed to describe a tone-prominence interaction: i.e. a DTE, a tone, and the relation between them. The alternative is to allow constraints less restricted reference: instead, they may refer to sequences of tone as in the constraint $*H^{+}L$ "Incur a violation for every Δ bearing a high tone which is followed by a low tone". Such theories will be referred to as 'sequential' here.

Sequential theories are initially appealing when the Mixtec languages are encountered. After all, the description of Huajuapan stress, for example, makes reference to tone sequences:

(47) Stress the leftmost high-toned syllable followed by a lower-toned syllable.

In a sequential theory, a set of constraints that prefer the sequences $\acute{\sigma}^{+}\grave{\sigma}$ and $\acute{\sigma}^{+}\bar{\sigma}$ over all others would be employed.

This theory potentially has properties that the atomistic theory does not. For example, there is no need to refer to prosodic constituency. So, there is no need to mention the foot to analyze the Mixtec systems. The constraints that prefer an $H^{+}L$ sequence will equally prefer $(H^{+})L$ and $(H^{+}L)$. In comparison, reference to prosodic constituency is a necessary part of atomistic constraints: it is not possible to refer to tone in a constraint without also referring to a prosodic element.

Another property of sequential theories is that reference to the 'non-DTE' can be eliminated. Reference to the non-DTE is encoded in a constraint indirectly. Instead of requiring that the non-DTEs of feet be low-toned, for example, the sequential theory can emulate this result by requiring that a DTE be followed by a low tone (or preceded, as the case may be). In the constraint $*H^{+}L$, for example, there is no mention of a non-DTE.

Of course, these are both only potential properties of a sequential theory – whether the constraints are required or may refer to prosodic constituency or non-DTEs is a matter of choice.

Mechanisms that have already been proposed to account for other phenomena can also be used to construct sequential theories. For example, Local Conjunction is a mechanism that produces a single constraint within a specified domain from two other constraints (Smolensky 1993). The constraints *Δ/H and *-Δ/L could be locally conjoined within the foot (or any other) domain as $[*\Delta/H\&*\text{-}\Delta/L]_{Ft}$. This conjoined constraint is violated only if both its subparts are violated – i.e. only if a foot contains a high-toned DTE and a low-toned non-DTE.

When constraints in a fixed ranking are conjoined the ranking of the subparts of those constraints are preserved (Smolensky 1993, Aissen 1998, Artstein 1998). For example, since *Δ/L outranks *Δ/H, [*Δ/L&*-Δ/H] outranks [*Δ/H&*-Δ/H]. Proceeding in this manner produces a lattice of hierarchical orderings of categories (identical, in fact, to the orderings produced by the Atomistic theory – see section 7). The local conjunction mechanism will not be used as exemplar of sequential theories in the remainder of this section.[26] The point of mentioning it is to underscore the point that a sequential theory is by no means implausible from a theoretical point of view, and the mechanisms to construct it may have been already proposed.[27]

Having outlined properties of a sequential theory above, the aim of the next section is to determine whether it could meet the conditions of adequacy on Categorization, Harmony, and Conflation.

4.2 Conditions of Adequacy

Like an atomistic theory, sequential theories must also meet the conditions of Harmony, Categorization, and Conflation. The Categorization condition requires the theory to make adequate distinctions between types of sequences. From Molinos, we know that these distinctions must be at least between $H^{+}L$/$H^{+}M$, $M^{+}L$, and all other sequences. The Harmony condition requires that some categories must be in a fixed ranking: $H^{+}L$ is always preferable to $M^{+}L$, for example. To give some substance to these conditions, the following constraints will be used:

(48) ||*Rise/Level » *$M^{+}L$ » *$H^{+}M$, *HL^{+}||

The constraint *Rise/Level bans sequences of tones which rise (e.g. LH) or stay level (e.g. LL). There is no doubt that this constraint is simply a 'cover term' for a number of other constraints (e.g. *LH, *LM, *LL, etc.). For the moment, though, it can remain unelaborated.

In terms of Categorization, this set of constraints produces the correct results for Molinos:

(49)

/MLHL/	*Rise/Level	*$M^{+}L$	ALIGN-σ^{+}-L	*$H^{+}M$	*$H^{+}L$
$M^{+}LHL$		x!			
$ML^{+}HL$	x!		x		
☞ $MLH^{+}L$			x x		x

From this tableau, it is evident how a sequential theory distinguishes categories. As an example, take the two categories $H^{+}L$ and $M^{+}L$. In the sequential theory, these are distinguished by the constraints *$H^{+}L$ and *$M^{+}L$. In this case, there is a one-to-one correspondence between constraints and categories: the $H^{+}L$ category is identified as that

[26] Local conjunction crucially relies on the existence of non-conjoined constraints. Hence, a constraint *Δ/H&*-Δ/L relies on the fact that *Δ/H and *-Δ/L exist elsewhere in the grammar. Of course, if the Atomistic theory was properly included in the local conjunction theory there would be no need to posit local conjunction at all since the Atomistic theory already can explain the pertinent facts.

[27] Another apparent proposal is a generalized type of OCP. The OCP prohibits adjacent identical elements. If it is extended to prohibiting elements of a near-identical nature, it could be used to value HL over HM over HH. However, this sort of OCP would predict that $L^{+}H$ and $H^{+}L$ would be the most optimal foot types since they have the most dissimilar tones. This prediction, along with others made by such approach (e.g. rising tones are always more harmonic than levels), show that such an approach is empirically inadequate.

sequence that violates *H$^+$L, while the M$^+$L category is the sequence that violates *M$^+$L. This sort of reference is the defining property of sequential theories.

This can be compared with an atomistic theory. In an atomistic theory, several different constraints conspire to distinguish H$^+$L from M$^+$L. In the theory proposed in this paper, for example, four constraints are employed: *Δ/L, *Δ/M, *-Δ/H, and *-Δ/M. H$^+$L is that sequence that does not violate *Δ/L,M and *-Δ/H,M, while M$^+$L is the sequence that does not violate *Δ/L and *-Δ/H,M:

(50)

	*Δ/L	*Δ/M	*-Δ/H,M
HL			
ML		x	

In other words, there is no simple one-to-one relation between constraints and categories in the atomistic theory.

This point is crucially important in regard to conflation. In previous sections, it was shown that ranking can conflate categories. However, some conflation is due to the form of constraints. For example, the constraint *Δ/L is equally satisfied by every sequence without L as a DTE (M$^+$H, M$^+$M, M$^+$L, H$^+$H, H$^+$M, and H$^+$L) and is equally violated by all sequences with L as a DTE (L$^+$H, L$^+$M, L$^+$L). In other words, *Δ/L conflates categories into two sets, each consisting of several different tone sequences. This is a property of atomistic theories, and follows from the fact that there is no 1:1 relation between sequences and constraints.

This situation is different in a sequential theory, though. Since there is a 1:1 relation between constraints and categories, conflation cannot be a side-effect of constraints. This fact creates problems when conflation cannot be achieved by constraint ranking. This situation occurs when categorization constraints are necessarily ranked above the blocking constraint.

To elucidate this point, let us consider three hypothetical examples that are somewhat like the Mixtec cases. The focus will be on {H,M,L}L sequences for the sake of brevity; other sequences will not be considered in the candidates. In language A, stress is attracted to the first syllable in a σ́σ̀ sequence, otherwise an ML sequence, otherwise it defaults to the initial syllable. The sequential theory can explain this by positing the following constraints and ranking:

(51)

/HLMLL/	*L$^+$L	*M$^+$L	*H$^+$L	ALIGN-σ$^+$-L
☞ (H$^+$L)MLL			x	x
HL(M$^+$L)L		x!		
HLM(L$^+$L)	x!			

In language B, the heavier categories are conflated: stress falls on the nearest HL *or* ML, otherwise defaults to an LL. Again, this system is handled in a straightforward manner:

(52)

/MLHLL/	$*L^{+}L$	ALIGN-σ^{+}-L	$*M^{+}L$	$*H^{+}L$
☞ $(M^{+}L)HLL$			x	
$ML(H^{+}L)L$		x x!		x
$MLH(L^{+}L)$	x!	x x x		

In this system, HL and ML have been conflated. This conflation was achieved by constraint ranking: by ranking *ML and *HL below the blocking constraint ALIGN-σ^{+}-L, their effect was nullified, so eliminating the distinction between ML and HL.

The crucial case is when the effect of a constraint cannot be due to constraint ranking. In the sequential theory, this is when conflation takes place between 'lighter' categories. To illustrate, consider language C, where stress falls on the first HL sequence. Otherwise, it falls on the leftmost ML or LL. In this language, the 'lighter' categories ML and LL have been conflated.

This conflation is impossible to achieve in the sequential model. This is shown in the tableaux below. No matter how *LL and *ML are ranked, an undesirable result emerges:

(53) *LL » *ML

/LLML/	$*L^{+}L$	$*M^{+}L$	ALIGN-σ^{+}-L	$*H^{+}L$
$L^{+}LML$	x!			
💣 $LLM^{+}L$		x	x x	

(54) *ML » *LL

/MLL/	$*M^{+}L$	$*L^{+}L$	ALIGN-σ^{+}-L	$*H^{+}L$
$M^{+}LL$	x!			
💣 $ML^{+}L$		x	x	

In these examples stress should fall on the leftmost syllable since stress placement is blind to the distinction between ML and LL. In both cases, though, preference is shown for either ML or LL.

