Tonal Complexes: The Prosodic Organization of Tones[1]

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1. Introduction

During the late 1970s, the study of tone, accent and stress produced several insights that revolutionized phonology. These included the impact of representations richer than segment-by-feature matrices, the concept of explaining patterns in terms of the interaction of constraints rather than the application of pattern-action rules, and the idea of factoring phonological patterns into simple, independent interactions in different phonological dimensions. Two decades later, these ideas have flowered profusely in other areas of phonology, but their application to problems of lexical tone has been notably less successful.

What accounts for this paradox? Our view is that researchers have generally missed one specific implication of these earlier insights: tonal features may be organized into simple structures, analogous to the familiar segments, syllables and feet, but formally independent of them.[2] We call these structures "tonal complexes". In this paper, we will develop this idea by applying it to the tonal phenomena of Yoruba and Kɔnni, where we show that it can help us to factor a long list of intricate morphotonological details into a few simple generalizations about tonal complexes. We will also sketch some relevant features of Lokaa and Tem, which we cover in detail in a companion paper. Finally, we will suggest that the idea of tonal complexes has value in understanding typological variation among varieties of tone and accent, across languages and across time.

1.1 The Analogy with Syllable Structure

In the sound structure of human languages, the signs of syllables are everywhere. Whether the topic is child language acquisition or historical change, morpheme structure or inflectional paradigms, dialect geography or individual variation, speech production or perception, we quickly encounter syllable-related notions.

These concepts have a purely physiological side, associated with the natural oscillatory motions of the articulators, and the perceptual salience of acoustic changes, especially those associated with rapid increases in amplitude. But syllabic concepts also have a

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[2] Similar ideas can be found in Bamba (1991), Manfredi (1995), Leben (2002) and elsewhere. See section 6 for details.

cognitive side, which has emerged, in one way or another, in every attempt to make scientific sense of speech.

In some approaches, a mass of intricately patterned phonological detail is created by the interaction of minimal base forms with a compact set of phonological generalizations. Others prefer to see phonological generalizations as emergent properties of a stored set of concrete exemplars. Phonological generalizations may be framed as systems of ordered rules, or as ranked and violable constraints, or as emergent properties of neural networks. There may be a single system of generalizations, or several, operating in parallel or in series. But in every case, the cognitive atoms of speech interact, one way or another, in a sort of molecular framework composed of syllable-related concepts.

From other parts of the system, other structures arise. The physical divisions created by respiratory rhythms, for example, shape the sound stream on a time scale of seconds, and their cognitive counterparts are the phrasal structures or symbolic junctures that also play a role in every theory of sound structure. Because breath control is physiologically independent of the control of the larynx, jaw, velum, lips and tongue, and also takes place on a different time scale and has independent functional consequences, it makes sense for the cognitive structures associated with breath groups to be different from those associated with syllabic organization.

What about the other ways in which the stream of speech can be factored into independent parts? In terms of the physiology and physics of speech production, and at the same time in terms of the dimensions of acoustic perception, the most salient division is between the frequency- and amplitude-modulated source of sound in the larynx -- the melody, in subjective acoustic terms -- and everything else.

Since the work of Leben (1973), Goldsmith (1976) and Williams (1976), phonologists have taken it for granted that pitch contours should described on a separate representational "tier" from vowels and consonants. But on the phonetic side, just as the mouth opens and closes, so the pitch goes up and down; just as rapid opening or closing resonance transitions form perceptual units, so do rapid pitch movements; just as the muscles of lips and tongue and velum need to be coordinated, so do the actions of the thyrohyoid, the strap muscles, the genioglossus, the vocalis, and the other muscles that cooperate to control pitch.

In the sections that follow, we'll argue that the cognitive structures associated with pitch contours, in at least some tone languages, should be richer than simple sequences of tonal features. In particular, grouping these features into local rises and falls will help us to make better sense of complex facts about contextual variation in both the phonological patterning and the phonetic implementation of lexical tone.

1.2 What are Tonal Complexes?

Tonal complexes are structured combinations of tonal features, analogous to the structured combinations of non-tonal features in segments, moras, syllables and feet. In the examples we will consider, tonal complexes are "bound states" of (two or more) unlike tones, such as [HL] or [LH], and we propose that they have a role in organizing tonal features somewhat analogous to that of moras and syllables in organizing segmental features.

Constraints on such tonal structures may motivate deletion, epenthesis, spreading or re-ordering of tonal features, just as constraints on syllable or foot structure may motivate such processes in well-known cases of segmental phonology:

(a) Tone contour formation is like re-syllabification, in which a coda consonant becomes an onset for a following syllable.
(b) Tone polarization and polarized tone epenthesis are like the alternation of features between vocalic and consonantal forms, or the epenthesis of vowels and consonants, which often rescue forbidden or marked syllable structures. And the phonetic dissimilation of tone sequences (such as the raising of H before L) is like the different phonetic interpretation of high vowels or nasals in onset vs. rhyme positions in syllables (such as the closer articulation of [j] as compared to [i]).
(c) H tone insertion is like the insertion of vowels to allow orphan consonants to be syllabified, or to satisfy minimality constraints.
(d) Tonal metathesis is like the metathesis of segments dictated by syllabic well-formedness considerations.

Each of the tonal phenomena in (a) – (d) is illustrated in at least one of the languages discussed in this paper.

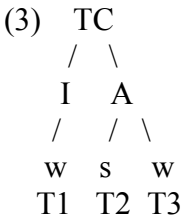
1.3 The Form of a Tonal Complex

A tonal complex has a maximal form **(L (H L)).** This can be seen as roughly like a CVC syllable, with the **High** tone playing the part of the vowel in most cases. As in the syllabic case, the permitted partial forms must include the core High tone, so that apart from (**LHL)** the expected variants are (**H L**), (**L H**) and (**H**).

(1) Maximal form of a *tonal complex*: **(L (H L))**
(2) Other variants: (a) **(H L)** (b) **(L H)** (c) **(H)**

As in the case of syllabic sequences, there may be further restrictions, for example forbidding word-internal clusters of Low tones. One crucial difference between syllables and tonal complexes is that unlike syllables the domain of a tonal complex may vary from a single tone-bearing unit to a phrase. Domains may be morphosytactic categories, such as V^0 or N^0, or the well known prosodic domains such as syllable and prosodic word. This variation is language dependent.

