The Representation of Tone

Larry M. Hyman
University of California, Berkeley

Submitted to Marc van Oostendorp, Colin Ewen, Elizabeth Hume, and Keren Rice (eds.),
The Blackwell Companion to Phonology • April 2009

1. Introduction

No issue has had a greater impact on phonological representations than the study of tone. Although receiving only passing attention in both pre- and early generative phonology, tone quickly moved out of its marginal status to occupy center stage leading to the development of non-linear phonology. While both level and contour tones had been traditionally transcribed with either accents or numerals, as in (1) and (2),

(1)

	Awa		Falam		Obokuitai	
H(igh)	ná	'breast'	páa	'mushroom'	kuik^{1}	'rock'
L(ow)	nà	'house'	kèe	'leg'	kuik^{2}	'insect' (sp.)
HL (falling)	nâ	'taro'	sâa	'animal'	kuik^{12}	'lizard' (sp.)
LH (rising)	pă	'fish'	zŭu	'bear'		
	(Loving 1966:25)		(pers. notes)		(Jenison & Jenison 1991:85)	

(2)

	Jingpho			Ayutla Mixtec	
H	mu̱^{55}	'word'	H-H	ši^{1}ñuʔ^{1}	'pineapple'
M(id)	mu^{33}	'delicious'	H-L	ši^{1}niʔ^{3}	'hat'
L	mu^{31}	'to see'	M-L	ši^{2}niʔ^{3}	'head'
HL	nu^{51}	'mother'	L-L	ti^{3}kuʔ^{3}	'louse'
(Qingxia & Diehl 2003:401)			(Pankratz & Pike 1967:291)		

the assumption in early generative phonology was that tones consisted of features which could be added at the bottom a segmental (e.g. vowel) feature matrix, as in (3).

(3) a. H tone /á/

$$\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ +\text{back} \\ +\text{low} \\ +\text{HIGH} \end{bmatrix}$$

b. HL falling tone /â/

$$\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ +\text{back} \\ +\text{low} \\ +\text{FALLING} \end{bmatrix}$$

A major representational problem was how to account for the properties of contour tones. Although falling and rising tones could be expressed by combining accents (â, ă) or numerals (31, 13 etc.), features such as [±FALLING] and [±RISING] fail to capture what is known as "edge effects": a high to low falling tone acts like a H(igh) tone with respect to what precedes, but as a L(ow) tone with respect to what follows. Similarly, a low to high rising tone acts like a L tone

with respect to what precedes, but as a H tone with respect to what follows. Representations such as in (4), which were occasionally entertained, would simply be incoherent in a framework in which a segment consists of a single vertical matrix of features:

(4) a. Falling tone /â/

$$\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ +\text{back} \\ +\text{low} \\ [+\text{HIGH}]\ [+\text{LOW}] \end{bmatrix}$$

b. Rising tone /ǎ/

$$\begin{bmatrix} +\text{syll} \\ -\text{cons} \\ +\text{back} \\ +\text{low} \\ [+\text{LOW}][+\text{HIGH}] \end{bmatrix}$$

In order to solve this and other representational problems, Goldsmith (1976a,b) proposed a theory of "autosegmental" phonology in which segments and tones appear on separate "tiers", as in (5).

(5) Autosegmental representations of H, L, HL, LH

a. level tones

```
a   a
|   |
H   L
```

b. contour tones

```
a   a
/\  /\
HL  LH
```

By so doing, Goldsmith was able to capture the traditional intuitions implicit in the accent and numeral notations and make predictions about what should vs. should not be found in tone systems. Armed with the autosegmental framework, enormous strides were made in the analysis of tone as well as in other applications of the framework, e.g. segmental harmonies (Clements 1977, 1981, Hoberman 1988), feature geometry (Clements 1985, Clements & Hume 1995), and prosodic morphology (McCarthy 1981; McCarthy & Prince 1986).

The main question to be addressed in this chapter is the extent to which the key insight of autosegmental phonology, expressed in (6), is still valid:

(6) Tones are semi-autonomous from their tone-bearing units (TBUs)
  a. tones are on a separate tier, but
  b. they are linked to their TBUs by association lines

The chapter is organized as follows: In §2 we consider some of the predictions of autosegmental tonology in order to see how they have fared over the past 30+ years. In §3 I consider the issue of underspecification, while §4 addresses the issues of tone features, tonal geometry, and tone-bearing units. §5 considers potential limitations of autosegmental representations, while §6 concludes the chapter with a brief consideration of tone in constraint-based phonology. We will see that there is much reason to hold on to the autosegmental insight even as phonological frameworks have evolved.

2. Autosegmental tonology

One can distinguish two consequences of autosegmental phonology, as applied to tone: Those which follow directly from the architecture vs. those which involve additional principles or conventions. We take up the first of these here and postpone discussion of the second until §5.

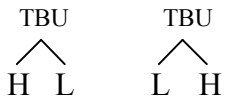
There are at least three direct consequences of the two-tier autosegmental architecture proposed by Goldsmith, as in (7).

(7) a. non-isomorphism between the tiers
b. zero representation on one vs. the other tier
c. stability effects

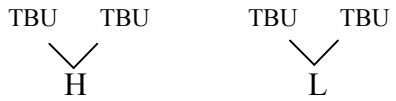
2.1. Non-isomorphism

Using TBU to represent the tone-bearing unit to which tones link (see §4), the first of these is schematized in (8).

(8) a.



b.



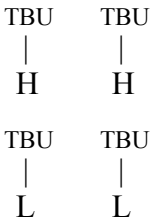
We have already seen that more than one tone can link to a single TBU, resulting in falling and rising contour tones as in (8a). Complex contours are also attested, as exemplified in (9).

(9)	a.	falling-rising:	Iau	be^{243}	'tree fern'	ba^{243}	'sticking to'	(Bateman 1990)
	b.	rising-falling:	Nzadi	mwa̰ːn	'child'	dzĩ	'eye'	(personal notes)

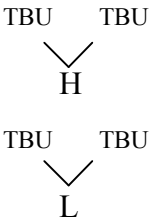
In addition, Lomongo is said to have LHLH on one syllable derived from elision (Hulstaert 1961:164): /èmí là wɛ̌ bǎsàngì/ → *èm'â w'ǎːsàngì* 'it's you and I who are related'.

The second type of non-isomorphism in (8b) shows that the same tone can link to more than one TBU. What this means is that there is a potential contrast between the representations in (10a) vs. those in (10b).

(10) a.



b.



The representations in (10a) were originally thought to be prohibited by the obligatory contour principle (OCP), which disallows successive identical features on the same tier. However, the contrasts in (10) are clearly needed. Typically, the one-to-one representations in (10a) occur when the tones belong to different morphemes (ultimately, words), while those in (10b) are expected when the H-H or L-L sequence occurs tautomorphemically. This makes sense if one considers that morphemes are spelled out separately, such that they may be concatenated with other morphemes carrying identical tones. Examples follow.

As reported by Paulian (1975), Kukuya noun stems are limited to five shapes (CV, CVV, CVCV, CVVCV, CVCVCV) and four tonal "melodies": /H, L, HL, LH/. (A fifth melody, /LHL/, occurs only on polymorphemic verb stems.) When a /H/ noun stem consists of more than one TBU, the H is multiply linked, producing representations such as in (11).

(11) a. (mà-) bágá 'show knives' b. (lì-) bálágá 'fence'

H H

Now consider the two words *má-bá* 'they are oil palms' and *wátá* 'bell'. The first consists of a /H/ copular tone assigned to the toneless prefix /ma-/ followed by a /H/ stem, while the latter lacks a prefix and instead has a single /H/ linked to both TBU's of the stem. The two words are pronounced identically as H-H in medial position, as in (12a), but not in prepausal position in (12b), where there is a lowering to M(id) tone:

(12) a. Medial b. Prepausal

má-bá	wátá		má-bā	wātā
| |	\ /		| |	\ /
H H	H		H M	M

If we assume that the prepausal lowering rule refers only to the tonal tier, targeting the last H "autosegment", as in (13),

(13) H → M / ___ //

the right results are obtained: one H is lowered in *má-bā*, while both Hs are lowered in *wātā* (Hyman 1987). While the two representations in (12a) are expected to correlate with hetero- vs. tautomorphemic H tones, Odden (1982) shows that Shambala requires both representations within noun stems. A noun such as *nyóká* 'snake', pronounced H-H, has a single /H/ linked to both syllables of the stem. The question, then, is how to analyze stems such as *ngó↓tó* 'sheep', pronounced H-↓H (H followed by downstepped H tone). Since successive heteromorphemic /H/ tones produce downsteps, i.e. /H/ + /H/ → H-↓H, the logical move is to represent *ngó↓tó* with two successive /H/'s on the monomorphemic stem. (Odden analyzes Shambala with a privative /H/ tone which contrasts with /Ø/ rather than /L/.) Although a rare occurrence, the tautomorphemic version of the OCP is thereby violated.

Similar contrasts and OCP problems are found with respect to /L/ tones in Dioula d'Odienné (Braconnier 1982). In this language there is a rule of the form in (14).