The reason for this failure is that in order to conflate two categories, they must violate the same active categorization constraints (see discussion in section 2). However, since there is a 1:1 correspondence between constraints and categories in the sequential model, if there are *n* active categorization constraints, there will be *n* distinct categories. So, when two categorization constraints are forced to outrank the blocking constraint, they will distinguish two categories, and establish a hierarchy between them.

Generally speaking, this result shows that the property of a sequential theory – that there is a 1:1 correlation between categories and constraints – prohibits conflation.

This can be compared with an atomistic theory. As pointed out above, some conflation in atomistic theories is due to the constraints themselves, not only by ranking with respect to a blocking constraint. In the case above, for example, the correct results can be achieved by using the constraint $*\text{-}\Delta_{PrWd}/H$. This constraint has the effect of minimizing H-toned non-DTEs. One way of doing this is to force a H-toned syllable to be a DTE. By referring to H-toned syllables alone in this way, M and L are effectively conflated:

(55)

1. /MLL/	$*\text{-}\Delta_{PrWd}/H$	ALIGN-σ^{+}-L
☞ $(M^{+}L)L$		
$M(L^{+}L)$		x!
2. /LLML/	$*\text{-}\Delta_{PrWd}/H$	ALIGN-σ^{+}-L
☞ $(L^{+}L)ML$		
$LL(M^{+}L)$		x x!
3. /MLHL/	$*\text{-}\Delta_{PrWd}/H$	ALIGN-σ^{+}-L
$(M^{+}L)HL$	x!	
☞ $ML(H^{+}L)$		x x

As shown in the tableau the constraints achieve the correct results, with ML and LL treated as identical in (1) and (2), while HL attracts stress in (3).

In short, the problem with the sequential theory is that it encodes too many category distinctions directly in its constraints. This has the effect of resisting conflation. In comparison, atomistic constraints refer to sets of tone sequences since they only refer to part of that sequence. In other words, the property that some conflation is a side-effect of constraint form is crucial to an adequate theory. The 1:1 correspondence between categories and constraints in the sequential theory makes this option impossible.

It would not be fair to give up on the tone sequence so quickly, though. There may be ways to solve this problem. The problem in the tableau above is that 'lighter' categories cannot be conflated. If positive constraints are used, this problem is avoided. If the constraint $\Delta \rightarrow HL$ "The DTE must be a high-toned syllable followed by a low-toned one" is employed the lower categories are automatically conflated (as shown in section 3.2.1.1). This does not solve the problem, though, but merely pushes it into another area: the system will now fail with respect to language B, which conflates the 'heavier' categories HL and ML. The active categorization constraints $\Delta \rightarrow HL$ and $\Delta \rightarrow ML$ will serve to resist conflation. This underscores the point that it is not constraint ranking that is crucial to conflation here, but the constraints themselves: the fact that the sequential theory's constraints cannot refer to sets of categories means that they cannot conflate, so all conflation must be done by ranking, which is obviously impossible to do.

This fact also eliminates a number of potential alternatives: all those that propose some kind of reranking to deal with the conflation problem. As shown above, it is not the ranking of constraints that produces the conflation difficulties, it is the properties of the constraints themselves. Positing partial rankings of constraints instead of fixed rankings, for example, will do no good simply because ranking is not the issue.

Since the problem is in the constraints themselves, the alternative is to posit other less specific (and therefore more cross-classifying) sequential constraints. For example, $*H^{+}T$ bans sequences of a high tone followed by any other tone. Armed with such constraints, a variety of conflations emerge. For example, with the constraint *LT ranked above a blocking constraint, LL, LM, and LH sequences are differentiated from all other sequences and conflated. Since LL, LM, and LH all violate the same constraints, they are conflated into a single category.

With 'underspecified constraints' like *LT and *HT, the correct results may emerge.[28] However, this is at a significant cost. $*H^{+}T$, for example, effectively states nothing about the nature of a tone-sequence *per se*: it simply requires that H be followed by another tone. Such a restriction was achieved in the present work by appealing to foot form. Hence, *HT is equivalent to *Δ/H, and there is no need to mention a following tone. In this case, the atomistic constraints are a proper subset of the tone-sequence constraints. If, however, the atomistic constraints are adequate to account for the attested facts, there is a great deal of redundancy here, eliminating the sequential constraints would be in no way detrimental to the theory, and make for a conceptually more elegant theory.

4.3 Other Mechanisms

Another response to the failure of the sequential theory identified in the previous section would be to reject one of the premises of the arguments in this paper – namely that conflation should be effected by constraint ranking and by the nature of the constraints themselves. Instead, other mechanisms could be used to achieve conflation. As argued throughout this paper,. The alternative is to introduce a new relation between constraints. The aim of this is to make violations of one constraint identical in import to violations of another: if $*ML \oplus *MH$, where $\oplus$ is the new relation, then violations of ML are identical to violations of MH.

Proposals in this vein have been presented in Hewitt & Crowhurst (1995). Constraints can be related by a disjunction operator $\vee$. The disjoined constraint conglomeration $[C_1 \vee C_2]$ is violated if either C_1, or C_2, or both C_1 and C_2 are violated. For example, $[*M^{+}L \vee *M^{+}H]$ is violated if $*M^{+}L$ or $*M^{+}H$ are violated. Other mechanisms such as unranked constraints (Antilla 1995) and 'encapsulation' (Smolensky 1993) have a similar effect. In short, this approach deals with the conflation problem by introducing a new operator designed to produce this effect.

Such approaches deny that conflation should be effected by constraint ranking so eliminating it as a factor that bears on empirical adequacy. Instead, an adequate theory only needs to be concerned with producing the requisite number of categories and the correct harmony relations between them.

There is no simple empirical argument against such an approach. Ultimately, the question is whether it is conceptually justified to complicate the theory by introducing new constraint relations. Introducing such relations is by no means a trivial matter. In classical Optimality Theory, the only relation between constraints is one of ranking. In comparison, the approach advocated in this paper requires no new formal mechanisms. Since a theory employing extra relations between constraints properly includes a theory without such

[28] Whether they do emerge or not is dependent on the particular types of underspecified constraints allowed. For example, a constraint *{M,L}L is necessary to account for language C above, but whether it is formulable as a single constraint is contingent upon other factors (e.g. the theory of tone features employed and the ability to allow disjunctive formulations of constraints).

relations, the burden of proof is on proponents of extra constraint relations to show that conflation is necessarily effected by those relations, and not by constraint ranking.

A final, and far more radical, departure from the proposals in this paper is that categorization has nothing to do with constraints and constraint ranking at all. Instead, categories are ranked in a prominence hierarchy, and constraints such as PKPROM (Prince & Smolensky 1993) refer to this hierarchy.

A number of problems arise with this approach. The essence of such an approach is that restrictions on categories are distinct from restrictions on inventories. To illustrate, there are two aspects to any markedness constraint, such as ONSET. One is in terms of categorization: ONSET differentiates a syllable with an onset consonant from onsetless syllables. In a language that permits onsetless syllables, it indicates that syllables with onsets are more preferred than onsetless ones. However, ONSET also can have an inventory-defining role: if it is ranked above constraints on faithfulness, it can *require* syllables to have onsets.

If the categorization of syllable or foot types with respect to DTEs is removed from the purview of constraints, and relegated to a prominence hierarchy as PKPROM does, this predicts that the relevant categories will not play an inventory defining role in any language. The facts that, for example, in Golin high-toned DTEs are preferred to low-toned ones would be entirely unrelated to the fact that some languages require high-toned DTEs (e.g. Lithuanian – see section 6.1). It is evident that categorization – whether of foot types as in Mixtec, syllable types (Prince & Smolensky 1993), or any other sort of prosodic category – must be expressed in terms of constraints if they are to have any inventory defining role.[29]

There are benefits to an atomistic theory. As pointed out above, an atomistic theory allows sets of categories to be referred to. One side-effect of this is that variable harmonic ranking of categories can result. For example, the constraint $*\text{-}\Delta/H$ ranks ($M^{+}L$) above ($H^{+}H$) while the constraint $*\Delta/M$ ranks ($H^{+}H$) above ($M^{+}L$). The value of variability has been discussed for Ayutla (also see section 5). Variability imposes a condition on the form of prominence theories. One thing such a theory cannot do is impose a fixed ranking on all identified categories. To do so is to impose a fixed prominence implication, and to exclude variability as part of the grammar. In short, variability is an important property that any theory must be able to capture.

In conclusion, sequential theories confront difficulties in terms of the conflation of categories. This can be traced back to the fact that some conflation is necessarily accomplished by constraint form, not constraint ranking. Because of the 1:1 nature of constraints and categories in a sequential theory, conflation due to constraint form is impossible. This problem is avoided in an atomistic theory since constraints refer to properties of tone sequences instead of directly to the sequences themselves.

5 Typology of Processes and Levels

So far, the theory of tone-prominence interaction proposed in section 2 has only been applied to a small number of languages. The constraints proposed herein have a far

[29] For empirical evidence against PKPROM in a case of prominence-driven stress see de Lacy (1997:§4.1).

broader scope, though. The purpose of this section is to briefly examine some of the predicted effects of the Atomistic theory in situations other than tone-dependent stress and at levels other than the foot. Section 5.1 shows how the constraints produce a typology of tone-prominence interactions. The effect of the Atomistic theory at other prosodic levels is dicsussed in section 5.2.