We propose that the true form of a tonal complex may actually be something like (3) (I is “initial tone” and A is “accent”):

(3)


In the default case a tonal complex is binary branching with the positions I and A as seen above. The stronger position is the head. If there is a single tone it occupies the head (or strong) position, with the other position left vacant, or filled by "spreading" or "epenthesis", depending on the constraint hierarchy of the language.[3]

1.4 Structure of the paper

We develop the details of these proposals in the following sections through a number of case studies, with varying types of allowed complexes and tonal complex domains. Each of the sections discusses a different phenomenon, providing different kinds of support for tonal complexes.

In section 2, we use the concept of tonal complexes to explain contour tone formation in Yoruba, where adjacent tones reorganize themselves to form accent-like contours, just as segments may reorganize themselves to repair otherwise defective syllables. We describe Yoruba as a case in which the tonal complexes have just two positions maximally, LH and HL. In addition, the domain of a tonal complex in Yoruba is the syllable. In section 3 we describe several unexpected connections between (derived) tonal complexes in Yoruba and (underlying) accents in languages like Japanese.

Section 4 discusses some some cases of tonal dissimilation and epenthesis in Kɔnni, a Gur language, where tones are changed or created in order to satisfy word-level constraints on the presence and location of tonal complexes, just as segmental features may be changed or created in order to satisfy syllable-structure constraints. Here the maximal tonal complex is LHL, and the domain is the prosodic word.

In section 5, we briefly sketch some relevant tonal phenomena in Lokaa, an Upper Cross language of Nigeria, and in Tem, a central Gur language of Togo and Benin. The treatment of these languages is given in greater detail in a companion paper, since space does not permit a full treatment in this one. However, our brief treatment here will offer useful additional information about the kinds of "conspiracies" that often arise in the morphophonology of tone, and provide additional motivation for the idea of tonal complexes.

[3] The above proposal notwithstanding, L and H tones can also be interpreted as functioning like high and low vowels respectively in certain situations. Thus in occupying the HEAD of a tonal complex, a High tone is the more natural choice. But in the absence of a High tone, a Low tone can occupy the HEAD. This is found especially in cases where there is only one specified tone (L) within a tonal complex domain.

Finally, section 6 briefly compares tonal complexes to the idea of "tonal foot", using Leben (2002) as the model of the latter.

2. Contour Formation in Benue Congo

In the Benue Congo languages of West Africa, we often see a process in which the transition from one tonal level to another is delayed so as to create a salient tonal contour on the syllable beginning the new level. In a notation in which vowels are tagged as "High", "Low", "Rising", "Falling", etc., this leads to the creation of rises and falls, as in the examples below from Yoruba[4] and Edo (Bini):

(4) (a) Yoruba rising example

àlá (LH)	→	àlă	(L LH)	'dream'

(b) Yoruba falling example

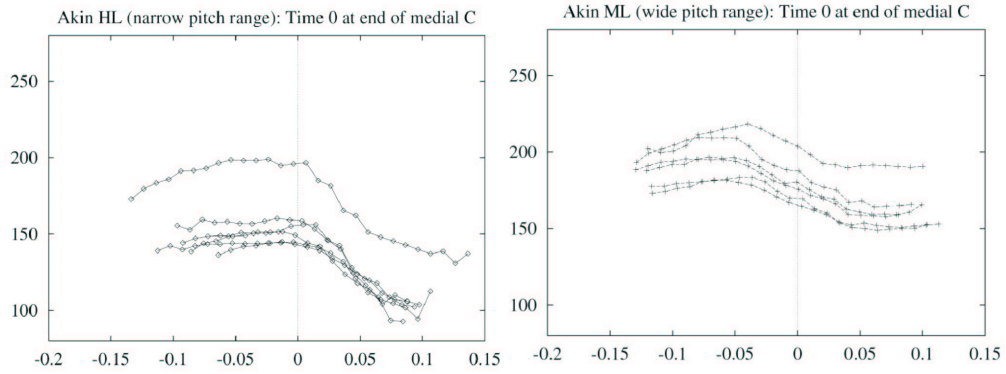
rárà (HL)	→	rárâ	(H HL)	'elegy'

(c) Edo (Bini) falling example

ẹ́kpò (HL)	→	ẹ́kpô	(H HL)	'bag'

Phonetically, F0 transitions are always contours, not step functions; however, the effects symbolized by the notations in (4) are not just the necessary phonetic consequence of tonal co-articulation. The most striking evidence for this assertion is the fact that a language may form phonologically-significant contours for some tonal sequences and not others. Thus Edo forms phonologically-significant contours in the case of High Low but not Low High sequences; while Yoruba does so for both Low High and High Low, but not for any case where Mid tone precedes or follows High or Low.

(5) Yoruba HL and ML plots



The difference between the Yoruba H L and M L cases can be seen in the pitch tracks in (5). Each plot shows the F0 tracks for six VCV sequences, taken from the

[4] Note that in Yoruba, the standard orthography shows the input to this process, not the output, so that the resulting contours are not normally indicated in the written forms; therefore the examples in (4) are written as in the left hand column.

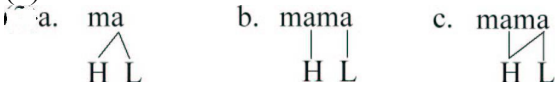
middle of longer phrases. Time 0 marks the point of release of the medial consonant, here always a nasal or liquid. The HL cases were spoken in a relatively narrow pitch range, while the ML examples were spoken in a relatively wide pitch range.

As a result, the amount of pitch change is similar, but the timing of the pitch change is different: in the HL examples, the pitch fall does not begin until after the release of the medial consonant and continues throughout most of the following vowel, while in the ML examples, the fall is about half complete by the release of the medial consonant, and generally ends early in the following vowel. Informal experimentation suggests that this roughly (half-segment-long) difference in timing can be crucial for native-speaker perception of Yoruba tonal identity.[5]

In some level-tone languages, for example Igbo and Ijo (Kalabari, Nembe, Kolokuma), phonologically-significant contour tone formation does not appear to occur. Note however that in a language where there is no phonological contrast between the presence and absence of contour formation, it may remain to be determined whether the situation should be described as invariable absence of contour formation, or rather invariable formation of contours.

For the past few decades, phonologists have generally followed Hyman and Schuh (1974:88) in treating this process of tonal contour formation as "tone spreading." In this approach, all tonal specifications are built up from a small number of level tone primitives, such as High and Low, with rises and falls treated as Low+High or High+Low sequences respectively. Strings of tones are represented on a separate tier from strings of non-tonal segments, with the alignment of tonal and segmental strings indicated by association lines connecting them. In this perspective, a falling tone is just a tonal sequence HL associated with a single segment, as in (6a) below. When L follows H on successive syllables, as in (6b), such a contour can be created on the second syllable simply by adding an association line, as in (6c).