(14) L → H / {//, L} ___ H

As seen in (15), the rule is not iterative, as only one L autosegment can be raised:

(15) a.	/ì mà dɛ̀ tá/	→	ì mà dɛ́ tá	'you didn't take any child'	(*ì má dɛ́ tá)
b.	/ì mà tùrù tá/	→	ì mà túrú tá	'you didn't take any oil'	(*ì má túrú tá)

However, the following examples show that all monomorphemic L tone nouns have different properties before H:

(16)	a. before pause	b. before H	
	sɛ̀bɛ̀	sɛ̀bɛ́	'paper'
	tùrù	túrú	'oil'
	kàràkà	kàràká	'bed'
	sùmàrà	sùmárá	'soumbala' (a spice)

One solution is to give the above nouns the representations in (17a), where the OCP is violated similarly to Odden's tautomorphemic Hs in Shambala.

```
(17) a.  sɛbɛ     turu     karaka     sumara
         | |       V       V  |       |   V
         L L       L       L  L       L   L

     b.  sɛbɛ     turu     karaka     sumara
            |       V          |          V
            L       L          L          L
```

(Another solution in (17b) might be to posit a distinction between /L/ and toneless TBU's, which later become L by default.) While the OCP is violable in the ways just seen, it is important to note that the autosegmental representations provide a straightforward way of encoding the contrastive tonal properties of Kukuya, Kishambaa, and Dioula d'Odienné. Other frameworks would have to resort to unmotivated junctures or diacritics.

2.2. Zero representation

The second consequence which directly flows from the autosegmental architecture is the possibility that a tone can exist without a TBU, and vice-versa. When a morpheme consists solely of a tone, it is referred to as a tonal morpheme. An oft-cited example is the associative (genitive) marker in Igbo (see Williamson 1986 and references cited therein) which is most transparently observed when preceded and followed by a L-L noun. As seen in (18), the H tonal morpheme is assigned to the preceding TBU in Central Igbo and to the following TBU in Aboh dialect:

(18)								
	Central Igbo:	àgbà	+ ´ +	èŋwè	→	àgbá	èŋwè	'jaw of monkey'
	Aboh Igbo:	ẹ̀gbà	+ ´ +	èŋwè	→	ẹ̀gbà	éŋwè	'jaw of monkey'

Floating tones can also be lexical. In Aghem, the nouns *kɨ́fú* 'rat' and *kɨ́wó* 'hand' are both pronounced with H tones in isolation (Hyman 1979). However, as seen in (19), they have different effects on the following word (the *kɨ́-* prefix drops when the noun is modified):

```
(19) a.  fú     kɨ́à     'your sg. rat'          b.  fú     kɨ́n     'this rat'
         |.......|                                    |          |
         H       L                                    H          H

         wó      kɨ̀à     'your sg. hand'             wó      ↓kɨ́n    'this hand'
          |       |                                    |          |
```

H L L H L H

In (19a), the H of the stem /-fú/ spreads onto the /L/ of /kìà/ 'your sg. (class 7)'. As seen, the floating L of /-wó`/ 'hand' blocks the spreading. When followed by the /H/ tone demonstrative /kín/ 'this (class 7)' in (19b), 'this rat' is realized H-H, while 'this hand' has a downstep conditioned by the same lexical floating L of /-wó`/ which was originally due to a historically lost syllable (cf. Proto-Bantu *-*bókò* 'hand').

Corresponding to floating tones, which lack a TBU, are TBU's which lack tones. Such toneless morphemes may receive their tonal specification by context or by default tone assignment (see §3). An oft-cited example of the former comes from Mende (Leben 1973, 1978):

(20)		base noun		+ hu 'in'	+ ma 'on'
a.	/H/	kɔ́	'war'	kɔ́-hú	kɔ́-má
b.	/L/	bɛ̀lɛ̀	'trousers'	bɛ̀lɛ̀-hù	bɛ̀lɛ̀-mà
c.	/HL/	mbû	'owl'	mbú-hù	mbú-mà
d.	/LH/	mbǎ	'rice'	mbà-hú	mbà-má
e.	/LHL/	nyàhâ	'woman'	nyàhá-hù	nyàhá-mà

As seen, the tone of the two locative postpositions is the same as the last underlying tone of the nouns to which they attach. The /HL/, /LH/ and /LHL/ "melodies" are linked one-to-one to the noun + postposition constituent.

2.3. Stability effects

The third consequence of autosegmental representations, stability, is related to the second: When a TBU is deleted, its tone may still remain, and vice-versa. An example of this comes from Tangale, which Kenstowicz & Kidda (1987:230) interpret as having an underlying /H/ vs. /Ø/ contrast. As seen in the following examples, the final vowel of a word is deleted "when it is followed by another word in a close syntactic configuration":

(21) a.	/tuuže/ + /lawo/	→	tuuž	lawo	→	tùùž	láwò	'child's horse'
	H		H			H		
b.	/yaara/ + /lawo/	→	yaar	lawo	→	yáár	làwò	'child's arm'
	H		H			H		

In (21a), we observe that the deletion process targets only the TBU: When the final /e/ of /tuužé/ is deleted, its H tone thus floats and is relinked to the first TBU of the second noun. In (21b), on the other hand, when the final /á/ of /yáará/ is deleted, its link to the H tone is also lost. Since a floating H tone does not result from vowel-deletion, the pronoun is realized L-L by default. This is exactly what is expected from the doubly linked H enforced by the OCP in the autosegmental representation in the input in (21b). If /yáará/ had been represented with two H autosegments, the second would have floated, and could potentially have been relinked to the possessive pronoun. While one might preclude this possibility by introducing a floating-H deletion process, the autosegmental representation makes exactly the right prediction without stipulation.

3. Tonal Underspecification

Another representational issue in the study of tone concerns underspecification: the possibility that some TBU's do not have a tone at all. The example seen above in (21a) demonstrates how a tone can shift onto another TBU which was claimed to be underlyingly toneless. Such shifts can be quite long-distance, as seen in following examples from Giryama, which contrasts /H/ vs. /Ø/ (Philippson 1998:321):

(22) a. ku-tsol-a ki-revu 'to choose a beard' /-tsol-/ 'choose'
b, ku-<u>o</u>n-a ki-révu 'to see a beard' /-ón-/ 'see'

In (22a) both the infinitive /ku-tsol-a/ 'to choose' and the object noun /ki-revu/ 'beard' are underlyingly toneless (and pronounced all L by default). In (22b), on the other hand, the infinitive /ku-ón-a/ 'to see' consists of an underlying H tone root, which however shifts to the penultimate syllable of the following word. Such long-distance processes, which make little sense in a segmental interpretation of tone, are best described as displacing a tone, here H, across toneless TBU's. If one instead proposed that these TBU's have L tones which are permeable, one would have to establish a system of, say, markedness conventions to predict when tones can cross each other. The representation of L as /Ø/, on the other hand, allows for such long-distance processes without requiring further complications.

Just as in the case of single vs. multiply linked tones, underspecification potentially allows for more distinctions than fully specified representations. Limiting ourselves first to languages which have only two tone heights, (23) summarizes the possible analyses:

(23) a. /H/ vs. /L/
b. /H/ vs. /Ø/
c. /L/ vs. /Ø/
d. /H/ vs. /L/ vs. /Ø/

As seen, the tonal contrast may be binary with /H/ contrasting with /L/, privative, with either /H/ or /L/ contrasting with /Ø/, or both, in the case of where a ternary system of /H, L, Ø/ is required. Thus, the central question concerning any such system is to determine which of the above representations best accounts for the properties of the surface [H] vs. [L] contrast.

A /H, L/ system is most appropriate, if not required, when both features are phonologically active. This is seen in Kuki-Thaadow, which has both H- and L-tone spreading (Hyman, in press):

(24) a. /kà + zóoŋ + lìen + thúm/ [kà zòoŋ líen thǔm] 'my three big monkeys'
L H L H

b. /kà + kèel + góoŋ + gùup/ [kà kèel gòoŋ gûup] 'my six thin goats'
L L H L

Not only do both /H/ and /L/ spread onto a following /L/ and /H/ syllable, respectively, but the result in final position is a rising (LH) or falling (HL) contour tone. Both spreading and contour tones would be difficult to represent if one of the tones were underspecified. The same would be true of a language which has both floating H and L.

While /H, L/ systems are those in which the phonology refers to both tone values, in a privative tone system only one of the two tones is phonologically active. Many Bantu languages have a /H, Ø/ system, as was seen in the Giryama examples in (22). A few have a /L, Ø/ system, such as Ruund, for which Nash (1992-4) gives the following arguments:

(25) a. H's are by far more numerous than L's, hence "unmarked"
b. floating L exists, while floating H does not
c. morphological rules assign L tones, not H's
d. phonological rules manipulate L tones, not H's

Athabaskan languages are also known for having H- vs. L-marked tone systems (see the various studies in Hargus & Rice 2005). The closely related South American languages, Bora (Weber & Thiesen 2000) and Miraña (Seifart 2005) have been reported to have /L, Ø/ systems based on properties similar to (25), but with the additional OCP argument that two phonological /L/ tones cannot occur in sequence.