5.1 A Typology of Tone-Prominence Interactions

There are three general sets of constraints that govern the location of prosodic structure, tone, and tone-prosody interaction:

(56) (i) Tone Constraints – constraints on the association and preservation of tone.
(ii) Prosodic Structure constraints – constraints on the formation and preservation of prosodic structure.
(iii) The tone-prominence *(-)Δ/T constraints.

A variety of effects take place depending on the ranking of these constraints with respect to each other.

For tone and prosodic structure to affect each other, the Tone-Prominence constraints must outrank at least one of the Tone constraints or Prosodic Structure constraints. This is illustrated in the tableau below. The Prosodic Structure constraint is ALIGN-σ^{+}-L, requiring the head syllable to be leftmost. The Tone constraint FAITH-T requires preservation of underlying tone:

(57)

/tàká/	ALIGN-σ^{+}-L	FAITH-T	*Δ/L
☞ a) tà$^{+}$ká			x
b) tàká$^{+}$	x!		
c) tá$^{+}$ká		x!	

The tableau shows that the effect of the tone-prominence constraints is blocked: placement of prosodic structure and tone takes precedence:

(58) Tone-Prominence Interaction:
||*(-)Δ/T » *Prosodic Structure* and/or *Tone* constraints||
Tone-Prominence Independence:
|| *Prosodic Structure, Tone* constraints » *(-)Δ/T » ||

The second ranking obtains in languages without any tone-stress interaction (e.g. Angaatiha – Huisman & Lloyd 1981, Hopi – Jeanne 1982, Saramaccan – Rountree 1972, Eastern Popoloca – Kalstrom & Pike 1968, Tlacoyalco Popoloca – Stark and Machin 1977).

Tableau (54) shows that the constraints are in conflict: satisfying the tone-prominence constraints entails violating either the prosodic structure or tone-placement constraints. This means that permuting the ranking will produce different results:

(59) Tone-Dependent Prosody

/tàká/	FAITH-T	*Δ/L	ALIGN-σ⁺-L
a) tà⁺ká		x!	
☞ b) tàká⁺			x
c) tá⁺ká	x!		

(60) Prosody-Dependent Tone

/tàká/	ALIGN-σ⁺-L	*Δ/L	FAITH-T
a) tà⁺ká		x!	
b) tàká⁺	x!		
☞ c) tá⁺ká			x!

As the tableaux above show, the essential aspect of tone-prominence interaction is that the tone-prominence constraints outrank at least one of the Tone or Prosodic Structure constraints. If the Tone constraints outrank the Prosodic Structure constraints, as in tableau (56), tone is preserved and prosodic structure alters to satisfy the tone-prominence requirements. Tableau (57) shows that the opposite ranking – with Prosodic Structure constraints over Tone constraints – forces tone placement to change.

There are many examples of Prosody-Dependent tone. Many Bantu languages have been analyzed as having tone attracted to positions of prosodic prominence (Goldsmith 1987, 1988, Downing 1990, Sietsema 1989, and see Zulu and Digo in section 2). Other cases include Ci-Ruri (Massamba 1984, Goldsmith 1988:85), Kpelle (Welmers 1962), Lamba (Bickmore 1995), Slave (Rice 1987), and the Chimaraba dialect of Makonde (Odden 1990). Because the same tone-prominence constraints are employed in the cases of tone-dependent prosody and prosody-dependent tone, the same tendencies are predicted to hold. So, since higher tone attracts stress, stress is predicted to attract higher tone. This prediction is borne out in the languages cited above.

As a final note, this typology also predicts that there may be mixed systems, where prosody is in part dependent on tone, and tone is in part dependent on prosody. This is due to constraint ranking: for tone-dependent prosody, some tone constraint must outrank some prosodic constraint, while for prosody-dependent tone, some prosodic constraint must outrank some tone constraint. It is possible to have different tone constraints and prosodic constraints, with some of the former dominating some of the latter and vice-versa in the same system. An example of this type is found in the Neo-Štovakian of Serbo-Croatian (see Zec 1994 for details).

5.2 A Typology of Prosodic Levels

The *(-)Δ/T constraints were shown to be active at the Ft level in Huajuapan, Ayutla, and Molinos Mixtec. However, the formulation of the tone-prominence constraints predicts that they hold at every level of the prosodic hierarchy. The aim of this section is to give a synopsis of phenomena that support this claim.

At the syllable level, the *(-)Δ/T constraints predict that head moras attract higher tone, and non-head moras attract lower tone. This is shown in the northern Min language Fuqing (Jiang-King 1996:§3.3.2): only H and M tone can appear on head moras, and only L tone can appear on non-heads (i.e. monomoraic syllables can have H or M tone, and bimoraic syllables can have HL or ML contours). This can be explained by using the *(-)Δ_σ/T constraints; these refer to the DTEs of syllables – i.e. the head moras of syllables – and the non-DTEs – i.e. the non-head moras. The Fuqing inventory restriction can be accounted for by the following ranking: ||*Δ_σ/L, *-Δ_σ/H » *-Δ_σ/M » FAITH-Tone|| (see section 6 for discussion regarding this ranking).

Just like the *Δ_{Ft}/T constraints, the tone-prominence constraints at the syllable level predict that the most harmonic contour will be HL since it does not violate any tone-prominence constraints.[30] The rising contour LH is predicted to be less harmonic since it violates both the DTE and non-DTE constraints. This produces an implication that if a language has LH contours it will always have HL, since the latter is always more harmonic than the former. This is borne out in typological surveys of tone contours (e.g. Cheng 1973, Maddieson 1978).

The fact that HL does not violate any constraints means that it is guaranteed to appear in any inventory. In fact, it is predicted that there could be languages with only HL contours over bimoraic syllables – such a case is found in a dialect of Serbo-Croatian (Babić 1988:3,8).

Tonal interactions at the foot level have been discussed for Mixtec in section 3. Further evidence for this level comes from the language game Ngóɓòóɓò, described by Bamba (1991). In this game, trochaic feet are constructed from left to right on native words (from the language Mahou). Heads of feet are assigned high tone, and non-heads are given low tone, producing (σ́σ̀) feet throughout the word. This can be accounted for by ranking *Δ_{Ft}/L and *-Δ_{Ft}/H above tone-faithfulness (see section 6).

Tonal restrictions at the PrWd level have been discussed for Vedic Sanskrit above. A variety of tonal interactions have been reported at levels above the PrWd. As shown in section 2, the head of a Phonological Phrase in Digo attracts high tone (Kisseberth 1984, Goldsmith 1988:85). This is a case of stress-dependent tone, with the constraint *Δ_{PPh}/L playing a decisive role. A case analogous to Vedic Sanskrit is found in Korean. Kim (1997) argues that every Major Phrase must contain at least one high tone, and that no other high tones are permitted. The constraints *Δ_{MaP}/L and *-Δ_{MaP}/H must outrank tone-faithfulness to achieve this result.

---

[30] This is true for contour tones where there is one tone per mora (as in Bantu languages). However, the situation is different for 'true' contours, when more than one tone may associate to a single mora. In this case, the constraints actually predict that HM contours on head moras will be more harmonic than HL ones since the former only violates *Δ_σ/M while the latter violates the higher-ranked *Δ_σ/L. This prediction seems to be borne out – see Jiang-King (1996, 1999) for relevant discussion.

There are a variety of other relevant phenomena above the PrWd. For example, the phonologically assigned (i.e. default) intonational tune in the Polynesian language Maori is H*L⁻ on every Major Phrase (de Lacy 1998).[31] This can be explained if *Δ_{MaP}/L and *-Δ_{MaP}/H are employed.

In short, higher tones are attracted and restricted to DTEs at every level in the prosodic hierarchy, while lower tones are attracted and restricted to non-DTEs. Although a more extensive survey of tonal restrictions is certainly desirable, this cursory overview supports the predictions of the tone-prominence theory.

To summarize, the tone-prominence constraints are not just relevant for tone-dependent stress at the sub-PrWd level. They explain cases of stress-dependent tone and tonal processes that take place at every level in the prosodic hierarchy.

6 Typology of Inventories

The permutability of constraints in Optimality Theory means that any markedness constraint can both trigger a process and restrict inventories. For example, the constraint *NUC/n "/n/ may not be a syllable nucleus" helps to determine syllabification in Imdlawn Tashlhiyt Berber (Dell & Elmedlaoui 1985, 1988, 1992, Prince & Smolensky 1993). In the sequence /na/, it forces the nucleus to fall on the segment [a]. However, it does not absolutely prohibit /n/ from being a nucleus in this language – just in case there is no better available segment, *n* becomes the nucleus: /tn/ → $[t\underline{n}]_\sigma$. In other languages, /n/ is banned outright from being a syllable nucleus; this sort of prohibition is an 'inventory restriction', albeit a position-sensitive one.

In most of the examples in previous sections, the tone-prominence constraints were used to motivate a process. The aim of this section is to examine their ability to produce inventory restrictions. Section 6.1 introduces the constraints and ranking needed to produce tone inventory restrictions. A typology of inventory restrictions is presented in section 6.2.

6.1 Faithfulness and the Tone-Prominence Constraints

If a constraint ℂ causes an inventory restriction, ℂ must outrank a relevant faithfulness constraint – a constraint that preserves aspects of the underlying form (McCarthy & Prince 1995). If it simply motivates a process, ℂ is necessarily outranked by faithfulness constraints (McCarthy & Prince 1995). This can be illustrated for the tone-prominence constraints by Golin and Lithuanian.