(6)



2.1 Towards a Solution

Using arbitrary phonological rules or constraints, formal specification of the desired outcome in such cases is easy: in certain contexts, certain association lines are added; in other contexts, they are not.

As Hyman and Schuh observed in 1974, there is a general pattern to be accounted for. Such tone contour formation is common, but by no means universal. When it happens, the change is always in the direction of a delay rather than an advance of the F0

[5] Observations of these phenomena go back to the earliest linguistic treatments of the languages in question. Thus in Ida Ward's 1952 work "An Introduction to the Yoruba Language", she remarks (p. 34) that "[t]he juxtaposition of high and low tones, either high-low or low-high, needs some comment." Citing an example of the form HL, she observes that there is a fall on the second syllable that is "heard as a more or less deliberate glide," and warns that "[u]nless the English speaker makes it, he is apt to give the impression of gliding down on the first syllable …, which does not satisfy the Yoruba."

transition. It is possible to speculate about general articulatory reasons why F0-transition delays might be more likely to happen than F0-transition advances, or general acoustic reasons why delays might be more salient than advances. However, we will argue instead (or in addition) for an account of the asymmetry in terms of formal properties of the phonological representation of tone.

In current approaches to phonology (e.g. Prince and Smolensky 2004), systematic changes like the one exemplified in (6) are attributed to the existence of general constraints that prefer the output to the input. However, there is no generally-recognized constraint that would motivate the kind of contour formation shown in (6). In fact, as we will see in detail in the next section, the facts of Yoruba seem to motivate a constraint that is ironically opposite to the well-known "wellformedness constraint" proposed by Goldsmith (1976) for tonal association: a tone spreads if and only if the adjacent syllable already has a tone.

Why then does tone contour formation tend to occur? We believe that the answer to this question is tied up with the answer to several other, apparently unrelated questions about tone and accent: Why do tone polarization and polarized tone epenthesis tend to occur? Why do multiple-tone sequences sometimes but not always simplify? Why do high-before-low raising and low-before-high lowering tend to occur?

None of these phenomena are inevitable, but all are commonplace, and typologically typical of tonal systems. We believe that all of these cases are symptoms of the same cause, namely the formation of tonal complexes. As we have suggested, tonal complexes are "bound states" of (two or more) unlike tones, such as [high low] or [low high], and Benue-Congo tone contour formation is like (re-)syllabification, in which an unaffiliated consonant, or a coda consonant, becomes an onset for a following syllable. Tone polarization and polarized tone epenthesis are like the epenthesis of vowels and consonants in rescuing forbidden or marked syllable structures. And the phonetic dissimilation of tone sequences is like the different phonetic interpretation of high vowels or nasals in onset vs. rhyme positions in syllables.

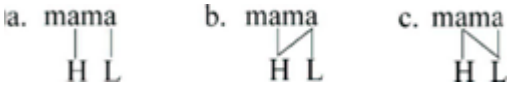
In such cases, the availability of alternative structural configurations can provide a tool for motivating constraint-based restructuring, or explaining differing phonetic interpretations.

This is enough to suggest why (6c) is sometimes preferred to (6b). After spreading, the adjacent H and L tones form a tonal complex, and a constraint requiring tones to be bound into tonal complexes will then be satisfied.

As we have explained things so far, however, we have left a crucial observation of Hyman and Schuh 1974 unexplained. We have shown how to motivate the particular kind of tone-onto-tone spreading that results in tonal contour formation. However, we have not explained their important generalization that this process always delays and never advances the point of pitch fall or rise. For example, HIGH LOW always become HIGH FALLING, usually not FALLING LOW, even though both outcomes produce a tonal

complex in our sense. Using autosegmental notation, the result of an input like (7a) is always as in (7b) below, usually not as in (7c):

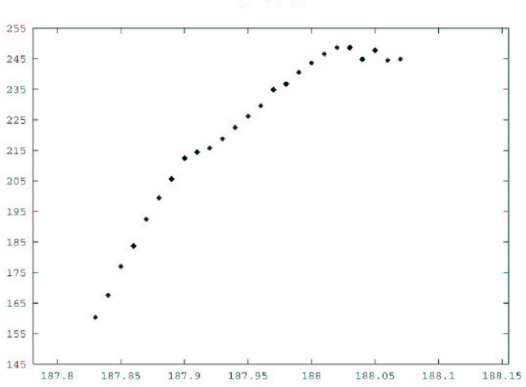
(7)



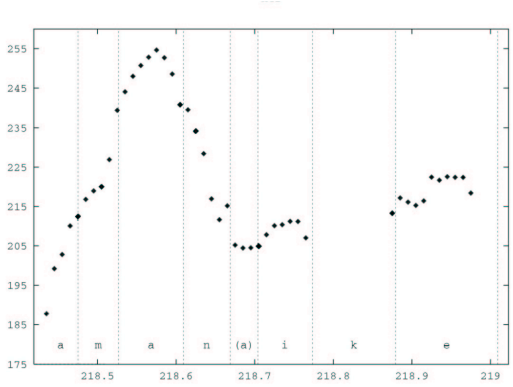
In order to explain this generalization, we will need to look further into the kind of thing that a "tonal complex" is. Hints are provided by two other general observations about the phonetic realization of tone, namely that the F0 target for a single static tone tends to occur at the (temporal) end of the associated phonetic region, and that the simplest cases of "dynamic" or contour tones force us to posit a second, earlier (phonetic) alignment point within the associated time region.

The plot in (8a) shows fundamental frequency as a function of time for the Igbo word yá meaning “he”. Although this monosyllabic word has high tone, the pitch is not a uniform level high. Instead, the pitch rises throughout the syllable, with the peak value found near the end. In languages like Igbo and Yoruba, other things equal, the phonetic target value of a tone – the highest F0 of a High tone, or the lowest F0 of a Low tone – is found at the end of the span of time corresponding to the associated tone-bearing unit.

(8)a. Igbo: yá (“he”)



b. Igbo: ámá nà íké (“Ama and Ike”)



We need an additional F0 target at the start of the utterance. We can think of this as a junctural value, or as a default value, but in any case, it usually falls in between the target values of an initial High and an initial Low tone, so that a low-tone stretch would be falling, just as this high-tone syllable is rising.