A similar argument is made for Munduruku (Picanço 2005), but with the need to distinguish two kinds of L tone: a /L/ which both triggers and undergoes a change to H after L vs. a /Ø/ tone which does not trigger, but undergoes the change to H. Other /H, L, Ø/ systems in which toneless /Ø/ receives its tone from context or by default include Margi (Pulleyblank 1986) and Kinande (Mutaka 1994). A variation on this is Luganda, which Hyman, Katamba & Walusimbi (1987) analyze with underlying /H, Ø/ and surface [H, L], but with a three-way H vs. L vs. Ø contrast at an intermediate level of representation. While Luganda introduces the L at the word level (where the dissimilatory process known as Meeussen's Rule converts /H-H^n/ to H-L^n), other /H, Ø/ systems introduce L tones at the phonological or intonational phrase levels. Still others may introduce L targets in the phonetic interpretation or perhaps not at all (Myers 1998). In Tangale, an utterance-final L TBU is pronounced extra low, but not a L which results from the lowering of /tuužé/ 'horse' before pause. While Kenstowicz & Kidda (1987) account for this by a rule delinking a singleton H before pause, an analysis more in line with what happens in other tone systems, e.g. in Grassfields Bantu (Hyman & Tadadjeu 1976), would involve L tone spreading into a prepausal H, as in (26a).

(26) a. tùužè˚ 'horse' b. laŋóró

```
|  ≠          |  V
L  H //       L  H
```

As in Grassfields Bantu, the symbol L˚ means that a L tone doesn't fall (or lower) before pause (//). (Since Kenstowicz and Kidda propose an underlying /H, Ø/ system, default Ls would first have to be introduced to trigger the delinking of the prepausal H.) As seen in (26b), the L spreading rule only targets a immediately following H TBU which occurs directly before pause.

Corresponding to the four different analyses of two-height tone systems in (23) are those characterizing systems with three tone heights in (27).

(27) a. /H/ vs. /M/ vs. /L/
b. /H/ vs. /Ø/ vs. /L/
c. /H/ vs. /M/ vs. /Ø/
d. /Ø/ vs. /M/ vs. /L/
e. /H/ vs. /M/ vs. /L/ vs. /Ø/

As in the case of /H, L/, where three tone heights are phonologically active, the system will most likely require underlying /H, M, L/. Examples are Mɔnɔ (Kamanda-Kola 2003, Olson 2005), where all three heights occur as floating tones and combine to form all six tonal contours (HM, HL, MH, ML, LM, LH) and Gwari (Hyman & Magaji 1970), which has H-, M- and L- tone spreading.

It is generally assumed that M is the unmarked tone of a three-height tone system (Maddieson 1978, Pulleyblank 1986). Both Akinlabi (1985) and Pulleyblank (1986) propose that Yoruba has the system in (27b), where M tone is not only unmarked, but underspecified. Among the arguments is the fact that Yoruba allows only HL and LH contours, but none involving M tone (*MH, *LM, *HM, *ML). If M = /Ø/, it follows that Ø cannot form a contour with either H or L. Another argument derives from alternations in which H or L overrides M tone. While all of these properties naturally follow from the underspecification of M, the latter can be set up as /M/ as long as other mechanisms are put in place to capture the recessiveness of M tones. Pulleyblank (2004), for instance, proposes an account within optimality theory in which, essentially, M tones need not be preserved in outputs to the same degree as H or L. An argument for a /H, Ø, L/ system comes from Peñoles Mixtec (Daly & Hyman 2007), which has an OCP constraint disallowing successive Ls or Ls which are separated by any number of /Ø/ TBU's. The result is the L tone deletion rule in (28a).

(28) a. L → Ø / L ___
b. ɨɨ^{N} dì<u>i</u>-ni-kwe-ši kada-kwe-ši ɨɨ^{N} ɨɨ^{N} čì<u>i</u>u^{N} → ɨɨ^{N} d<u>i</u>-ni-kwe-ši kada-kwe-ši ɨɨ^{N} ɨɨ^{N} č<u>i</u>u^{N}
one alone-only-pl-she POT.do-pl-she one one work L Ø
'only one of them will do each of the jobs'

As seen, this rule is responsible for the loss of the second L in (28b), which is separated from the first L by 12 toneless TBU's! That the two L tones can "see" each other over long distances is strong evidence for the underspecification account.

Returning to the systems in (27), (27c,d) seem to be rare or non-occurring. Paster (2003) proposes /H, M, Ø/ for Leggbó with /Ø/ alternating between H and L in the verb morphology (cf. §4). If correct, the relatively few short-vowel LH, HL and LM contours would have to be exceptionally marked: *èggŭ* 'catfish (sp.)', *gēppyôn* 'afternoon', *lèssŏ̄l* 'last year'. While I am unaware of any three-height tone system being analyzed as /Ø, M, L/, the system in (27e) seems at first appropriate for Yatzachi Zapotec (Pike 1948). Although this language has only the three surface tones H, M, L (and HM and MH contours on monosyllabic words), there are two kinds of L tones, those which alternate with M vs. those which do not. Pike identifies these, respectively as class A vs. class B. For example, a class B L will become M when followed by a M or H within or across words, while a class A L tone will not be affected. This is seen in the minimal pair in (29).

(29) a. L_a : [bìa] 'cactus' bìa gōlī 'old cactus'

b. L_b : [bìa] 'animal' bīa gōlī 'old animal'

A natural interpretation would be to recognize L_a as /L/ and L_b as /Ø/. Where the /Ø/ tone is not realized M, i.e. when not occurring before a /M/ or /H/, it will be realized with a default L tone, hence merging with class A /L/. However, it is hard to evaluate this proposal without considering what the featural representation is of all of the tones in the language. As will be seen in §4 one also should consider the possibility that L_b is only partially underspecified. It is likely that Yatzachi Zapotec has two kinds of L tone because it originally contrasted four tone heights. The L_b /Ø/ could therefore have been a tone level between M and L, which Pulleyblank (1986), interestingly, considers the underspecified tone of a four-height tone system.

In all of the above discussion, we have been only considering systems which have the same number of underlying and surface tone levels (perhaps with downstep). It is also possible for languages to have fewer underlying tone levels than on the surface. For example, Kom has underlying /H/ and /L/, which spread, float and form LH and HL contours. However, as discussed in §5 below, there is a rule H → M / L __ which results in many H TBU's being realized M on the surface. Although Welmers (1962) analyzes Kpelle with three tone heights, the surface Ms are clearly the realization of the /LH/ melody, whether realized on one TBU or more. This raises the possibility of a /H, M/ or /L, M/ system, where the two highest or two lowest tones are underlying and the third tone derived. Smith (1968) and Stahlke (1971) posit /H, M/ for Ewe dialects with H, M and L tone, while Clements (1977) does the same for a dialect which has four tone heights: H, M, L and ↑H (raised H). While the second-to-lowest height has been hypothesized to be the unmarked, if not underspecified, tone in a four-height tone system, it is not clear what to propose for systems with five contrastive tone heights, the maximum number which has been attested (Maddieson 1978, Edmondson & Gregersen 1992). The value of underspecification seems greatest in two-height tone systems, the ultimate case being culminative tone systems such as Somali which allow at most one H tone per word. The status of underspecification becomes less clear in systems which have multiple tone levels and tonal contours. As will be seen in the next section multilevel systems do not necessarily lend themselves naturally to an analysis of in terms of features.

4. Tone features, tonal geometry, and tone-bearing units

In the preceding sections we have followed the common practice of symbolizing tones in terms of H, M, L, and their combinations. It is generally assumed, however, that tones should be analyzed in terms of features and feature geometry. Take, for example, the question of tonal contours. We have already seen several pieces of evidence that these should be decomposed into level tones (or tone features), but there have been recurrent claims that at least some contour tones should be analyzed as units, i.e. they are contour tones rather than being sequences of tones which happen to be linked to the same TBU (Biber 1981, Newman 1986). Although most or all of the putative cases are reinterpretable, nowhere is the intuition "contour = unit" stronger than in the study of Chinese-type tone systems. Yip (1989) tackles this issue and proposes two different tonal geometries for true contour tones vs. tone clusters:

(30) a. tonal contours b. tone clusters

In (30) the tones link to a tonal node (TN) which in turn links to the TBU. As seen, a tonal contour is one where the H and L tones link to a single TN, while a cluster is one where each tone has its own TN. This, then, nicely captures the intuition that there is something different about a Chinese 51, 35 or 214 vs. a LH rising or HL falling tone found in other tone systems. Thus, in Chinese it is not uncommon for a sandhi rule to replace one tonal contour by another, possibly unrelated contour. Such is unheard of in African tone systems where the tone clusters rarely, if ever, behave as units.