In Golin, stress falls on the rightmost high-toned syllable (Bunn & Bunn 1970). As shown in previous sections, the constraint *Δ_{PrWd}/L motivates this constraint, requiring PrWd DTEs to be high-toned. However, it does not produce an inventory restriction since DTEs are not required to be high-toned: there are low toned DTEs in forms with

[31] If declarative intonation is assumed to be the phonological default (phonologically assigned) tonal melody, the tone-prominence constraints explain why the most common pattern is H*L%, with a high tone on the head of a MajorP/IntonationalP.

entirely low tone. Because of this, faithfulness constraints to underlying tonal specification ('FAITH-T' here – see below for discussion of types of faithfulness constraint) must outrank the tone-prominence constraints. This ranking is shown below:

(61)

/kàwlìgì/	FAITH-T	$*\Delta_{PrWd}/L$
☞ kàwlìgì⁺		x
kàwlìgí⁺	x!	

The specifications of underlying tones remain unchanged despite the pressure imposed by the $*\Delta_{PrWd}/L$ constraints for the PrWd DTE to have high tone.

Lithuanian is similar to Golin in that 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). Of present interest, though, is the fact that *every* form surfaces with a high-toned syllable. Even underlyingly low-toned words surface with a high tone:[32]

(62) /prà-nèʃù/ → [prá⁺nèʃù], *[prà⁺nèʃù] 'I announce' (Blevins 1993:244)

This can be explained if Δ_{PrWd}/L outranks tone-faithfulness constraints:

(63)

/prà-nèʃù/	$*\Delta_{PrWd}/L$	FAITH-T
prà⁺nèʃù	x!	
☞ prá⁺nèʃù		x

As shown in this tableau, the requirement for DTEs to bear high tone (due to $*\Delta/L$) outweighs the need to retain underlying tonal specifications (FAITH-T). This produces an inventory restriction: only high tone is permitted on stressed syllables.

Before considering the range of inventories predicted by the tone-prominence constraints, it is necessary to examine the faithfulness constraints needed for tone.

With fixed markedness hierarchies that have more than two distinctions, the ranking or form of faithfulness constraints must also be restricted. Allowing unfettered ranking permutation of faithfulness constraints effectively eliminates the predictive power of fixed markedness rankings that have more than two distinctions.[33]

As an example, take the Place of Articulation fixed markedness hierarchy ||*dorsal » *coronal » *pharyngeal|| (Smolensky 1993 and others). If there are three faithfulness constraints IDENT(coronal), IDENT(dorsal), and IDENT(pharyngeal) (which require coronal, dorsal, and pharyngeal features to be preserved respectively) and these are freely rankable,

[32] As an aside, note that such languages show that positional faithfulness cannot supplant the tone-prominence markedness constraints: while positional faithfulness constraints can preserve features, they cannot *require* them (Beckman 1998, Casali 1996).

[33] For a similar observation, see Prince (1998), although Prince does not discuss cases of 'context-sensitive' fixed hierarchies (such as the nucleus/onset sonority and Δ/T~$-\Delta/T$ constraints).

almost any possible inventory can emerge. The exception is that the least marked element – pharyngeal – will always be possible.[34] Apart from that, systems vary as to whether they have coronals, dorsals, or both. The rankings to generate the different possible systems are presented below; the constraints *PHARYNGEAL and IDENT(pharyngeal) are not included for the sake of brevity.

(64) (a) Coronals, not dorsals: || IDENT(coronal), *dorsal » *coronal, IDENT(dorsal)||
(b) Dorsals, not coronals: || IDENT(coronal), *dorsal » *coronal, IDENT(dorsal)||
(c) Both: || IDENT(dorsal), IDENT(coronal) » *dorsal » *coronal||

In system (a), the ranking of *DORSAL above IDENT(dorsal) ensures that underlying dorsal specifications will be eliminated, surfacing as the least-marked [pharyngeal]. In system (b), though, dorsals will surface, but coronals are eliminated due to the ranking ||*coronal » IDENT(coronal)||.

In effect, any possible inventory can be produced: the predictive power of the markedness hierarchy ||*dorsal » *coronal » *pharyngeal || is several compromised by allowing the free ranking of faithfulness constraints.[35]

There are two ways to avoid this: (1) either faithfulness constraints have a fixed ranking, or (2) faithfulness constraints are prohibited from referring to the distinctions that the markedness constraints refer to. In the first case, IDENT(coronal) would universally outrank IDENT(dorsal), ensuring that if dorsal appears in an inventory, coronal does also. In the second case, faithfulness constraints could only refer to 'Place of Articulation' as a unit, not to [coronal] and [dorsal] individually.

The issue is more complex with context-sensitive symmetric fixed rankings (where a set of constraints asserts that a markedness hierarchy is $\alpha>\beta>\gamma$ in context K_1 and $\gamma>\beta>\alpha$ in context K_2). The tone-DTE hierarchy is such an example, with tonal markedness being H>M>L for DTEs and L>M>H for non-DTEs.

In order for the tone-DTE constraints $||*\Delta_\alpha/L$ » $*\Delta_\alpha/H||$ to have any predictive value, either there is a fixed ranking ||IDENT(H) » IDENT(L)|| or there is a single constraint IDENT(Tone). The first option can be eliminated when the non-DTE scale $||*\text{-}\Delta_\alpha/H$ » $*\text{-}\Delta_\alpha/L||$ is considered: to have any predictive power, the opposite fixed ranking of faithfulness constraints ||IDENT(H) » IDENT(L)|| is required.[36] This contradiction leads to the conclusion that faithfulness constraints cannot be allowed to refer to different types of tone, but must refer to 'tone' as a unit.

Accordingly, the faithfulness constraints include (but are not limited to) the following (also see Tranel 1996, Zoll 1997, Myers 1997):

[34] The least marked specification will always be produced in the output because the alternatives do not increase in faithfulness or unmarkedness. They cannot increase in faithfulness for obvious reasons; they cannot decrease markedness because of the fixed ranking: any other specification is more marked than *PHARYNGEAL. So, the results reported here do not apply to two-step hierarchies.

[35] Fixed markedness hierarchies can still have a limited effect in terms of 'emergence of the unmarked.'

[36] This contradiction could be resolved by relativizing faithfulness constraints to both DTEs and non-DTEs. Something similar to the former sort of constraint has already been proposed (i.e. positional faithfulness – Beckman 1998), but the latter has no precedent and may lead to pathological results.

(65) MAX-T "Every tone in the input has a correspondent in the output."
DEP-T "Every tone in the output has a correspondent in the input."
IDENT-T "An Input tone is identical to its corresponding output tone in terms of its specification (H, M, L)."

Crucially, there can be no constraints that refer to individual tones (e.g MAX-H, MAX-M, etc.). The next section shows how these interact with the tone-prominence constraints to produce a variety of inventories.

6.2 A Typology of Tonal Inventories

The aim of this section is to explore the possible tonal inventories predicted by the tone-prominence constraints. As mentioned in section 2, it is not necessarily true that every mora bears a tone: some may be tonally specified. So, among the possible tonal specifications in a system, 'no specification' – ∅ – must be considered.

As they stand, the tone-prominence constraints militate against tone. In fact, they predict that the best tone is no tone at all:

(66)

/σ/	*Δ/L	*Δ/M	*Δ/H
σ́⁺			x!
σ̄⁺		x!	
σ̀⁺	x!		
☞ σ⁺			

The only specification that does not violate any constraint is ∅. Since some languages are fully specified for tone, there must be a conflicting constraint that requires the presence of tone:

(67) μ→T "Moras (or more generally Tone Bearing Units) must bear tone."

μ→T has its precedent in the earliest work in autosegmental phonology – in the first clause of Goldsmith's (1976:27) Well-Formedness Condition, which requires every Tone Bearing Unit to be associated to a tone.

In a language where every mora bears tone, μ→T must outrank DEP-T. This ensures that underlyingly toneless moras can have a tone inserted to ensure full tonal specification.[37] The opposite ranking allows underlyingly ∅ specification to persist at the surface.

For the sake of simplicity, the typology of fully specified systems – where ||μ→T » FAITH-T|| – will be examined first. An additional complication is that the tone-prominence

[37] It cannot simply be assumed in Optimality Theory that every TBU in such languages has tone underlyingly, due to the principle of Richness of the Base (Prince & Smolensky 1993).

constraints consist of two independent sets of constraints: those on DTEs and those on non-DTEs. This predicts that the inventory of tones on DTEs is not determined by the inventory of non-DTEs. The DTE inventory will be examined first.

Predicted DTE inventories are presented in the following table:

(68) **DTE Inventories**

Ranking	**Δ Inventory**	**Examples**
1. FAITH-T » *Δ/T	H, M, and L	Mixtec languages
2. *Δ/L » FAITH-T	H and M only	Fuqing (Jiang-King 1996)
3. *Δ/L,M(,H) » FAITH-T	H only	Lithuanian, Serbo-Croatian (Inkelas & Zec 1988), Korean (Jun 1993, Kim 1997)

In the first type of language, faithfulness outranks all the *Δ/T constraints, ensuring that the full complement of tones – H, M, and L – can appear.[38] Examples of such systems are found in the Mixtec languages. In the second language type, the faithfulness constraint is ranked between *Δ/L and *Δ/M,H, so prohibiting low tone on DTEs. Fuqing is a language of this type: it allows only H and M tones on the DTEs of syllables. The third type of language is even more restrictive: it only allows high tone on DTEs. Lithuanian was identified as an example of this above.