When we look at tone sequences, and at phrases involving longer stretches of tone-bearing units with the same tone, the same pattern generally holds. For example, consider the pitch track shown in (8b) for the Igbo phrase ámá nà íké “Ama and Ike”. The first two syllables are High, but they are neither uniformly high, nor rising followed by high. Instead, there is a rise distributed over the two-syllable high-tone region, with the highest point falling at the end of that region. The next syllable is Low, and the low

target is unsurprisingly at its end. The last two syllables are High again, and again the high target (lower than before because of downdrift and final lowering) is at the end of the two-syllable low-tone region.

Thus a crude but roughly correct way to synthesize sentential pitch contours for a language like Igbo is:

i. Divide the utterance into maximal regions of like tone.
ii. Place a mid-valued tonal target at the start of the utterance.
iii. Place a tonal target at the end of each region, chosing an F0 value determined by the tonal type, downdrift/downstep, and final boundary effects if any.[6]
iv. Interpolate linearly from target to target.

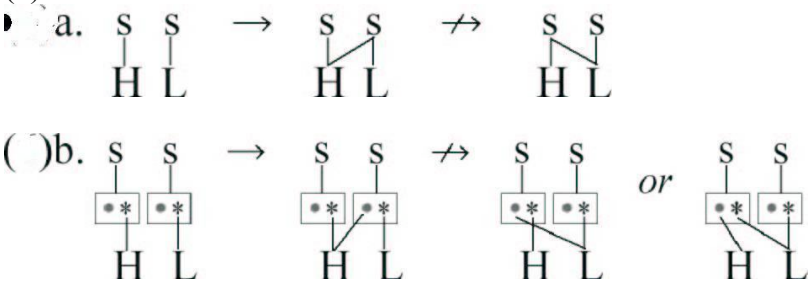
When we look at tone-bearing units that carry a contour tone, as in the Yoruba HL examples in (5), we can see the need to postulate additional phonetic anchor points at the beginning of some phrase-internal tone-bearing regions. We believe that these phonetic modeling practices point the way to an appropriate phonological structure for tone.

Let's assume that in Igbo or Yoruba every tone-bearing region has two potential tonal targets. The one at the end is obligatory, while the one at the beginning may remain unfilled. We propose to reify this pair of potential tonal targets, and call it a "tonal complex." In this sense, a tonal complex (TC) is an entity that binds two (or perhaps more) tonal positions to a tone-bearing region (which is one or more moras or syllables). These two tonal positions are a bit like the onset and rhyme of a syllable: whenever one is present, the other "ought" to be there, even though it may often be lacking. And as with the onset and rhyme of a syllable, these structurally differentiated positions are not equally optional.

In the simple binary tonal complexes we are considering, the second tonal "hook" is the stronger of the two positions, and therefore is the default. If only one tone is available, it will go there[7], with the earlier tonal position in the TC remaining empty.

Therefore we can reformulate (9a) below as (9b):

(9)



[6] See Liberman et al. (1993) for a simple model of downdrift and downstep in Igbo phrases.
[7] See also Manfredi (1995) for the argument that an L tone can head a tonally branching foot in Yoruba.

In both (9a) and (9b), the **s** symbols in the top row stand for syllables (or other tone-bearing units). In (9b), we've used boxes to symbolize two-element tonal complexes. Each tonal complex as a whole connects to a tone-bearing unit (here a syllable), as indicated in the diagram by the fact that the upper association line connects to the box. (Although it is not shown in (9b), a tonal complex might also link to a string of adjacent tone-bearing units, as we will see in the next two sections). Within the tonal complex, we've used an asterisk and a dot to symbolize the primary and secondary tonal association points. The tones link to these association points within the tonal complex.

Given this notation, the diagrams in (9b) make it is easy to see why the "forward-spreading" option should be more natural than the "backward-spreading" one. Forward spreading requires adding one association line while deleting none, as shown in the second configuration in (9b). We can create backward spreading, graphically speaking, by adding a crossing association line, as in the third panel of (9b) – but this is presumably a configuration that a proper formalization of association wouldn't even permit to be stated. We can also do it by deleting one association line and adding two, one of which links a tone to a non-adjacent association point, as in the fourth panel of (9b) – another configuration that should probably be formally impossible. Finally, we could do it by deleting one association line and adding three (not shown, but obvious), thus at least creating a formally plausible configuration, but producing an output that is much less faithful to the input.

Just as not all syllables are CV, so some tonal complexes might be more complicated. Several languages have been cited, for example, in which the maximal tonal pattern allowed for a word is of the form L+HL, where the L if present must align with the start of the word, while the HL constitutes an optional accent. Kyoto Japanese and Mawukakan are both examples of this type.[8] This would naturally be treated as a three-element tonal complex, analogous to a CVC syllable, associated with a domain such as the accentual phrase or the prosodic word.

In sections 2.2 and 2.3, we will apply this style of analysis to the simple but subtle case of Yoruba, and in section 3 we will suggest that pitch accents should in general be analyzed formally in terms of tonal complexes (as has long been the informal analytic practice).

2.2 Yoruba

Yoruba has three phonemically distinctive tones-H(igh), M(id), and L(ow). H occurs in word-initial position only in marked consonant-initial words, which reveal an implicit initial vowel when preceded by another word in genitive construction. Most words start with a vowel, which is L or M but not H. Except for this minor tonotactic restriction, tones occur freely in lexical representations, without apparent restrictions on word melodies. So there are three possible tonal patterns for monosyllables, nine possible tonal patterns for disyllables, and so on, as in (10).[9]

[8] See Poser (1985) for a discussion of Kyoto Japanese, and Bamba (1991) and Liberman (1995) for discussion of Mawukakan

[9] The examples in this paper are given in the standard Yoruba orthography. In this orthography, ẹ = [ɛ], ọ

(10) Lexical tone contrast:

ra H 'to disappear'	**ra M** 'to rub'	**ra L** 'to buy'
ọkọ MH 'hoe'	**ọkọ MM** 'husband'	**ọkọ ML** 'vehicle'
ilu LH 'town'	**ilu LM** 'opener'	**ilu LL** 'drum'
pako HH 'plank'	**kese HM** mythological place name	**pako HL** 'chewing stick'

2.2.1 Non-specification of the Mid tone

The Yoruba mid tone has been analyzed as underlying tonelessness since Akinlabi (1985) and Pulleyblank (1986). In both Akinlabi's and Pulleyblank's works, several arguments are given for this hypothesis. We will briefly sketch two examples, relating to *tonal stability and tone spreading*.