Since Yip (1980) it has generally been assumed that two tone features are needed, one to make a basic tonal distinction between high and low, the other to make a further split into higher vs. lower registers of high and low. Adopting UPPER and RAISED for these functions, this produces the distinctions in (31), where <u>M</u> represents a lower mid tone:

(31)

	H	M	<u>M</u>	L
UPPER	+	+	-	-
RAISED	+	-	+	-

As seen, the natural classes are {H, M} vs. {<u>M</u>, L}, which differ in the feature UPPER, and {H, <u>M</u>} vs. {M, L}, which differ in the feature RAISED. The need for a grouping of non-contiguous levels, {4, 2} vs. {3, 1} is seen from studies of tonogenesis and tonal bifurcation in East and Southeast Asia (Matisoff 1973): If [±UPPER] represents the original tonal opposition, often attributable to a laryngeal distinction in syllable finals, [±RAISED] can potentially modify the original contrast and provide the four-way opposition in (31).

Yip (1980), Pulleyblank (1986) and others have implemented this or slightly revised interpretations of the two binary contrasts, including the assignment of the second feature to a register node in an elaboration of the tonal geometry in (30). One issue which immediately arises is how to represent the fifth tone level attested, for example, in Kam (Shidong) (Edmondson & Gregerson 1992):

(32)

ʈa^{11}	ʈa^{22}	ʈa^{33}	ʈa^{44}	ʈa^{55}
'thorn'	'eggplant'	'father'	'step over'	'cut down'

(Note in passing that with this many contrasts numbers seem to be more useful than letters to represent the tone levels.) Concerning the distinctions that UPPER and RAISED do make, how would one express {M, <u>M</u>} as a natural class? Although they are contiguous on the pitch scale, they do not share a feature. Work on this topic has been nonconclusive. Rules such as M → <u>M</u> / L __ which cannot be attributed to phonetic implementation typically target a sequence of Ms and are therefore equally interpretable as M → $^{\downarrow}$M (Hyman 1986). While the phenomenon of tonal downstep ($^{\downarrow}$) is best known for establishing H vs. $^{\downarrow}$H contrasts in underlying two tone-height systems, M vs. $^{\downarrow}$M and L vs. $^{\downarrow}$L contrasts are also attested. The outstanding question here

is how to represent downstepped tones. One possibility in (33a) is that the downstep in a H-$^{\downarrow}$H sequence is represented only structurally, e.g. as a floating L tone wedged between H tones, as Clements & Ford (1979) originally proposed for Kikuyu:

(33) a.
```
TBU   TBU
 |     |
 H  L  H
```
b.
```
TBU   TBU
 |     |
 H     H
```

However, it was mentioned with respect to Shambala in §2.1 that the downstep might instead be left to the phonetic interpretation of two contiguous H TBU's, as in (32b). A floating tone trigger of downstep appears to more versatile: H-$^{\downarrow}$M requires a floating L, while L-$^{\downarrow}$L requires a floating H. On the other hand, no cases are known where successive M or L autosegments cause contrastive downstep as Hs are said to do in (33b).

The question still remains whether M and <u>M</u> ever function as a natural class. The feature specifications in (31) predict they shouldn't. Actually, they predict that in a three-height tone system, M tone might have either of two specifications: [+UPPER, -RAISED] or [-UPPER, +RAISED]. In fact, in a three-level tone system, there could be two phonetically equivalent M tones which realize both of these feature combinations. In a number of three-height systems where there is an lexical contrast of /H/, /M/ and /L/ on nouns, verbs instead fall into two tone classes whose realizations vary according to inflectional features and clause type. In (34) I distinguish two such systems:

(34)

		Type I		*Type II*	
	e.g.	Gokana, Day		Fe'fe', Leggbó	
a.	Higher tone class	H	M	M	H
b.	Lower tone class	M	L	M	L

In Type I languages the contrasting tones have a higher and lower variant in the two environments: H ~ M vs. M ~ L. The problem here is double. First, one has to decide what the underlying (input) tones are: /H, M/, /M, L/ or maybe even /H, L/? It all depends on whether one views the alternations as raising or lowering (or both). The second problem is determining the feature representations. One possibility would be to start with one tone as [+UPPER] and the other as [-UPPER]. The assigned grammatical feature would then be [+RAISED] in (33a) and [-RAISED] in (33b). In this analysis M would be [+UPPER, -RAISED] in (34a) vs. [-UPPER, +RAISED] in (34b). In the Type II languages, one verb tone is /M/, which doesn't change, while the other tone varies between H and L. Since H and L do not share either feature value of UPPER and RAISED (and certainly not to the exclusion of M), we can either introduce another feature they could share such as [+EXTREME] (Maddieson 1971) or seek another solution. Paster (2003) posited /M/ vs. /Ø/ for Leggbó, with the morphology assigning a H or L prefix which takes the place of the /Ø/ but cannot override /M/. A third possibility is simply to represent the contrast as /H/ vs. /M/ with H → L being a morphologically conditioned rule.

Besides capturing the natural classes between tones, another reason to consider the featural content of tones is the effect it may have on claims of underspecification. While we considered the arguments for completely underspecifying a tone in §3, it is possible that a tone is specified for one feature, but unspecified for another. Recall the discussion of Yatzachi Zapotec and the alternation between (class B) L and M. It was suggested that alternating Ls are underlyingly /Ø/,

while non-alternating (class A) Ls are /L/. There is a second difference between the two L tones, which Pike (1948:92-3) describes as follows (3 = L, 2 = M, 1 = H):

> "If the first member of the compound is tone /3/, class A, the second member, tone /1/ is perturbed to tone /2/.... If the first member of the compound is tone /3/ (class B) it is perturbed to tone 2 and the second syllable, tone /1/ is also perturbed tone /2/)."

In other words, /L + H/ → L-M and /Ø + H/ → M-M. While the H of the second member of a compound might be expected to lower to M after /L/, why does it lower also after /Ø/? (The raising of the /Ø/ TBU follows from the rule exemplified in (29b).) Two alternatives present themselves. First, we could fully specify all tones distinctively as in (35a).

(35) a.

	H	M	L_b	L_a
UPPER	+	+	-	-
RAISED	+	-	+	-

b.

	H	M	L_b	L_a
UPPER	+	+	-	-
RAISED	+	-		-

As seen, alternating L_b would have the same feature [-UPPER, +RAISED] specifications as <u>M</u> (lower-mid) in (31). If unmodified, it would be phonetically non-distinct from the [+UPPER, -RAISED] specifications of /M/. Rather than undergoing raising, as in Pike's (1948) account, L_b would lower to [-RAISED] when not followed by a H or M. If we assume that there is a boundary L% at the end of a phrase, this lowering can be expressed as an assimilation to a following [-UPPER, -RAISED]:

(36) [-UPPER] → [-RAISED] / __ [-UPPER, -RAISED]

Both features are needed in the environment to guarantee that the rule is triggered only by a true /L/. In this analysis the rule lowering /H/ to M in compounds would presumably be expressed as an assimilation of [+UPPER] to the preceding [-UPPER], as in (37).

(37) [+UPPER, + RAISED] → [-UPPER] / [-UPPER] # __

Both of the specifications [+UPPER] and [+RAISED] have to be included in the input so that /M/ does not become L in the same environment.

The above analysis assumes full specification and rules which involve feature changing. A second strategy might be to underspecify the feature value of RAISED of L_b, as in (35b), in which case (36) would not be replaced by the feature filling processes in (38).

(38) a. [o RAISED] → [+RAISED] / __ [+UPPER]
b. [o RAISED] → [-RAISED]

As indicated, L_b would become [+RAISED] before [+UPPER], otherwise [-RAISED]. Rule (37) would remain the same. While (38a) can be expressed as a feature-filling rule, what is lost is the possibility of expressing the raising of L_b as an assimilatory process involving one feature: Whereas (36) may be conceptualized as the spreading of [-RAISED], this is not be possible in (38a), where two different features are involved. It is not clear that anything is gained by underspecifying RAISED as in (35b).

Both (35a) and (35b) assume that there are two featurally distinct M tones specified with the opposite features [α UPPER, -α RAISED]. We might instead require a single representation of all output Ms, with L_b being underspecified as in (39).

(39)

	H	M	L_b	L_a
UPPER	+	-	-	-
RAISED	+	+		-

As seen, L_b is non-distinct from both /M/ and /L/ since it shares [-RAISED] with both, but has no specification of RAISED, whose values are filled as in (40).

(40) [o RAISED] → [α RAISED] / __ [α RAISED]

By (40), L_b acquires the same [+RAISED] value as /M/ before a H or M. Otherwise, it receives the same [-RAISED] value as /L/ before L or L% (pause). However, this analysis runs into the serious problem of how to formalize the lowering of a /H/ to M after both Ls in compounds. Although both L_a and L_b are [-UPPER], so is /M/ in this analysis. For more discussion of these options, see Hyman (2009).