This typology also makes predictions about which languages cannot exist. For example, no language can prevent DTEs from bearing high tones. Similarly, no language can ban mid tones from DTEs without also banning low tones.[39]

The tone-prominence constraints for non-DTEs can also interact with faithfulness constraints. A case of an inventory restriction on non-DTEs is found in Vedic Sanskrit: all high tones are neutralised to low tone on non-DTEs (Halle & Kiparsky 1977, Halle & Mohanan 1985:68ff, Halle & Vergnaud 1987:84, Hayes 1995:297):

(69) /màrút + é/ → [màrú$^{+}$tè], *[màrú$^{+}$té] 'wind'.

The elimination of high tones can be explained by ranking *-Δ_{PrWd}/H above IDENT-T:

(70)

	/màrút + é/	*-Δ_{PrWd}/H	IDENT-T
	màrú$^{+}$té	x!	
☞	màrú$^{+}$tè		x

The high-ranking *-Δ_{PrWd}/H eliminates high tones on non-DTEs, so forcing the high tone on /e/ to delete.

A table listing the predictions made for non-DTE inventories is given below:

38 By 'full complement' I do not mean to imply that tonal inventories can at most consist of three tones. 'H, M, and L' are taken here as a conveniently sized tonal inventory, but the generalizations made here apply equally to systems with more than three distinctions.

39 Of course, this statement must be qualified since there are languages with high and low tone yet do not have mid. See the final two paragraphs of this section for discussion.

(71) **Non-DTE Inventories**

Ranking	**-Δ Inventory**	**Examples**
1. FAITH-T » *-Δ/T	H, M, and L	Mixtec languages
2. *-Δ/H » FAITH	M and L only	–
3. *-Δ/L,M » FAITH	L only	Vedic Sanskrit, Fuqing

It remains to consider the cases where no tone – ∅ – is a permitted specification. This has been argued to be the case for many Bantu languages, for example. An underlying toneless specification can be permitted to surface by ranking FAITH-T above μ→T. Of more interest are the cases where tonelessness is required. For example, some analyses of Vedic Sanskrit assume that all non-DTEs bear no tone, not low tone. To achieve this result, the ranking ||*-Δ/T » μ→T|| must hold. This prohibits any tonal specification from appearing on non-DTEs.

One problematic result seems to be that ∅ tonal specification can be required on DTEs; the ranking ||*Δ/T » μ→T|| would produce this. Since the DTE and non-DTE constraints are independent, this predicts a language which allows tonal specifications on non-DTEs but requires ∅ on DTEs. It seems unlikely that such a language exists. One solution to this problem is to eliminate the constraint *Δ/H.[40] This proposal eliminates the possibility of languages that ban H on DTEs: it is impossible to exclude high-toned DTEs since there is no constraint against them:

(72)

	*Δ/L	*Δ/M
σ́⁺		
σ̄⁺		x!
σ̀⁺	x!	
σ⁺		

The second benefit has to do with tones and attraction to stress. If *Δ/H exists, stress could be forced to fall on an unspecified syllable in a tone-dependent stress system:

(73)

/páta/	*Δ/H	ALIGN-σ⁺-L
pá⁺ta	x!	
☞ páta⁺		

If *Δ/H is eliminated, though, the relative harmony of H and ∅ must be determined by other constraints such as *-Δ/H. With *-Δ/H low-ranked, a H-toned DTE is preferred over a toneless DTE:

[40] This proposal has parallels in proposals that the lowest constraint of the place hierarchy – *pharyngeal – also does not exist (Clements 1997).

(74)

/tapá/	*-Δ/H	ALIGN-σ⁺-L
ta⁺pá	x!	
☞ tapá⁺		x

This has the desirable result that high-toned DTEs are always more harmonic than toneless ones.

In summary, the *Δ/T and *-Δ/T constraints can interact with faithfulness constraints to produce a variety of tonal inventories. There is evidence, from systems that permit ∅ tonal specification, that *Δ/H should be eliminated as a constraint.

As a caveat, while the tone-prominence constraints can be used to account for a variety of tonal inventories, they are not the *only* inventory-defining constraints. An analogous situation is found with sonority constraints. According to Prince & Smolensky (1993), the following syllable nucleus constraints exist:

(75) ‖ … » *NUC/i,u » *NUC/e,o » *NUC/a ‖

These imply that /a/ is the most harmonic nucleus, /e/ and /o/ the next most harmonic, and /i/ and /u/ the next most harmonic. While these constraints can be used to restrict inventories, they cannot account for some languages. For example, Mari has only /i/, /a/, and /u/ as syllable nuclei (Holzknecht 1989). If only the nucleus-sonority constraints existed, such an inventory should be impossible since /i/ and /u/ are less harmonic nuclei than /e/ and /o/. In effect, the constraints imply that every language with /i/ or /u/ should also have /e/ and /o/. The fact that they do not shows that there are other constraints at work. For example, constraints banning mid vowels can outrank the nucleus-sonority constraints, hence eliminating /e/ and /o/ from the inventory and retaining /i u a/.

The same situation holds in tonal inventories. The tone-prominence constraints predict that if a language allows low tone on DTEs it should also allow mid tone. This follows from the ranking ‖FAITH-T » *Δ/L » *Δ/M » *Δ/H‖. However, there are many languages that only contrast low and high tone, and have no mid tone. In these cases, entirely different constraints – e.g. *M – must be responsible for the failure of mid-tone to appear.[41,42]

However, by no means does this imply that *any* constraint is possible. For the tone-prominence constraints to have any predictive power at all, there can be no contradictory constraints. For example, a freely rankable constraint such as *Δ/H cannot exist since this directly contradicts the typological predictions of the tone-prominence constraints, banning high tone on DTEs. Similarly, ALIGN(L, Δ_{PrWd}) requires a low tone to be associated to the DTE of a PrWd. This contradicts the tone-prominence constraints: if

[41] It is not the concern of this paper to delve into the exact constraints that should be used to achieve this difference. For work relating to inventories and context-free markedness constraints see, for example, Kirchner (1997) and Smolensky (1995).

[42] The propensity for types of tone to resist or undergo change is another faithfulness-related issue. Some tones – such as M – tend to be particularly prone to change. If ‘change’ is seen as a reduction in markedness, it is to be expected that tones would tend to neutralize to H on DTEs and to L on non-DTEs. Mid tone, then, would give the impression of being the least stable since it is not most harmonic on either DTEs or non-DTEs. I leave this issue for further research.

it were allowed in the grammar, low-toned DTEs could be preferred over high-toned ones. For example, the ranking ||ALIGN(L, Δ_{PrWd}) » IDENT-T|| would effectively restrict the tonal inventory on a DTE to low tone. If the tone-prominence constraints are to have any predictive effect, they must not be contradicted by other constraints.[43] This condition rules out a large number of constraints that refer to the relation between tone and prominence. In fact, the most restrictive hypothesis at this point would be that the Atomistic constraints presented here are the *only* constraints that refer to the tone-prominence relation.

7 Typology of Prominence

The purpose of this section is to examine the predictions made by the Atomistic theory about which tones and tone sequences will always be more harmonic than others and which will be variably ranked.

The most obvious prediction made by the Atomistic theory is that higher tone is attracted to DTEs and lower tone to non-DTEs. Of course, this does not ensure that every DTE at every level will always attract higher tone (or that non-DTEs will always attract lower tone). If a constraint *-Δ_α/T outranks *Δ_β/T where α is higher than β in the prosodic hierarchy, then the effect of *Δ_β/T is effectively nullified. This is illustrated in the following tableau: *-Δ_{PrWd}/H bans high tone on the non-DTEs of PrWds, but *Δ_σ/L bans low tone on syllable DTEs. With the former constraint ranked over the latter, though, every Δ_σ except for the Δ_{PrWd} ends up with low tone:

(76)

/pataka/	*-Δ_{PrWd}/H	*Δ_σ/L
☞ a) pá$^+$.tà.kà		x x
b) pá$^+$.tá.ká	x x !	

Candidate (a) violates *Δ_σ/L since the syllable DTEs in [ta] and [ka] are low-toned. However, [ta] and [ka] also contain non-DTEs of the PrWd, hence they satisfy the higher constraint. Candidate (b) fares worse since there is high tone on the PrWd non-DTEs [ta] and [ka].

The predictions made by the theory are more complex for tone sequences. The most harmonic tone sequence consists of a high tone on a DTE and a low tone on all non-DTEs. This predicts that if *any* tonal sequence within a constituent α is permitted, it will be $[(L_0)H^+(L_0)]$. This is because this sequence violates the tone-prominence constraints the least in every possible permutation of ranking: a high tone appears on the DTE of α, and low tones on the non-DTEs. In comparison, $[(H_0)L^+(H_0)]_\alpha$ is the most disharmonic sequence. Other possible sequences are arrayed between these two extremes.