2.2.2 Tonal Stability

When an object noun follows a verb in Yoruba, the two words are combined phonologically by deleting either the final vowel of the verb or the initial vowel of the object. Any High or Low tones of the deleted vowel are retained in the result. However, Mid tones are not "stable" in this sense, but instead behave in various combinations with other tones as if they were simply not there. Thus a Mid tone verb followed by an object whose initial vowel is Low will yield a combined form whose first vowel is simply Low, not some sort of Mid-Low contour, or a Mid with a following downstep, or anything else of the sort.

The crucial cases are exemplified below. The tone patterns in each of the (a) and (b) examples in (11) - (15) are the same; in the (a) examples the vowel of the verb is deleted whereas in the (b) examples the vowel of the noun is deleted.[10]

H verb + L initial noun

(11)a.	wa (H) +	ẹkọ (LH)	→	wẹ̀kọ (H LH)
	look (for)	education		look for education
b.	mu (H) +	iwe (L H)	→	muwe (H LH)

= [ɔ], ṣ = [š], p = [kp], j = [ɟ]. A nasal vowel is written as an oral vowel followed by "n", otherwise an "n" before a consonant represents a syllabic nasal. An accute accent on a vowel indicates a (H)igh tone, a grave accent marks a (L)ow tone. (M)id tones are unmarked. Where necessary we indicate the tones with the letters HML in addition to marks on the vowels.

[10] We will not discuss vowel deletion, which is a complex question requiring a monograph-sized treatment of its own.

	take	book		take a book
(12)a.	wa (H) +	ọnọ (L L)	→	wọnọ (H L)
	look (for)	way		look for a way
b.	wa (H) +	imọ (L L)	→	wamọ (H L)
	look (for)	knowledge		look for knowledge
(13)a.	ji (H) +	ọbẹ (L M)	→	jọbẹ (H (L) M)
	steal	knife		steal a knife
b.	fẹ (H) +	iwo (L M)	→	fẹwo (H (L) M)
	want	horn		want a horn

H verb + M initial noun

(14)a.	wa (H) +	owo (MH)	→	wowo (H H)
	look (for)	money		look for money
b.	wa (H) +	ile (MH)	→	wale (H H)
	look (for)	house		look for a house

M verb + L initial noun

(15)a.	jọ (M)	ajẹ (L H)	→	jajẹ(L H)
	resemble	witch		resemble a witch
b.	sin (M)	oku (L H)	→	sinku (L H)
	bury	dead (body)		bury the dead

A few remarks are necessary for the motivation behind the selection of the above forms. First, as noted above since V-initial nouns cannot start with H in Yoruba, no examples of the form X+HX can arise. Second, when a L-tone verb precedes its object, the tone always deletes even if the vowel is preserved, so the case L+XX offers no evidence in this matter.

Extracting the tonal input and output alone from the above examples, we have the following:

Summary of Tonal Input and Output in Yoruba V+N combinations:

(11)a-b	H + L H	→	H L H
(12)a-b	H + L L	→	H L
(13)a-b	H + L M	→	H L M[11]

[11] Any examples whose output is specified as (HL M) are pronounced exactly as this notation implies in

(14)a-b H + M H → H H

(15)a-b M + L H → L H

Thus in all the cases that can arise, and whose output is not obscured by the deletion of the verbal L, we can say that H and L always remain when their lexically-associated vowel deletes, while M never does. We assume therefore that Yoruba has privative H and L tones, and that the Mid tone is simply lack of tone.

2.2.3 "Tonal Spreading" treats Mid as nonexistent

In Yoruba, a sequence of L H is realized as L LH and a sequence of H L is realized as H HL, that is adjacent H and L tones always spread (rightwards) onto each other, creating LH and HL contours.

(16)	ala (LH)	→	ala (L LH)	'dream'
	rara (HL)	→	rara (H HL)	'elegy'

On the contrary, an M L sequence does not become *M ML and an M H sequence does not become *M MH. That is, M never spreads to any other tone; and so there are no MX contours, as indeed there could not be if Mid does not exist.

(17)	ole (ML)	'thief'
	ile (MH)	'house'

Furthermore, when H or L is spread onto M, M is (usually) completely erased. Thus in monomorphemic words with initial M, a following H or L can optionally spread backwards onto the first syllable. In this case the initial M is completely supplanted, and the result is homophonous with an underlying HH or LL sequence.

(18)a.	MLL		LLL / MLL	
	erĩrà	→	èèrà / eèrà	'ants'
	erùpẹ̀	→	èèpẹ̀ / eèpẹ̀	'sand'
(18)b.	MHH		HHH /MHH	
	egúngún	→	éégún / eégún	'maquarade'
	orúkọ	→	óókọ / oókọ	'name'

2.3 The paradox of Yoruba tone (non-)spreading and (non-)relinking

The Yoruba cases of tone non-spreading and non-relinking present a paradox. In configurations (19a) and (19b) below (illustrated in 20a), where each syllable has its own

---

some dialects, but in standard Yoruba, they are pronounced as a raised H followed by an M. In earlier studies (see Bamgbose 1966, Akinlabi 1985, Pulleyblank 1986), this was thought to be an H followed by a tone between M and L, a sort of "downstepped Mid." The essential point is that the L tone is in some sense preserved.

tone, the first syllable's tone insists on crowding onto the second syllable. In configurations (19c) and (19d), where the second syllable is unspecified for tone, the first syllable's tone stays home, leaving its neighbor tonally empty (i.e. Mid). (See examples in (20b))

(19)	a.	σ σ H L	b.	σ σ L H	c.	σ σ H	d.	σ σ L

(20)a.	ala (LH)	→	ala (L LH)	'dream'
	rara (HL)	→	rara (H HL)	'elegy'
(20)b.	kese (HØ)	→	kese (HØ)	‘mythological place name’
	ilu (LØ)	→	ilu (LØ)	‘opener’

Furthermore, in vowel deletion a Low tone “relinks” if the final syllable has a high tone (21a), but again not if the final syllable is tonally empty (21b). Examples are in (22a) and (22b) respectively.

(21) a.	σ σ σ H L H	→	σ σ H LH	b.	σ σ σ H L	→	σ σ HL

(22)a	Input m u + i w e | | | H L H	→	Output m u w e ⌊‾⌉ H L H	(11)b	Input fẹ + iwo | | H L	→	Output fẹ wo | H L

Yoruba thus presents a case ironically antithetical to the original Williams/Goldsmith Well-Formedness Condition: the rule seems to be that a tone “spreads” or “relinks” if and only if the target syllable already has its own tone!

Another three-tone language with similar facts to Yoruba is Ghotuo (Elugbe 1985, 1995).