In the preceding discussion it has been assumed without discussion that tone heights should be characterized by features which are binary rather than multivalued (Stahlke 1977) or binary and hierarchized (Clements 1983). Anderson (1978) provides a comprehensive appraisal of the different feature proposals up to that date. Although the assimilations in (36) and (37) are represented as feature copying, an explicit autosegmental account would formalize these rules as feature spreading. For this to work, the two features must occur on independent tiers. This then raises the question of where these tiers link up, e.g. to a laryngeal node or directly to the TBU? There have been numerous proposals in the literature (see the surveys and discussion in Bao 1999, Snider 1999, Yip 1995, 2002, Lee 2008). The advantage of the first proposal is that tones frequently interact with other laryngeal properties. Halle & Steven's (1971) system in (41), an early attempt to capture the relation between tone and obstruent voicing, fails, however, to characterize more than three tone heights:

(41)

	tones			voiceless obstruents	sonorants	voiced obstruents
	H	M	L	p t k f s	m, n, l, w, y	b d g v z
stiff	+	-	-	+	-	-
slack	-	-	+	-	-	+

Clearly one wants to account for the relation between tone and (non-modal) phonations, or the interference of obstruent voicing with tonal assimilations, but not at the expense of losing the generalization that tones are distributed by TBU's. While tones have an autosegmental independence, they ultimately must be realized on something, e.g. a vowel or syllabic consonant. A language may consistently assign tones by mora, such that a CVV syllable receives two tones, or it may assign tones by syllable. Sometimes it is difficult to distinguish between the two. The complexities and corresponding representational possibilities are many.

5. Possible limits of autosegmental representation

Two general conclusions can be drawn from the preceding sections. First, there is still much merit in the autosegmental insights on tone. Second, there is much more work to do. In this section we first address real or apparent problems for autosegmental tonology. The arguments for autosegmental tonology were enumerated in §2. Some of the evidence concerned the non-isomorphism between the tones and their TBU's: more than one tone can link to a TBU, in which case we get a tonal contour or cluster; conversely, one tone can link to more than one TBU. Contrasting representations such as in (12a) and (17a) were said to be needed. The question here is whether they ever get in the way: Are there cases where it is disadvantageous to represent a tautomorphemic H-H or L-L as a single tone linked to two TBU's?

An awkward such case would seem to arise in Kom, which has an underlying contrast between /H/ and /L/, but a surface contrast between H, M and L. All M tones are derived by a rule which lowers a H TBU to M when preceded by a L or initial phrase boundary (which can be represented by a %L boundary tone). This produces outputs such as the following:

(42)	a.	/fe-gham/ H L	→	fẽ-ghâm	'mat'	(M-HL)
	b.	/fe-nywin/ H LH	→	fẽ-nywíñ	'bird'	(M-HM)
	c.	/fe-buʔ/ H HL	→	fẽ-búʔ	'gorilla'	(M-H)
	d.	/fe-tam/ H H	→	fẽ-tám	'fruit'	(M-H)

As in these examples, most nouns in Kom have a /H/ tone prefix followed by a monosyllabic stem which can have any of the four tone patterns exemplified in (42). As schematized in (43), the H of the prefix spreads onto a following L or LH stem:

(43) a. fẽ-ghâm
%L H L

b. fẽ-nywíñ
%L H L H

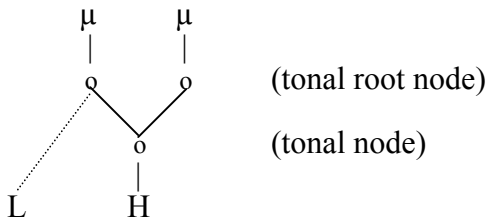
As seen in the transcriptions, the output is M-HL in (43a) and M-HM in (43b). The M tones in question are conditioned by the rule that lowers a H to M after a (linked, floating or boundary) L. In both forms the prefix is thus lowered M; in addition, in (43b), the (delinked) stem L lowers the following H to produce the HM contour. Since the prefix lowers to M without affecting the stem, the lowering rule cannot be written as a single-tier rule, as in (44), or we would get the wrong outputs *M-ML and *M-M:

(44) H → M / L __ (cf. the Kukuya rule in (13))

It is clear that the doubly linked H representation is not useful, but it also is not fatal for an autosegmental full tone-spreading account. At least three responses come to mind. First, assuming that the TBU is the mora and that stems are bimoraic, the M can be derived by delinking a H from the first TBU (mora) that immediately follows a L. Second, one can complicate the tonal

geometry to include a tonal root node, as in (45), to which the preceding L can link as a register feature (perhaps [-RAISED]):

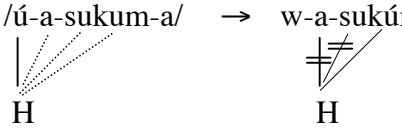
(45)



Third, assuming that floating tones persist into the output, one might argue that the M outputs are derived by phonetic implementation, where the M may be interpolated as part of the aligning of output tones with their segmental supports. (A fourth, non-assimilatory account could be to disassociate a H link that immediately follows a L.)

In other cases the autosegmental representations may have to be seriously "fixed up". In the Mijikenda languages Chikauma and Chirihe, the H tone of a prefix is displaced to the penult (Cassimjee & Kisseberth 1992:29).

(46) a. /ni-a-sukum-a/ → n-a-sukum-a 'I am pushing'
b. /ú-a-sukum-a/ → w-a-sukúm-a 's/he is pushing'



All of the morphemes in (46a) are underlyingly toneless, including the first person singular subject prefix /ni-/. In (46b), the class 1 (human singular) subject prefix /ú-/ has an underlying tone which, however, is realized on the penult. Cassimjee & Kisseberth argue that this should be accounted for by spreading and delinking of all but the last link of the H, as shown. Evidence for this analysis comes from the interaction of depressor consonants (voiced obstruents) with H tone spreading. Thus consider the forms in (47), where the verb stem /-galuk-/ 'change' begins with a depressor consonant:

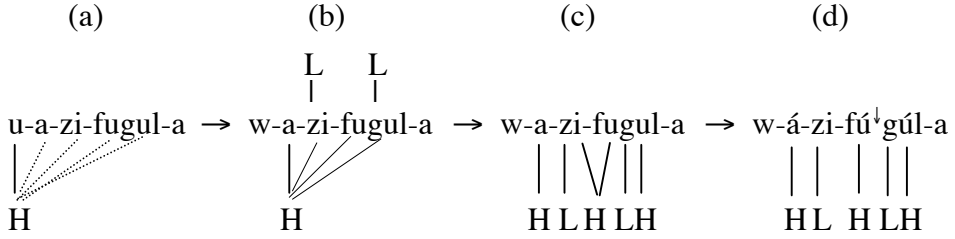
(47) a. /ni-a-galuk-a/ → n-a-galuk-a 'I am changing'
b. /ú-a-galuk-a/ → w-á-galúk-a 's/he is changing'

Again the input morphemes are all toneless in (47a). In (47b) we see that the one underlying H is realized both on the penult, where expected, but also on the marker -á-. In the final set of data, we see the toneless form in (48a) contrasting with three H tones in (48b).

(48) a. /ni-a-zi-fugul-a/ → n-a-zi-fugul-a 'I am untying them'
b. /ú-a-zi-fugul-a/ → w-á-zi-fú↓gúl-a 's/he is untying them'

Cassimjee & Kisseberth's analysis is schematized in (49), where the only underlying H tone is on the subject prefix /ú-/:

(49)



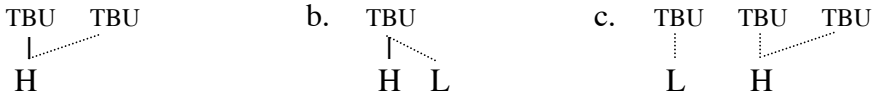
As indicated in (49a) the H of /ú-/ spreads to the penult. In (49b) a L tone feature is assigned to each depressor consonant, in this case to the /z/ of the object prefix /zi-/ and to the stem-internal /g/ of /-fugul-/ 'untie'. In (49c) these Ls are folded in with the multiply linked H tone. In a process which Cassimjee & Kisseberth term "fission", these Ls divide up the one H into separate H tone domains. After this, delinking occurs in (48d), where the downstepped ↓H is conditioned by the depressor L which is wedged between TBU's with H. In the Kom case, something needs to be added to fix the multiply linked structures derived from tone spreading. Despite the complications presented by Kom and Chikauma/Chirihe, there is no reason to abandon the autosegmental insights—rather we can extend and build on them as languages require.

On the other hand, there were some proposals of early autosegmental tonology which did not pan out. Most of these, listed in (50), concerned conventions that turned out to be too strong:

(50) a. Every TBU must have a tone, hence automatic spreading
b. Every tone must have a TBU, hence automatic contouring
c. Left-to-right mapping of tonal melodies

These conventions were felt to be needed to account for the dotted associations in (51).