---

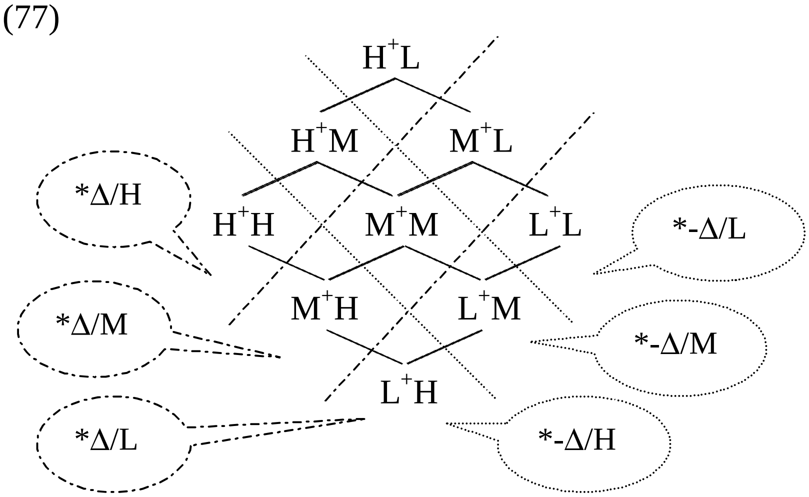
[43] This does not apply to morphemic tones: tones that are the exponents of some morpheme, as in intonational melodies (Pierrehumbert 1980 et seq). Constraints requiring such morphemic tones to appear on DTEs can force low tone to appear on a DTE if it is the exponent of that morpheme, even when there is an otherwise general ban on such a situation. For an example of such a case, see de Lacy (1998).

As discussed in previous sections, there are two types of harmonic ranking: fixed and variable. A fixed ranking is one that never changes no matter how constraint ranking is permuted. For example, no matter how constraints are reranked, $H^{+}L$ will always be the most harmonic sequence. Hence, $H^{+}L$ is in a fixed ranking with every other sequence. Similarly, $L^{+}H$ will always be the least harmonic, so it is in a fixed ranking with every other tone sequence outranking it.

There are a number of other fixed rankings, shown in the following lattice. This structure was constructed by altering the ranking of the DTE and non-DTE series of constraints in every possible way. This structure has no theoretical status; it is simply a convenient way to represent the results of permuting the rankings of the tone-prominence constraints.

The order of tones is not significant: $H^{+}L$ stands for $[L_0H^{+}L_0]$ (i.e. $[H^{+}L]$, $[LH^{+}]$, or $[L\ldots H^{+}L\ldots]$):

(77)



This lattice should be read from top to bottom in terms of ranking. Fixed rankings are shown by the lines connecting the tone sequences. For example, the sequence $M^{+}L$ is always more harmonic than $L^{+}L$, and $M^{+}L$ is always more harmonic than $L^{+}M$ (by transitivity, since $L^{+}L$ is more harmonic than $L^{+}M$). In comparison, the ranking between $H^{+}M$ and $M^{+}L$ is not fixed: their relative harmony can vary depending on constraint ranking. This is shown by the fact that there is no direct line linking $H^{+}M$ and $M^{+}L$. Depending on how the lattice is 'cut', their ranking may vary. This is discussed further below.

Every sequence above or below a diagonal line can be conflated. For example, the diagonal line running above $L^{+}H$, $L^{+}M$, and $L^{+}L$ indicates that (1) these sequences can be conflated (by the constraint *Δ/L), (2) every sequence to the left of the line can also be conflated by the same constraint, and (3) these latter sequences are more harmonic than the former ones.

More complex conflations are also represented. For example, if two intersecting diagonal lines are chosen, the sequences in the areas described by them can be conflated. For example, the two topmost diagonal lines intersect below $H^{+}L$, placing it in an area on its own. This indicates that it can form a category on its own (defined by $*\Delta/L$, $*\Delta/M$, $*\text{-}\Delta/H$, and $*\text{-}\Delta/M$).

As a word of caution, this lattice only presents categories defined in terms of the tone-prominence constraints. As shown in the Mixtec languages, other constraints, like the OCP, can also affect categories. The OCP, for example, bans all sequences of like elements: HH, MM, LL. The ranking of the OCP can affect the relative ranking of level tone sequences and rising sequences. With the OCP outranking all tone-prominence constraints, rising sequences will be preferred over level ones.[44] With the OCP ranked elsewhere, a variety of other effects can result (as shown for the Mixtec languages).

This concludes the examination of the predictive power of the tone-prominence constraints. In summary, the tone-prominence constraints instantiate a number of fixed rankings between tone sequences, but allow variability between others. They also provide evidence about which constraints cannot exist in Universal Grammar.

8 Conclusions

The aim of this paper was to present and argue for a set of constraints that regulate the interaction between tone and metrical prominence:

(78) (i) $\| *\Delta_\alpha/L \gg *\Delta_\alpha/M \gg *\Delta_\alpha/H \|$
(ii) $\| *\text{-}\Delta_\alpha/H \gg *\text{-}\Delta_\alpha/M \gg *\text{-}\Delta_\alpha/L \|$

A number of empirical claims are embodied in the constraints:

- There is a hierarchy of tonal preference, ranging from higher tone to lower tone.
- Higher tone and DTEs mutually attract each other.
- Lower tone and non-DTEs mutually attract each other.
- These attractions are evident at every prosodic level.

Central to the demonstration of the validity of these claims were the Mixtec languages Ayutla, Molinos, and Huajuapan (Cacaloxtepec).

As a concluding comment, the relation between tone and metrical prominence is not a unique phenomenon: elements such as sonorous segments, long vowels, and syllables with codas can also attract prominence (Hayes 1995, de Lacy 1997). Tone is just one of a number of elements that interacts with prominence. Because of this, the theoretical findings in this paper can be extended to other domains: the conditions of Categorisation, Harmony, and Conflation also apply to other prominence interactions. The interaction of tone and prominence, then, provides a window into the workings of a broader phenomenon – the role of prominence in phonology.

[44] This is borne out in languages that only have contour tones on bimoraic syllables (see Cheng 1973).

Paul de Lacy

<delacy@linguist.umass.edu>
http://www-unix.oit.umass.edu/~delacy

Linguistics Dept
South College
University of Massachusetts
Amherst, MA 01003
USA

References

Aissen, Judith. 1998. "Markedness and Subject Choice in Optimality Theory." ms. University of California, Santa Cruz.

Anttila, A. 1995. "Deriving variation from grammar: A study of Finnish genitives." ms. Stanford University. Rutgers Optimality Archive #63.

Anttila, Arto & Adams Bodomo. 1996. "Stress and Tone in Dagaare." Rutgers Optimality Archive #169.

Artstein, Ron. 1998. "Hierarchies." ms. Rutgers University.

Babić, Zrinka. 1988. "Accent Systems in Croatian Dialects." in van der Hulst & Smith (1988:1-10).

Baker, Brett. 1997. "Edge-Crispness Effects in Moraic Structure," *BLS* 23.

Bamba, Mossa. 1991. *De l'interaction entre tons et accent*. Doctoral dissertation, Université du Quebec à Montréal.

Bauer, W. 1981. "Hae.re vs. ha.e.re: A Note." *Te Reo* 24: 31-36.

Bauer, W. 1993. *Maori*. London, New York: Routledge.

Beckman, Jill. 1998. *Positional Faithfulness*. Doctoral dissertation, University of Massachusetts, Amherst.

Beckman, Mary & Janet Pierrehumbert. 1986. "Intonational Structure in English and Japanese." *Phonology* 3: 255-309.

Bickmore, Lee. 1995. "Tone and stress in Lamba." *Phonology* 12: 307-342.

Biggs, B. 1961. "The Structure of New Zealand Maaori." *Anthropological Linguistics* 3: 1-52.

Blevins, Juliette. 1993. "A tonal analysis of Lithuanian nominal accent." *Language* 69: 237-273.

Bradley, C.Henry. 1970. "A Linguistic Sketch of Jicaltepec Mixtec." SIL Publications.

Bunn, Gordon & Ruth Bunn. 1970. "Golin Phonology." *Pacific Linguistics A23: Papers in New Guinea Linguistics No.11*, pp.1-7.

Casali, Roderic. 1996. *Resolving Hiatus.* Doctoral dissertation, UCLA.

Cheng, Chin-chuan. 1973. "A Quantitative Study of Chinese Tones." *Journal of Chinese Linguistics* 1.1:93-110.

Churchward, C. Maxwell. 1951. *A Samoan Grammar*. Melbourne: Spectator Publishing Co.

Clements, G.N. 1990. "The role of the sonority cycle in core syllabification." in J.Kingston & M.E.Beckman (eds) *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*. London: Cambridge University Press.

Clements, G.N. 1997. "Berber Syllabification: Derivations or Constraints?" in Iggy Roca (ed) *Derivations and Constraints in Phonology*. Oxford: Clarendon Press. pp.289-330.

Clements, G.N & John Goldsmith (eds). 1984. *Autosegmental Studies in Bantu Tone*. Dordrecht: Foris Publications.

Crowhurst, Megan J. 1996. "An Optimal Alternative to Conflation." *Phonology* 13:409-424.

de Lacy, Paul. 1997. *Prosodic Categorisation*. MA Thesis, University of Auckland. [Rutgers Optimality Archive #236].

de Lacy, Paul. 1998. "Higher Prosody in Maori." ms. University of Massachusetts, Amherst.

Dell, François and Mohamed Elmedlaoui. 1985. "Syllabic Consonants and Syllabification in Imdlawn Tashlhiyt Berber." *Journal of African Languages and Linguistics* 7: 105-130.