2.4 Towards an analysis of Yoruba

Following the suggestions that we made in section 2.1, we propose that Yoruba tones do not spread or relink in order to satisfy the needs of adjacent tonally unspecified vowels (or moras or syllables), but rather do so in order to fill available positions in adjacent tonal complexes. These are prosodic combinations of HL or LH tones, roughly in the way that moras and syllables are prosodic combinations of segments. On this analysis, such tonal units, long postulated as underlying elements in accentual systems, also play a crucial role in this aspect of Yoruba tonal phonology.

There are several approaches we might take to formalizing this idea. One obvious one is to assume that every underlying Yoruba tone is connected to the primary association point of its own tonal complex, which has an “iambic” [w s] pattern. When two tonal complexes happen to be adjacent (i.e. associated with adjacent syllables), the

first tone will spread in order to link to the empty secondary association point of the second tonal complex. This is basically the same thing that happens when a consonantal segment links to an empty onset position in a following syllable.

It is gratifying that following this approach, we can resurrect the Williams/Goldsmith Well-Formedness Condition as a workable treatment of Yoruba. Echoing the Williams/Goldsmith language for old times' sake, the constraints might be something like:

1. Association lines can't cross (and can't skip either).
2. Don't delete underlying association lines.
3. Every tone must be associated with some tonal complex.
4. Every tonal complex must be associated with some tone-bearing unit.
5. Every strong position in a tonal complex must be associated with some tone.
6. Every weak position in a tonal complex must be associated with some tone.
7. Don't add association lines.
8. Every tone-bearing unit must be associated with some tonal complex.

We share with Williams/Goldsmith the prohibition against crossing associations. The original Williams/Goldsmith WFC had two other parts: every tone must be associated with some TBU, and every TBU must be associated with some tone. Since we mediate these associations through tonal complexes, which have two elements on their tone-linkage side, an analogous statement logically requires at least five constraints: 3, 5, 6, 4 and 8 in the list above.

These constraints are violable and ranked in the currently usual style (Prince and Smolensky 2004). Constraint 2 was implicit in Williams/Goldsmith. We need to add constraint 7, and to rank it higher than constraint 8, so as to permit Mid tones to survive, but we need to rank it lower than the other constraints, so as to permit spreading of High onto Low and Low onto High. The above constraints are obviously not meant to be exhaustive.

While the above explains "spreading" in Yoruba, including what drives spreading, we are yet to explain the partial typology of "spreading" in Benue-Kwa, which Manfredi (1993:135) as follows:

(23) Typology of tone spreading in Benue-Kwa.

Yoruba:	H spreads to L and L spreads to H
Edo:	H spreads to L
Central Igbo:	No spreading
Ghekoyo (Gikuyu):	L spreads to H

The account of Yoruba implies the existence of languages with similar characteristics, but with a [s w] "trochaic" pattern, where the only available tone in a tonal complex links to an initial strong position, and there is no "tone spreading". Central

Igbo (Manfredi 1993) may be such a system. In such systems, there is no following empty position of a TC to be filled, and so there is no "spreading".

To account for a language in which only H tones spread to L tones but L tones do not spread to H tones (Edo), we must assume a restriction on possible tonal complex types. In such a language, an LH complex is banned. This is achieved, not by banning the LH as a unit, but by making the initial L of a tonal complex marked. This is parallel to the marked status of codas in segmental syllable structure. Importantly, the full form of a tonal complex (L (HL)) shows that an HL complex is somewhat preferred to an LH complex, just as an HL contour is less marked than an LH contour. Finally, in a language in which only L tones spread to H (Ghekoyo (Kikuyu)), and not vice versa, we must assume that an H is not allowed in a non-head position. In such a language, "spreading" H to an initial weak position of a bipositional tonal complex makes the H occupy a weak position. This concludes our account Manfredi's partial typology.

There are in fact connections between (derived) tonal complexes in Yoruba and (underlying) accents in languages like Japanese, when we compare Yoruba downdrift to Japanese catathesis. We now examine these connections, and we suggest that pitch accents should in general be analyzed formally in terms of tonal complexes.

3. Phonetic and phonological similarities to Japanese pitch accent

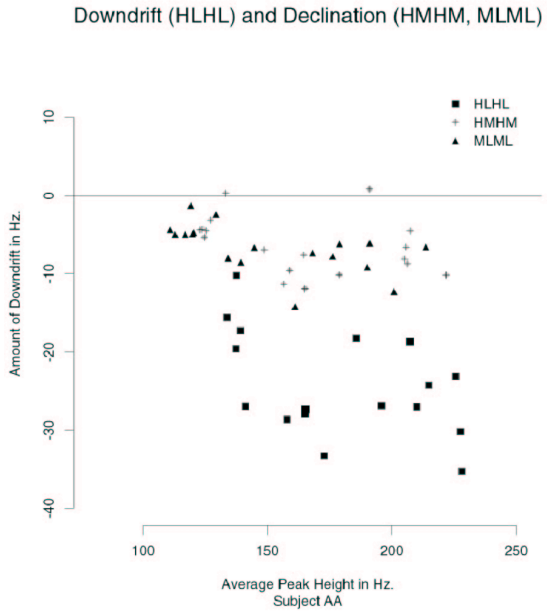
The tonal complexes postulated as derived structures in Yoruba have both phonetic and phonological similarities to (underlying) pitch accents in languages such as Japanese and English. Many descriptions, going back at least a century, have treated pitch accents (and also dynamic tones) as somehow singular entities, even if they are also sequences of tone levels. In the recent literature, Pierrehumbert (1980) argued that certain English pitch accents should be treated as sequences of two tones, and therefore should be called "bitonal", but that the two tones should share a single linkage to an accented syllable. Pierrehumbert and Steele (1987) proposed that alignment differences in such bitonal accents should be treated in terms of [s w] vs. [w s] labeling. Yip (1989) argued for branching structures of tones in the treatment of various Han dialects. Pierrehumbert and Beckman (1988) proposed that Japanese accents should be treated as branching units of H L tones with [s w] labeling and a single shared link to the accented mora (p. 124-5).

Two specific phonetic parallels between Yoruba and Japanese are particularly suggestive: the limitation of "catethesis" or "downdrift" to bound sequences of HL or LH; and the dissimilation of H and L levels in bound sequences.