(51)



In (51a) a toneless TBU follows a H tone TBU. Just as we saw in the case of the toneless locative postpositions in Mende in (20), it was proposed that the last tone on the left would automatically spread to any toneless TBU's to its right. Pulleyblank (1986) argued, however, against "automatic spreading" by showing that another option was for the toneless TBU(s) to receive a default tone, e.g. L. In (51b), the opposite is the case: There are more tones than TBU's. Early autosegmental tonology assumed that the left over tones would automatically link to the last TBU, as shown. However, numerous studies argued that certain tones should be left floating, e.g. a floating L to condition downstep, while Hyman & Ngunga (1994) presented data from Ciyao to argue that even a floating H does not undergo "automatic contouring". Finally, in (51c), we see the "automatic" left-to-right mapping of a LH melody to three TBU's. The proposal in early autosegmental tonology was that free tones link one-to-one from left to right. As seen, this produces a L-H-H sequence. However, an alternative of "edge-in" association was proposed by Yip (1988), by which the first tone would map to the first TBU and the last tone to the last TBU, and then intervening available tbu's would receive their tones from the left, thereby producing a L-L-H sequence. Edge-in association works perfectly for Kukuya (Paulian 1975, Hyman 1987), where /LH/ maps as L-L-H and /HL/ as H-L-L on trimoraic stems. On the other hand, Zoll (2003) argued that apparent directional effects may result from whether a language prefers multiple Hs or multiple Ls. Kukuya definitely prefers L sequences, violating Zoll's LAPSE

constraint vs. multiple Hs, which would violate her CLASH constraint. As a dramatic confirmation of Zoll's tone-specific approach, consider the realization of tonal schemas in Fore in (52), where (^{H}, ^{L}) = floating tones:

(52)

schema	1σ	2σ	3σ	4σ
/L/	L	L-L	L-L-L	L-L-L-L
/H/	H	H-H	H-H-H	H-H-H-H
/LH/	L^{H}	L-H	L-L-H	L-L-L-H
/HL/	H^{L}	H-L	H-L-L	H-L-L-L
/LHL/		$L\text{-}H^{L}$	L-H-L	L-H-L-L
/HLH/		$H\text{-}L^{H}$	H-L-H	H-L-L-H
/LHLH/			$L\text{-}H\text{-}L^{H}$	L-H-L-H
/HLHL/			$H\text{-}L\text{-}H^{L}$	H-L-H-L

As seen, there are no sequences of H tones if a L is present in the input. Scott (1990) summarizes the system as follows:

> "The simplest system which may be hypothesized for Fore is one in which only changes between high and low tone are recognised as being contrastive" (p.141)
> "There are no contrastive contours." (p.147)
> "...tones appear to spread by increasing the domain of the L tones in preference to the spreading of H tones.... From this it appears that H tones are to be considered as peaks of prominence or pitch targets...." (p.147)

In other words, the underlying /H/ and /L/ are constrained as follows in Fore: First, sequences of L are to be preferred to sequences of H, and second, there is no default L tone: If a word has a /H/ melody, the H will link to all of the TBU's. In the next and final section we consider the question of whether non-derivational approaches to phonology need change our view of tonal representations.

6. Constraint-based tonology

The above characterization of Fore is of course a way of describing the tonal distributions from a constraint-based perspective. Within optimality theory (Prince & Smolensky 1993, McCarthy 2002), the constraints might be ranked as follows:

(53) MAX(Tone) >> DEP(Tone) >> *H >> *L

MAX(Tone) says that any input tone has a corresponding tone in the output, while DEP(Tone) says that any output tone has a corresponding tone in the input. In other words, tones are neither deleted nor inserted. The constraint ranking *H >> *L is designed to account for the limited number of H tones in (52): Each TBU linked to a H tone is counted as a violation.

The ranked constraints in (53) are but one way one might try to conceptualize the Fore tonal distributions in such a framework. This therefore raises the question of what optimality theory (OT) has to offer tone and vice-versa. High among the contributions of tone to our

understanding of phonological systems is the family of OCP constraints which find a natural home in OT (Myers 1997). Building on his own and others' previous work, Myers shows that the OCP functions as a conspiracy in a number of languages. In Cibemba, which contrasts /H/ and /Ø/, there is a process of bounded HTS spreading illustrated in (54).

(54)	a.	tu-la-kak-a	'we tie up'	tu-la-súm-á	'we bite'
		tu-la-mu-kak-a	'we tie him up'	tu-la-mu-súm-á	'we bite him'
	b.	bá-lá-kak-a	'they tie up'	bá-la-súm-á	'they bite'
		bá-lá-mu-kak-a	'they tie him up'	bá-lá-mu-súm-á	'they bite him'
	c.	tu-la-bá-kák-a	'we tie them up'	tu-la-bá-súm-á	'we bite them'
		bá-la-bá-kák-a	'they tie them up'	bá-la-bá-súm-á	'they bite them'

In the above examples, all of the morphemes except /-súm-/ 'bite' and the plural class 2 prefixes /bá-/ 'they' and /-bá-/ 'them' are underlyingly toneless. As seen in the examples in the right column, the /H/ of /-súm-/ spreads onto the final inflectional vowel /-a/. In (54b) the H of the subject prefix /bá-/ spreads onto the toneless present tense marker /-la-/, except in *bá-la-súm-á* 'they bite'. This is because the spreading of H would have derived two H autosegments on successive TBU's, thereby producing an OCP violation. In (54c), the /H/ of the object prefix /-bá-/ spreads onto the toneless verb room /-kak-/, as expected. Once again the H of the subject prefix /bá-/ fails to spread because **-lá-bá-* would have constituted an OCP violation. However, note in the last examples to the right in (54c) that, when concatenated, the object prefix /-bá-/ and the verb root /-súm-/ constitute an OCP violation which is allowed to surface. In other words, the OCP blocks H tone spreading when the result would be a violation, but does not condition any change on input violations. Such a situation, known as The Emergence of the Unmarked (McCarthy & Prince 1994), is predicted and can be elegantly modeled within OT:

(55) MAX(H) >> OCP(H) >> SPREAD(H)

Max(H) guarantees that input Hs will be preserved in the output. OCP(H) says that there should not be Hs on successive TBU's. The constraint SPREAD(H) is designed to say that every input H should spread onto the following TBU. The above ranking establishes that the OCP will be violated rather than deleting offending input Hs, while spreading will not occur if the result is an OCP violation.

As we have seen, tone systems allow for a multiplicity of interpretations and solutions producing an indeterminacy that can be referred to as "the two many analyses problem". The problem is perhaps more pronounced in OT, where it is not clear how to interpret certain, potentially complex tonal processes. For example, in a rule-based framework bounded tone shift, where each input tone is realized on the following TBU, is straightforwardly described in terms of bounded spreading and delinking. While each of the two processes is independently motivated, it is not clear what is optimized in a system where the processes have been "telescoped" into a synchronic input/output relation of local tone shift. A number of tonal constraints have been proposed in the literature (see Akinlabi & Mutaka 2001 and Yip 2002 for extensive inventories).

While OT tonology is perhaps in an unsettled state, a lot will depend on the tonal representations that one assumes. At least one approach, optimal domains theory (Cassimjee & Kisseberth 1998), groups tones together into tonal domains rather than exploiting the

autosegmental many-to-one linkings between tones and TBU's (see also McCarthy's 2004 notion of "headed spans"). One area which seems crucial, but has not received the attention it deserves, is floating tones. Do the floating tones in (48) violate MAX(Tone) if they are allowed to survive as such in surface representations? To answer this one must first demonstrate that they are needed to survive in surface representations.

We saw in (33a) that a floating L wedged between two linked Hs is one of proposed representations of downstep. Since there would be no problem converting this structure into one where the floating L feature is assigned as a register feature on the following tone (and tonal sequence), the example is not conclusive. Let us then return to the tonal contrasts we saw on Kom nouns in (42). In (52) their input and output tones are shown as they occur between the L tone preposition /nè/ 'with' and the required H tone postposition /-fé/ (Hyman 2005:317):

(56)	a.	ne fe-gham -fe	→	nè fè-ghām̀ -fè˚	'with a mat'	[L-L-ML-L˚]
		L H L H		L H L H		
	b.	ne fe-nywin -fe	→	nè fè-nywīn -fé	'with a bird'	[L-L-M-H]
		L H L H H		L H L H H		
	c.	ne fe-buʔ -fe	→	nè fè-búʔ -fē	'with a gorilla'	[L-L-H-M]
		L H H L H		L H H L H		
	d.	ne fe-tam -fe	→	nè fè-tám -fé	'with a fruit'	[L-L-H-H]
		L H H H		L H H H		

As seen, Kom has both H- and L-tone spreading. In (56a), L tone spreading causes the following H to delink (producing a level L˚ tone on the postposition), while H tone spreading does not cause the following L to delink. With a H TBU lowering to M after L (cf. (43)), the noun stem /-ghàm/ 'mat' surfaces with a ML contour tone. Similarly, the stem /-nywìń/ 'bird' surfaces as M, each of the two linked H tones being lowered to M by a preceding L. The important examples are (49c,d). As seen, when the L of /nè/ spreads and delinks the H of the noun prefix /fé-/, the latter's H tone floats. As a result, the floating H shields the roots /-búʔ`/ 'gorilla' and /-tám/ 'fruit' from lowering to M. (The floating L of /-búʔ`/ is responsible for the lowering of the position /-fé/ to M in (56c).) Since the H to M lowering process is a late one for which we have even entertained the possibility that it applies in phonetic implementation, it should be clear that the floating Hs must persist into the surface representations. The alternative, that L tone spreading does not delink a following H, but rather creates LH rising tones which are simplified in phonetic implementation is perhaps suspect, if not ad hoc. If, on the other hand, the floating tones are allowed to occur in surface representations, the solution is straightforward.