Dell, François and Mohamed Elmedlaoui. 1988. "Syllabic Consonants in Berber: Some New Evidence." *Journal of African Languages and Linguistics* 10: 1-17.

Dell, François and Mohamed Elmedlaoui. 1992. "Quantitative Transfer in the Nonconcatenative Morphology of Imdlawn Tashlhiyt Berber." *Journal of Afro-Asiatic Languages* 3: 89-125.

Downing, Laura J. 1990. "Local and Metrical Tone Shift in Nguni." *Studies in African Linguistics* 21: 261-317.

Gerfen, Henry James. 1996. "Topics in the Phonology and Phonetics of Coatzospan Mixtec." Doctoral dissertation, University of Arizona.

Goldsmith, John. 1976. *Autosegmental Phonology*. Doctoral Dissertation, Massachusetts Institute of Technology.

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 van der Hulst & Smith (1988:81-93).

Goldsmith, John. 1992. "Tone and accent in Llogoori." in D.Brentari, G.Larson, L.MacLeod (eds) *The Joy of Syntax*. Philadelphia: John Benjamins. pp.7-94.

Goldsmith, John (ed.) 1995. *The Handbook of Phonological Theory*. Cambridge, MA: Blackwell Publishers.

Gordon, Matt. 1997. "Conflicted Weight Criteria and the Theory of Syllable Weight," ms., University of California at Los Angeles [To appear in *UCLA Working Papers in Phonology 3*].

Halle, Morris & Paul Kiparsky. 1977. "Towards a Reconstruction of the Indo-European Accent." in Larry Hyman (ed) *Studies in Stress and Accent.* Southern California Occasional Papers in Linguistics 4: 209-238.

Halle, Morris & Paul Kiparsky. 1981. "Review Article: Garde: Histoire de l'accentuation slave." *Language* 57: 150-181.

Halle, Morris & K.P.Mohanan. 1985. "Segmental Phonology of Modern English." *Linguistic Inquiry* 16: 57-116.

Halle, Morris & Jean-Roger Vergnaud. 1987. *An Essay on Stress*. Cambridge: MIT Press.

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

Hayes, Bruce. 1995. *Metrical Stress Theory: Principles and Case Studies*. Chicago: Chicago University Press.

Hewitt, Mark and Megan Crowhurst. 1995. "Conjunctive constraints and templates in Optimality Theory." ms. University of British Columbia and University of North Carolina.

Hohepa, P. 1967. *A Profile Generative Grammar of Maori*. Bloomington: Indiana University.

Holzknecht, S. 1989. *The Markham languages of Papua New Guinea*. Canberra: Department of Linguistics, Australian National University.

Hulst, Harry van der and Norval Smith (eds). 1988. *Autosegmental Studies on Pitch Accent*. Dordrecht, Holland: Foris Publications.

Huisman, Ronald & Joy Lloyd. 1981. "Angaatiha Tone, Stress, and Length." in Phyllis M. Healey (ed.) *Angan Languages Are Different: Four Phonologies.* Huntington Beach, CA: SIL, pp.63-82.

Hunter, Georgia G. and Eunice V. Pike. 1969. "The Phonology and Tone Sandhi of Molinos Mixtec." *Linguistics* 47:24-40.

Huttar, George L. & Mary Huttar. 1972. "Notes on Dyuka Phonology" in Joseph E. Grimes (ed.) *Languages of the Guianas*. Oklahoma: SIL Publications. pp.1-11.

Huttar, George L. & Mary L.Huttar. 1994. *Ndyuka*. Routledge Descriptive Grammars. London: Routledge.

Inkelas, Sharon & Draga Zec. 1988. "Serbo-Croatian Pitch Accent." *Language* 64.2:227-248.

Inkelas, Sharon & Draga Zec (eds) 1990. *The Phonology-Syntax Connection*. Chicago: Chicago University Press.

Ito, J. and A. Mester. 1992. "Weak Layering and Word Binarity." University of California at Santa Cruz.

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*. Doctoral dissertation, University of British Columbia. Rutgers Optimality Archive #266.

Jiang-King, Ping. 1999. "Sonority Constraints on Tonal Patterns." WCCFL 17, pp. 332-346.

Jun, Sun-Ah. 1993. *The Phonetics and Phonology of Korean Prosody*. Doctoral Dissertation, OSU.

Kalstrom, Marjorie R. and Eunice V.Pike. 1968. "Stress in the Phonological System of Eastern Popoloca." *Phonetica* 18: 16-30.

Kenstowicz, Michael. 1996. "Sonority-Sensitive Stress." Rutgers Optimality Archive #33.

Kenstowicz, Michael & Charles Kisseberth. 1990. "Chizigula Tonology: the Word and Beyond." in Inkelas & Zec (1990:163-194).

Kim, No-Ju. 1997. *Tone, Segments, and their Interaction in North Kyungsang Korean: A Correspondence Theoretic Account.* Doctoral dissertation, Ohio State University.

Kirchner, Robert. 1997. "Contrastiveness and Faithfulness." *Phonology* 14: 83-111.

Kisseberth, Charles. 1984. "Digo Tonology." in Clements & Goldsmith (1984:105-182).

Larsen, R. S. and E. V. Pike. 1949. "Huasteco intonations and phonemes." *Language* 25: 268-277.

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

Liberman, M. 1975. *The Intonational System of English*. Cambridge: MIT Press..

Liberman, M. & Alan Prince. 1977. "On Stress and Linguistic Rhythm." *Linguistic Inquiry* 8: 249-336.

Lubowicz, Ania. 1997. "Phrasal Tonology in Digo." ms. University of Massachusetts, Amherst.

Maddieson, Ian. 1978. "Universals of Tone." in Joseph H.Greenberg et al. *Universals of Human Languages*, Vol.2. Stanford: Stanford University Press.

Massamba, David. 1984. "Tone and Accent in Ci-Ruri." in Clements & Goldsmith (1982:235-254).

McCarthy, John. 1986. "OCP Effects: Gemination and antigemination." *Linguistic Inquiry* 17: 207-263.

McCarthy, John & Alan Prince. 1993. *Generalised Alignment.* in G.Booij & J.van Maarle. (eds) *The Yearbook of Morphology 1993*. Kluwer Academic Publishers.

McCarthy, J. J. and A. S. Prince. 1995. "Faithfulness and Reduplicative Identity." in J. Beckman, S. Urbanczyk and L. Walsh Dickey (eds). *University of Massachusetts Occasional Papers in Linguistics UMOP 18*. Amherst, MA, GLSA, pp. 249-384.

Meredith, Scott. 1990. *Issues in the Phonology of Prominence*. Doctoral dissertation, MIT.

Myers, Scott. 1997. "OCP Effects in Optimality Theory." *NLLT* 15: 847-892.

Nespor, Marina & Irene Vogel. 1986. *Prosodic Phonology*. Studies in Generative Grammar 28. Dordrecht: Foris Publications.

North, Joanne and Jana Shields. 1977. "Silacayoapan Mixtec Phonology." in William Merrifield (ed) *Studies in Otomanguean Phonology*. Dallas: SIL and University of Texas, Arlington. pp.21-33. SIL and the University of Oklahoma.

Odden, David. 1990. "Tone in the Makonde Dialects: Chimaraba." *Studies in African Linguistics* 21.1:61-106.

Odden, David. 1995. "Tone: African Languages." in Goldsmith (1995:444-475).

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*, University of Texas Press, Austin, pp. 161-184.

Peterson, Karen. 1987. "Accent in the Chichewa Verb." *CLS* 23:210-222.

Pierrehumbert, Janet. 1980. "The Phonology and Phonetics of English Intonation." Doctoral dissertation, MIT.

Pierrehumbert, Janet & Mary Beckman. 1988. *Japanese Tone Structure*. LI Monograph 15.

Pike, Eunice & John H.Cowan. 1967. "Huajuapan Mixtec Phonology and Morphophonemics." *Anthropological Linguistics* 9.4: 1-15.

Pike, Eunice & Joy Oram. 1976. "Stress and Tone in the Phonology of Diuxi Mixtec." *Phonetica 33:321-333*.

Prince, Alan. 1998. "Two Lectures on Optimality Theory, Kobe 1998." ms. Rutgers University.

Prince, Alan and Paul Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. Rutgers Technical Report #2.

Rice, Keren D. 1987. "Metrical Structure in a Tone Language: The Foot in Slave (Athapaskan)." *CLS* 23:239-252.

Rountree, S.Catherine. 1972. "The Phonological Structure of Stems in Saramaccan." in Joseph E. Grimes (ed.) *Languages of the Guianas*. Oklahoma: SIL Publications. pp.22-34.

Selkirk, Elisabeth. 1984. *Phonology and Syntax: The Relation between Sound and Structure*. Cambridge: MIT Press.

Selkirk, Elisabeth. 1995. "The prosodic structure of function words." in J. Beckman, L. Walsh Dickey and S. Urbanczyk (ed.) *Papers in Optimality Theory*. Amherst, MA: GLSA, pp. 439-470.

Senn, Alfred. 1966. *Handbuch der litauischen Sprache*. Heidelberg: Carl Einter Universitätsbuchhandlung.

Sietsema, Brian. 1989. *Metrical Dependencies in Tone Assignment*. Doctoral dissertation, MIT.