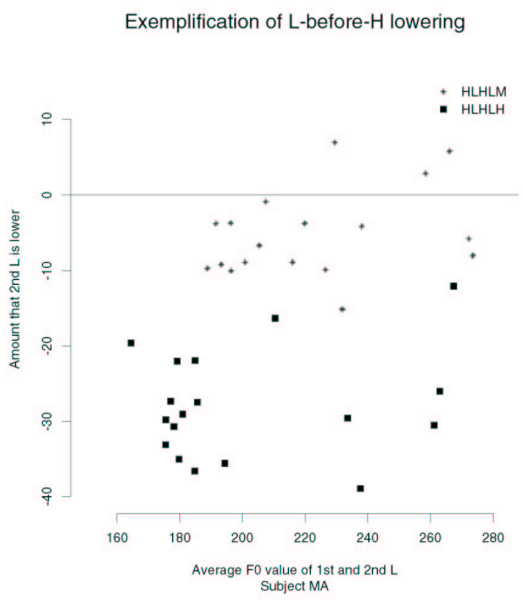
Poser (1985) showed that "catathesis" (his neologism for a strong local lowering and compression of pitch range) is triggered in Japanese by a pitch accent, but not by the otherwise similar sequence of higher and lower pitch created by an accentless word, which shows only a relatively weak downtrend that he called "declination." This result is a robust one, and has been replicated many times. In Yoruba, "downdrift" (the traditional Africanist term for the same phenomenon as catathesis) occurs in sequences of adjacent H and L tones, but not in HMHM, MLML, or HMLMHML sequences (LaVelle 1974). The scatterplot in (24a) shows this effect. Each point plots the relationship between two

successive F0 maxima, with the average of the two maxima plotted on the x-axis, and the difference between the two maxima plotted on the y-axis. The black squares (the HLHL case) are uniformly lower than the black triangles (MLML) and the gray stars (HMHM).

(24)a. Yoruba downdrift vs. declination



b. Yoruba L-before-H lowering



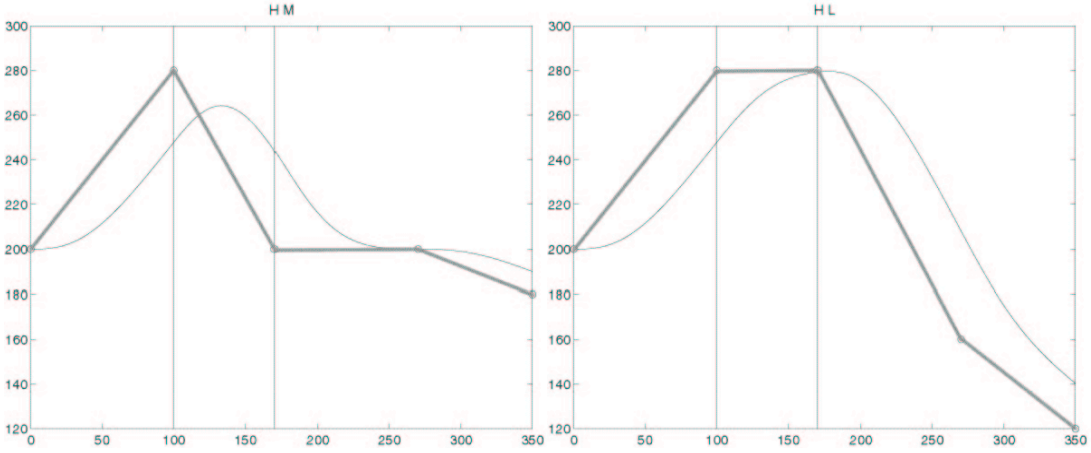
In Yoruba, H is well known to be raised before L as compared to before M (Akinlabi and Laniran (1987), Connell and Ladd (1990), Laniran (1992), Laniran and Clements (2003)). This is a general phenomenon of F0 dissimilation in the cases that we are characterizing as sequences bound into tonal complexes. The scatterplot in (24b) exemplifies L-before-H lowering in Yoruba: each points plots the relationship between two successive F0 minima, with the x-axis showing the average value of the two minima, and the y-axis showing the difference between them. The black squares (minima in HLHLH sequences) are uniformly below the gray stars (minima in HLHLM sequences).

Yoruba H-before-L raising is reminiscent of the long-observed fact that Japanese accentual H is higher than non-accentual H (called "accentual boost" by Kubozono (1993), who was the first to provide careful phonetic documentation). This is true even though Japanese accent is not stress-like, in that it does not cause greater segment durations, is not considered a strong position for alignment with musical meter, etc.

3.1 A speculative connection between tonal spreading and tonal dissimilation

There are a number of plausible reasons for the dissimilatory phenomena just described. For example, we know that the same segment will be phonetically different in different syllabic positions, often in a predictable way. Onset position is somehow more consonantal, so that tract closing gestures will be longer and stronger there than in the coda, whereas by contrast a nasal in coda position will have a longer and stronger velum opening gesture than in onset position. Perhaps something similar is happening in tonal complexes. Perhaps being in a [s w] or [w s] relationship with another tone always provides extra oomph. However, at least in the case of Yoruba, there is an interesting possibility that connects tone spreading with tone dissimilation.

(25)a. Undershoot in HM b. Less undershoot in HL with spread target



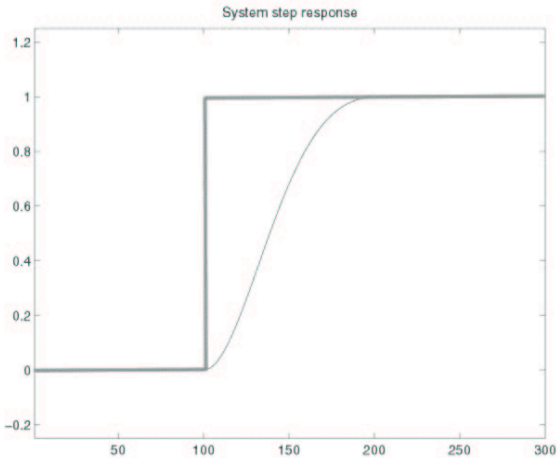
This idea depends on the observation, going back at least to Ohman (1967), that a simple linear model of co-articulation as smoothing shows a somewhat lifelike undershoot of articulatory targets, as long as the time constant of the low-pass filter is large enough relative to the time scale of sequence of target values in the input. We can be sure that the inertia of speech articulators creates a low-pass effect, and that the time constant involved is large enough to create such undershoot. In this situation, spreading out the target value in the input will certainly decrease or even eliminate the amount of undershoot.