Such a conclusion would also seem to have consequences for other analyses. Particularly within OT, the question arises whether a surviving, delinked floating tone should be able to satisfy MAX(Tone). Data from Kuki-Thaadow suggest maybe not. In this largely monosyllabic Tibeto-Burman language, words are underlyingly /H/, /L/ or /HL/ (Hyman, in press). As seen in (57a), however, a rising tone results from L tone spreading:

(57) a. /hùon + zóoŋ/ → hùon zǒoŋ 'garden monkey'

L H

b. /hùon + zóoŋ + gùup/ → hùon zòoŋ gûup 'six garden monkeys'

L H L

In (57b) we see that Kuki-Thaadow also has H tone spreading, and the H of /zóoŋ/ is delinked. This is because rising (LH) and falling (HL) tones are permitted only phrase-finally. Thus, the L of /hùon/ 'garden' is realized on /zóoŋ/ 'monkey', and the H of /zóoŋ/ is realized on /gùup/ 'six'.

Now consider the forms in (58).

(58) a. /hùon + zóoŋ + thúm/ → hùon zóoŋ thúm 'three garden monkeys'

L H H

b. /hùon + zóoŋ + gîet/ → hùon zòoŋ gîet 'eight garden monkeys'

L H HL

As seen, L tone spreading does not occur when the targeted H tone is followed in turn by a H or HL tone. The question is why not? To answer this we have but to consider what the output would have been if L tone spreading had applied in (58). The H of /zóoŋ/ would necessarily have had to delink, since a LH rising tone is well-formed only in phrase-final position. As a result, the underlying /H/ would, at best, have to float. The question, then, is why this would not be well-formed. It cannot be that an input link must remain as such in the output, since the H does delink in (57b). Instead, what seems to allow L tone spreading to apply in (57a,b) is that the input /H/ of /zóoŋ/ is preserved in the output: It is realized within the LH contour on its own syllable in (57a) and as part of the HL contour on the following syllable in (57b). In other words, MAX(H) is satisfied. We must suppose, therefore, that if L tone spreading applied in (58) and delinked the /H/ of /zóoŋ/, the resulting floating H would not satisfy MAX(H). By contrast, H tone spreading applies whether or not the targeted L remains linked on the surface (see Hyman, in press). We therefore can establish the ranking in (59).

(59) MAX(H) >> SPREAD(H,L) >> MAX(L)

In Kuki-Thaadow all input H tones make it to the surface—vs. closely related Hakha Lai, where the opposite ranking MAX(L) >> MAX(H) results in all input L tones being realized on the surface (Hyman & VanBik 2004). It should be noted that the non-application of L tone spreading in (58) results more straightforwardly from the ranked constraints in (59) rather than from a requirement on recoverability: Had L tone spreading applied in (58a), the output L-L-H sequence would have unambiguously pointed to underlying /L-H-H/, since /L-L-H/ would have been realized as L-L-LH. (The same is not true of (58b), since L tone spreading does not apply to a following HL tone.) If (59) is correct, OT will have made a unique contribution in providing a constraint, Max(H), which is responsible for the (non-) application of L tone spreading. By contrast, a rule-based approach would have to stipulate that that L tone spreading occurs to a L-H sequence when the H is followed either by pause or by a L tone and would not provide any motivation for why the rule does not apply when the H is followed by either H or HL. Whether

this is an indication that OT is on the right track—and can hence offer more improvements over the pre-OT conceptions of tonology remains to be seen. In fairness, it must be said that the blocking of an otherwise general L tone spreading process in (58) is unique to Kuki-Thaadow. As pointed out by Hyman (1973:157), we expect L-H-H to be a better target for L tone spreading than L-H-L. Except for Kuki-Thaadow, this is true whether the H-H sequence is from two /H/ tones or from one /H/ which is doubly linked.

Where does this leave the representation of tone? To summarize the foregoing sections, although the well-formedness and mapping conventions in (43) have been superseded in subsequent work, most of the essential representational insights of autosegmental tonology are still intact. The above discussion has only touched on a small part of the vast world of tone and of the growing constraint-based literature treating tone. Whatever the outcome of on-going OT interpretations of tone, it is likely that questions of representation will remain central.

References

Akinlabi, Akinbiyi. 1985. *Tonal underspecification and Yorùbá tone*. Doctoral dissertation, University of Ibadan.

Akinlabi , Akinbiyi and Ngessimo M. Mutaka. 2001. Tone in the infinitive in Kinande: an OT analysis. In Ngessimo M. Mutaka & Sammy B. Chumbow (eds), Research mate in African linguistics: focus on Cameroon, 333-356. Köln: Rüdiger Köppe Verlag.

Anderson, Stephen R. 1977. Tone features. In Victoria A. Fromkin (ed.), *Tone: a linguistic survey*, 133-175. New York: Academic Press.

Bao, Zhiming. 1999. *The structure of tone*. New York & Oxford: Oxford University Press.

Bateman, Janet. 1990. Iau segmental and tonal phonology. Miscellaneous Studies of Indonesian and Other Languages in Indonesia 10.29-42.

Biber, Douglas. 1981. The lexical representation of contour tones. *IJAL* 47.271-282.

Braconnier, Cassian.1982. *Le système du dioula d'Odienné, tome 1*. Institut de Linguistique Appliquée, Publication 86. Abijan, Ivory Coast: University of Abidjan, Ivory Coast.

Cassimjee, Farida & Charles W. Kisseberth. 1992. On the tonology of depressor consonants: evidence from Mijikenda and Nguni. *Special Session on Tone System Typology*, 26-40. Berkeley Linguistic Society 18.

Clements, G.N. 1977. The autosegmental treatment of vowel harmony. In Wolfgang U. Dressler & Oskar E. Pfeiffer (eds), *Phonologica 1976*, 111-119. Innsbruck: Innsbrucker Beiträge zur Sprachwissenschaft.

Clements, George N. 1978. Tone and syntax in Ewe. In Donna Jo Napoli (ed.), *Elements of tone, stress and intonation*, 21-99. Washington, D.C.: Georgetown University Press.

Clements, G. N. 1981. Akan vowel harmony: A non-linear analysis. *Harvard Studies in Phonology* 2.108-177.

Clements, G. N. 1983. The hierarchical representation of tone features. In Ivan R. Dihoff (ed.), *Current approaches to African linguistics* (vol. 1), 145-176. Dordrecht: Foris Publications.

Clements, G. N. 1985. The geometry of phonological features. *Phonology [Yearbook]* 2.225-252.

Clements, G. N. & Kevin C. Ford. 1979. Kikuyu tone shift and its synchronic consequences. *LI* 10.179-210.

Clements, G.N. & Elizabeth V. Hume. 1995. The internal organization of segments. In John A. Goldsmith (ed.), *The handbook of phonological theory*, 245-205. Cambridge, MA: Blackwell.

Daly, John P. & Larry M. Hyman. 2007. On the representation of tone in Peñoles Mixtec. *IJAL* 73.165-208.

Edmondson, Jerold A. & Kenneth J. Gregerson. 1992. On five-level tone systems. In Shina Ja J. Huang & William R. Merrifield (eds), *Language in Context: Essays for Robert E. Longacre*, 555-576. SIL & University of Texas at Arlington.

Goldsmith, John. 1976a. *Autosegmental phonology*. Doctoral dissertation. Cambridge, MA: MIT.

Goldsmith, John. 1976b. An Overview of Autosegmental Phonology. *Linguistic Analysis* 2.23-68.

Halle, Morris & Kenneth Stevens. 1971. A note on laryngeal features. *Quarterly Progress Report* 101.198-213. Research Laboratory of Electronics, MIT.

Hargus, Sharon & Keren Rice (eds). *Athabaskan prosody*. Amsterdam: John Benjamins.

Hoberman , Robert. 1988. Emphasis harmony in modern Aramaic. *Language* 64.1-26.

Hulstaert, G. 1961. *Grammaire du Lɔmɔngɔ*. Part I: Phonologie. Tervuren: Musée Royal de l'Afrique Centrale.

Hyman, Larry M. 1973. The role of consonant types in natural tonal assimilations. In Larry M. Hyman (ed.), *Consonant types and tone*, 151-179. Southern California Occasional Papers in Linguistics 1. Los Angeles: University of Southern California.

Hyman, Larry M. 1979. Phonology and noun structure. In Larry M. Hyman (ed.), *Aghem grammatical structure*, 1-72. Southern California Occasional Papers in Linguistics 7. Los Angeles: University of Southern California.

Hyman, Larry M. 1986. The representation of multiple tone heights. In K. Bogers, H. van der Hulst, & M. Mous (eds), The phonological representation of suprasegmentals. Dordrecht: Foris. 109-152.