Sievers, E. 1901. *Grundzüge der phonetik, zur einführung in das studium der lautlehre der indogermanischen sprachen*. Leipzig: Breitkopf & Härtel.

Smolensky, Paul. 1993. "Harmony, Markedness, and Phonological Activity." Rutgers Optimality Workshop 1. Rutgers Optimality Archive #87.

Smolensky, Paul. 1995. "On the Internal Structure of the Constraint Component *Con* of UG." Talk presented at UCLA, April 7, 1995. Rutgers Optimality Archive #86.

Stark, Sharon and Polly Machin. 1977. "Stress and Tone in Tlacoyalco Popoloca." in William R.Merrifield. (ed.) *Studies in Otomanguean Phonology*. Summer Institute of Linguistics & the University of Texas at Arlington, pp. 69-92.

Steriade, Donca. 1988. "Reduplication and syllable transfer in Sanskrit and elsewhere." *Phonology* **5**: 73-155.

Thompson, Henry. 1976. "A Phonology of Kuuku-Yaʔu." in Peter Sutton (ed) *Languages of Cape York*. Canberra: Australian Institute of Aboriginal Studies. pp.213-235.

Tranel, Bernard. 1991. "CVC light syllables, geminates and moraic theory," *Phonology* 8: 291-302.

Tranel, Bernard. 1996. "Rules *vs* Constraints: A Case Study." in Jacques Durand & Bernard Laks (eds) *Current Trends in Phonology: Models and Methods*. European Studies Research Institute, University of Salford Publications.

Tuttle, Siri. 1998. *Metrical and Tonal Structures in Tanana Athabaskan.* Doctoral dissertation, University of Washington.

Walker, Rachel. 1996. "Prominence-Driven Stress." Rutgers Optimality Archive #172.

Welmers, William W. 1962. "The Phonology of Kpelle." *Journal of African Languages* 1.1:69-80.

Wilson, Stephen A. 1967. "The development of tone in Heiltsuq." BLS 13: 321-329.

Woo, Nancy. 1969. *Prosody and Phonology*. Doctoral dissertation, MIT.

Yip, Moira. 1981. "The interaction of tone and stress in Molinos Mixtec." ms. MIT.

Yip, Moira. 1988. "The Obligatory Contour Principle and phonological rules: A loss of identity." *Linguistic Inquiry* 19: 65–100.

Yip, Moira. 1995. "Tone in East Asian Languages." in Goldsmith (1995:476-494).

Zec, Draga. 1988. *Sonority Constraints on Prosodic Structure*. Doctoral dissertation, Stanford University.

Zec, Draga. 1994. "Footed Tones and Tonal Feet: Rhythmic Constituency in a Pitch Accent Language." ms. Cornell University.

Zoll, Cheryl. 1997. "Conflicting Directionality." *Phonology* 14:263-286.

Appendix – Data

The forms below are taken from Pankratz & Pike (1967) for Ayutla, Pike & Cowan (1967) for Huajuapan, and Hunter and Pike (1969) for Molinos. The aim of presenting these form is to provide empirical justification for the stress descriptions of stress cited in these works.

The tables have four columns. The first contains a schematic representation of the form in terms of its tones. The second column states what the form shows. For example, in the first form in Ayutla, the form shows that it is the leftmost HL sequence that receives stress. In the second form, the form shows that it is preferential to stress an HL sequence than the leftmost H. Most of the data is devoted to showing the hierarchies of tone sequences invoked in the descriptions.

In some cases, a form necessary to show a hierarchical relation between sequences was not cited in the sources. For example, it is claimed in Huajuapan that the leftmost HL sequence attracts stress, but there are no HLHL sequences to show this. Similarly, HL and ML are claimed to be treated alike in Huajuapan, but the form that would show this – MLHL – is not present. In some cases, the ranking can be deduced by transitivity. For example, in Ayutla there is no form MLHL, so the claimed ranking between HL and ML cannot be checked. However, there is proof that HL > H and H > ML, so by transitivity HL > ML.

The reader is referred to the sources for further examples of the following data.

- <u>Ayutla</u>

1. Stress the leftmost H-toned syllable followed by a L-toned syllable.
2. else stress the leftmost H-toned syllable.
3. else stress the leftmost M-toned syllable followed by a L-toned syllable.
4. else stress the initial syllable.

Sequence	Demonstrates	Form	Gloss
H$^+$LHL	Leftmost HL	šá$^+$àšíìʔ	is not eating
HH$^+$L	HL > H	lúlú$^+$rà	he is small
MLH$^+$	H > ML	kūnùrá$^+$	his tobacco
MM$^+$L	ML > MM	lāšā$^+$rà	is small
LM$^+$L	ML > MM	tìkā$^+$čè	whirlwind
M$^+$MM	else leftmost	šĩñūrā	is small
L$^+$LL	else leftmost	šà$^+$tùì	my trousers

- <u>Huajuapan</u>

Sequence	Demonstrates	Form	Gloss
H$^+$LHL	Leftmost HL	*no data*	
M$^+$LHL	ML=HL	*no data*	
HH$^+$L	HL > H	sádí$^+$nà	he/she/they (known) are closing (it)
M$^+$LH	ML > H	ñā$^+$nìní	your (sg, adult) brother

MM^{+}L	ML > MM	nì-sōʔnī$^{+}$nà	he/she/they (known) tied (it)
LM^{+}L	ML > MM	kìđi^{+}sì	my jug
H^{+}HH	else leftmost	sá$^{+}$díní	you (sg, adult) are closing it
M^{+}MM	else leftmost	nì-kē$^{+}$ʔē^{n}dō	you (pl) teased (someone)
L^{+}LL	else leftmost	sò$^{+}$ʔò^{n}dò	will notify

- <u>Molinos</u>

Sequence	Demonstrates	Form	Gloss
HMH^{+}L	Rightmost HL/HM	sī-kúčīsá̜$^{+}$tì	I will bathe the animal
H^{+}MML	HL > ML	kā-ndí$^{+}$hādēžà	he will obey God
MLM^{+}L	Rightmost ML	k^{w}īnìdē$^{+}$tì	he will see the animal
M^{+}MH	else leftmost	kī$^{+}$tīnī	your animal
L^{+}LL	else leftmost	žù$^{+}$kùlì	my herbs
L^{+}MH	else leftmost	kú-vì̜$^{+}$hī̜sá̜	I am cold

APPENDIX – Comments on Tone and Prominence

This section contains a couple of random comments on aspects of tone-prominence interaction that I was unable to incorporate into this paper (because they are slightly tangential to the main theme). The questions arose from comments or questions that I have been asked about the paper, hence the question and answer style of the following paragraphs.

A1. Positive Constraints Again

Q: You have posed an objection to positive constraints because they fail to conflate categories (§3.2.1.1). Are there any other general properties of positive constraints that produce unwanted results in other areas (e.g. inventory restrictions)?
A: Yes. There is quite a fundamental difference in the predictions made by positive and negative constraints. For positive constraints "more is better", while for negative constraints "less is better". I'll give an abstract characterisation of this difference, and then show how it applies to tone.

Suppose there are two positive constraints α→*x* and α→*y*. Which structure will best satisfy these constraints?:

(79)

	α→*x*	α→*y*
α │ *x*		x!
α │ *y*	x!	
☞ α ╱╲ *x* *y*		

So, "more is better". Negative constraints are fundamentally different. Negative constraints militate against structure, so less is better (in fact, nothing at all is optimal):

(80)

	*α/*x*	*α/*y*
☞ α | *x*	x	
☞ α | *y*		x
α ╱╲ *x* *y*	x	x

This has quite significant effects for inventories. For example, take a system that permits 'true' contour tones: i.e. systems where two tones can be associated to to one mora. If the ranking $\|\Delta_\sigma \rightarrow H \gg \Delta_\sigma \rightarrow M \gg$ FAITH-T$\|$ obtains, this predicts that every syllable must have an HM contour:

(81)

	$\Delta_\sigma \rightarrow$H	$\Delta_\sigma \rightarrow$M	FAITH-T
σ́		x!	
σ̄	x!		
☞ σ̂			

This result is undesirable. It means that true contour tones can be the *only* tones in a language, and that level tones are excluded. There are no languages like this, to my knowledge (see Cheng 1973). The 'more is better' property is a general problem with positive constraints.

A2. Tone Features

Q: You mentioned in a footnote (fn.17) that tone features could be used to avoid some of the problems positive constraints posed. Can tone features help with every problem: conflation, categorisation, etc.?
A: As I pointed out in section 4, there are two ways to get conflation: by ranking, or by the nature of the constraints used. Certainly, tone features can conflate more easily than using H, M, and L as primitive units. This is because tone features cross-classify between H, M, and L. This cross-classification allows the constraints to do more of the work of categorisation.

However, the same problems are encountered using tone features as using H, M, and L. The reason for this is that some categorisation has to be achieved by constraint ranking (or by the influence of other constraints, like the OCP). If the Mixtec languages are analysed with tone features, you find that they get the same results as using H/M/L, but problems arise when faced with the conflation of the ‘lighter’ categories of feet, just as they arose with H/M/L (see §3.2.3). This is because constraint form cannot do all conflation. There are some fundamental distinctions that must be made between constraints (e.g. some refer to DTEs, others to non-DTEs), and these differences inherently militate against conflation. This is not to say that using tone features with finer distinctions than H/M/L is a bad thing – of course not. However, using fine-grained tone features will not solve every problem.