Hyman, Larry M. 1987. Prosodic domains in Kukuya. *NLLT* 5.311-333.

Hyman, Larry M. 2005. Initial vowel and prefix tone in Kom: Related to the Bantu Augment?" In Koen Bostoen & Jacky Maniacky (eds), *Studies in African Comparative Linguistics with special focus on Bantu and Mande: Essays in honour of Y. Bastin and C. Grégoire, 313-341*. Köln: Rüdiger Köppe Verlag.

Hyman, Larry M. 2009. Do tones have features? Paper presented at the Symposium on Tones and Features, University of Chicago Paris Center, June 18-19, 2009.

Hyman, Larry M. In press. Kuki-Thaadow: An African tone system in Southeast Asia. In Franck Floricic (ed.), *Mélanges offerts à Denis Creissels*. Les Presses de l'Ecole Normale Supérieure.

Hyman, Larry M., Francis X. Katamba & Livingstone Walusimbi. 1987. Luganda and the strict layer hypothesis. *Phonology [Yearbook]* 4.87-108.

Hyman, Larry M. & Daniel J. Magaji. 1970. *Essentials of Gwari grammar*. Occasional Publication No. 27 of the Institute of African Studies, University of Ibadan Press, Nigeria.

Hyman, Larry M. & Armindo Ngunga. 1994. On the Non-Universality of Tonal Association 'Conventions': Evidence from Ciyao. *Phonology* 11.25-68.

Hyman, Larry M. & Maurice Tadadjeu. 1976. Floating tones in Mbam-Nkam. In Larry M. Hyman (ed.), *Studies in Bantu tonology*, 57-111. Southern California Occasional Papers in Linguistics 3. Los Angeles: University of Southern California.

Hyman, Larry M. & Kenneth VanBik. 2004. Directional rule application and output problems in Hakha Lai tone. In *Phonetics and Phonology, Special Issue, Language and Linguistics* 5.821-861. Academia Sinica, Taipei.

Jenison, Scott, D. & Priscilla B. Jenison. 1991. Obokuitai phonology. *Workpapers in Indonesian Languages & Culture* 9.69-90.

Kamanda-Kola, Roger. 2003. *Phonologie et morphosyntaxe du mɔnɔ: Langue oubanguienne du Congo R.D.* Munich: Lincom Europa.

Kenstowicz, Michael & Mairo Kidda. 1987. The obligatory contour principle and Tangale phonology. In David Odden (ed.), *Current approaches to African linguistics* (vol. 4), 223–238. Dordrecht: Foris Publications.

Leben, William R. 1973. *Suprasegmental phonology.* Doctoral dissertation. Cambridge, MA: MIT.

Leben, William R. 1978. The representation of tone. In Victoria A. Fromkin (ed.), *Tone: a linguistic survey*, 177-219. New York: Academic Press.

Lee, Seunghun Julio. 2008. *Consonant-tone interactions in optimality theory*. Doctoral dissertation, Rutgers University.

Loving, Richard E. 1966. Awa phonemes, tonemes, and tonally differentiated allomorphs. *Papers in New Guinea Linguistics* 5.23-32.

Maddieson, Ian. 1971. The inventory of features. In Ian Maddieson (ed.), *Tone in generative phonology*, 3-18. Research Notes 3, parts 2 and 3, Department of Linguistics and Nigerian Languages, University of Ibadan, Nigeria.

Maddieson, Ian. 1978. Universals of tone. In Joseph H. Greenberg (ed.), *Universals of human language*, vol. 2 (Phonology), 335-365. Stanford University Press.

Matisoff, James A. 1973. Tonogenesis in Southeast Asia. In Larry M. Hyman (ed.), *Consonant types and tone*, 71-95. Southern California Occasional Papers in Linguistics 1. Los Angeles: University of Southern California.

McCarthy, John J. 1981. A prosodic theory of nonconcatenative morphology. *LI* 12.373-418.

McCarthy, John J. 2002. *A thematic guide to optimality theory*. Cambridge: Cambridge University Press.

McCarthy, John J. 2004. Headed spans and autosegmental spreading. Ms. ROA 685-0904.

McCarthy, John J. & Alan Prince. 1986. Prosodic morphology. Ms. University of Massachusetts & Brandeis.

McCarthy, John J. & Alan Prince. 1994. The emergence of the unmarked. *NELS* 24.333-379.

Mutaka, Ngessimo. 1994. *The lexical tonology of Kinande*. Munich: Lincom Europa.

Myers, Scott. 1997. OCP effects in optimality theory. *NLLT* 15.847–892.

Myers, Scott. 1998. Surface underspecification of tone in Chichewa. *Phonology* 15.367-392.

Nash, Jay A. 1992-94. Underlying low tones in Ruwund. *Studies in African Linguistics* 23.223-278.

Newman, Paul. 1986. Contour tones as phonemic primes in Grebo. In Koen Bogers, Harry van der Hulst, and Maarten Mous (eds), The phonological representation of suprasegmentals, 175-193. Dordrecht: Foris.

Odden, David. 1982. Tonal phenomena in Kishambaa. *Studies in African Linguistics* 13.177-208.

Olson, K.S., 2005. *The Phonology of Mono*. Dallas: SIL International & the University of Texas at Arlington.

Paster, Mary. 2003. Tone specification in Leggbo. In John M. Mugane (ed.), *Linguistic Description: Typology and Representation of African Languages. Trends in African Linguistics* 5.139-150.

Pankratz, Leo & Eunice V. Pike. 1967. Phonology and morphophonemics of Ayutla Mixtec. *IJAL* 33.287-299.

Paulian, Christiane. 1974. *Le kukuya: langue teke du Congo*. Paris: SELAF.

Philippson, Gérard. 1998. Tone reduction vs. metrical attraction in the evolution of Eastern Bantu tone systems. In L. M. Hyman & C. W. Kisseberth (eds), *Theoretical aspects of Bantu tone*, 315–329. Stanford: CSLI.

Picanço, Gessiane. 2002. Tonal polarity as as phonologically conditioned allomorphy in Mundurukú. *Berkeley Linguistic Society* 28.237-248

Pike, Eunice Victoria. 1948. Problems in Zapotec tone analysis. IJAL 14.161-170. Reprinted in Ruth M. Brend (ed.), *Studies in tone and intonation*, 84-99. Basel: S. Karger.

Prince, Alan and Paul Smolensky (1993). *Optimality theory: constraint interaction in generative grammar*. [Rutgers Optimality Archive; ROA-537-0802]

Pulleyblank, Douglas. 1986. *Tone in lexical phonology*. Dordrecht: D. Reidel.

Pulleyblank, Douglas. 2004. A note on tonal markedness in Yoruba. *Phonology* 21.409-425.

Qingxia, Dai & Lon Diehl. Jingpho. 2003. In Graham Thurgood & Randy J. LaPolla (eds), *The Sino-Tibetan Languages*, 401-408. London & New York: Routledge.

Scott, Graham. 1990. A reanalysis of Fore accent. La Trobe University Working Papers in Linguistics 3.139-150.

Seifart, Frank. 2005. *The structure and use of shape-based noun classes in Miraña (North West Amazon)*. Doctoral dissertation, Radboud Universiteit Nijmegen. Nijmegen: MPI Series in Psycholinguistics.

Smith, Neil. 1968. Tone in Ewe. Quarterly Progress Report No. 88, 290-304. Cambridge, MA: MIT Research Laboratory of Electronics. Reprinted (1973), Eric E. Fudge (ed.), *Phonology*. London: Penguin.

Snider, Keith. 1999. *The geometry and features of tone*. Dallas: Summer Institute of Linguistics.

Stahlke, Herbert F. W. 1971. The noun prefix in Ewe. *Studies in African Linguistics*, Supplement 2, 141-159.

Stahlke, Herbert F. W. 1977. Some problems with binary features for tone. *IJAL* 43.1-10.

Weber, David & Wesley Thiesen. 2000. A synopsis of Bora tone. Ms. SIL. *Work Papers of the Summer Institute of Linguistics*, North Dakota Session 45. Online 2001.

Welmers, Wm. E. 1962. The phonology of Kpelle. *Journal of African Languages* 1.69-93.

Williamson, Kay. 1986. The Igbo associative and specific constructions. In Koen Bogers, Harry van der Hulst & Maarten Mous (eds), *The phonological representation of suprasegmentals*, 195-208. Dodrecht: Foris.

Yip, Moira. 1980. *The tonal phonology of Chinese*. Doctoral dissertation, M.I.T.

Yip, Moira. 1988. Template morphology and the direction of association. *NLLT* 6.551-577.

Yip, Moira. 1989. Contour tones. *Phonology* 6.149-174.

Yip, Moira. 1995. Tone in East Asian languages. In John A. Goldsmith (ed.), *The handbook of phonological theory*, 476-494. Cambridge, MA: Blackwell.

Yip, Moira. 2002. *Tone*. Cambridge University Press.

Zoll, Cheryl. 2003. Optimal tone mapping. *LI* 34.225-268.