The two plots in (25) demonstrate this effect. Each show a VCV sequence, with vertical lines marking the start and end of the medial C, which has a duration of 70 milliseconds. In both plots, we start with a mid-valued tonal target at the beginning of the first vowel. (25a) shows a HM sequence: in this case, the H target is at the end of the first V, whereas the M is implemented by supplying mid-valued targets for both the initial and the final target positions of the second vowel. (25b) shows a HL sequence: in this case, the H target spreads to occupy both the final position of the first vowel, and the initial position of the second vowel, while the L target applies to the final position of the second vowel. Straight-line interpolation among these input values creates the thick lines, representing the inputs. These inputs are thus a literal phonetic translation of the

phonological representations we have proposed.

The inputs are then smoothed with a low-pass filter whose step response, shown in (26) below, requires roughly 100 milliseconds. The thin lines in (25a) and (25b) are the results. Unsurprisingly, the input with the spread-out target is released from undershoot, and thus appears to show dissimilation (here H-before-L raising).

(26) Step response of the low-pass filter

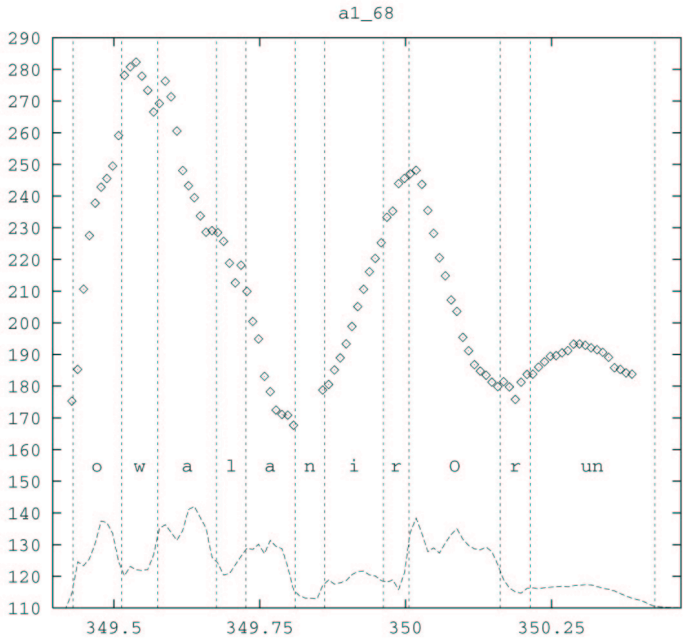


3.2 A remark on sparse tone association

In addition to the phonetic similarities that we have cited between Yoruba tonal complexes and Japanese accent, we might remark in passing on the issue of sparse vs. dense tonal association. Pierrehumbert and Beckman (1988) argue at some length that tonal association in Japanese is sparse, in the sense that there may be arbitrarily long stretches of moras without any tonal association. Their primary argument is a phonetic one: they show that these unspecified regions tend to show gradual transitions between the F0 target created by one associated tone to the F0 target created by the next one, with the slope of the transition depending on its duration.[12]

[12] See also Myers (1998) for "surface underspecification" of tones in Chichewa.

(27)



ó wà là ní rọ̀ run 'he drove Alani to heaven'
H (L) H L M

Our analysis of Yoruba requires tonally unspecified regions for phonological reasons – that is our analysis of the Mid tone. However, we want to point out that stretches of material that is all tonally specified, in languages like Igbo and Yoruba, may also show exactly the kind of gradient transitions that Pierrehumbert and Beckman found in Japanese. This is because (as a factual matter) the tonal targets are placed at the ends of each stretch of like-toned material: according to our analysis, a single tonal complex, with one or two tonal target points, is associated with the whole stretch. We showed this before for Igbo in (8); for a simple example in Yoruba, see the F0 track in (27), where a fall is distributed over the two L syllables wà là.

4. Tone polarization and epenthesis in Kɔnni

In the preceding sections we discussed the phenomenon of "tone spreading" in Yoruba, which in our proposal forms binary tonal complexes of LH and HL that take the syllable as domain. In the case of Yoruba the head position of a tonal complex can be occupied by H or L, since Yoruba permits words with all L tones. In this section, we turn to tone polarization[13] and epenthesis in Kɔnni, a language of the Gur family. We discuss the facts of Kɔnni in some detail and then briefly compare them to those of Dagaare, another Gur language, at the end of the section. Kɔnni differs in two ways from Yoruba. First, the domain of a tonal complex is the prosodic word. Second, the head of a tonal complex must be a High tone. Kɔnni utilizes the maximal form of a tonal complex **(L (HL))**, and this structure accounts for both the surface distribution of tone in Kɔnni words, and also the output of tonal processes.

Word-level constraints on the distribution of tonal complexes are a familiar phenomenon in accentual systems, where it is normal to find (for instance) that there must be a High tone on the last or next-to-last syllable of any noun. (See van der Hulst and Smith 1986 and references contained therein.) In this section, we will argue that some of the characteristic complexities of Gur tonal systems can be explained by stipulating word-final accent as an output constraint on certain phonological domains, while permitting a wide range of lexical tonal specifications. Other facts about Gur tonology follow from a requirement that lexical tones be parsed into a series of tonal complexes, just as lexical segments must be parsed into syllables.

This approach allows us to make sense of some constraints on word-level tonal patterns that are otherwise disconnected, and may even seem rather peculiar. For example, consider the case of the tone patterns of nouns in Kɔnni, a language of the Gur family (of Niger Congo) spoken by about 2500 Kɔma people in the Northern region of Ghana (Naden 1989, Cahill 1999, and others).

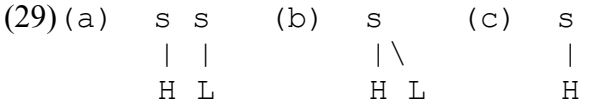
(28) Kɔnni nominal tone patterns

- (i) All Kɔnni nouns must contain at least one High tone.
- (ii) Although any number of initial syllables may be Low, at most one syllable at the end of a noun may be Low.
- (iii) Noun-internal HLH sequences are possible – they surface as H$^{\downarrow}$HH – but noun-internal HLLH sequences are not found.

This much is point-for-point analogous to the word patterns allowed by a simple syllabic system, in which non-final syllables must be V or CV, while word-final syllables may be V, CV or CVC. The remaining issue is to specify the principles of alignment

[13] In this section, we use the terms "polarization" and "dissimilation" interchangeably. We use polarization to keep the term that our primary source, Cahill (1999), uses. In principle one might distinguish between polarization and dissimilation by reserving polarization for segments without input tone, where an opposite tone is created, and dissimilation for cases where an input tone changes to become different from a neighbor. We argue below that the Kɔnni segments involved have an input tone.

between the tonal and non-tonal (structured) tiers. In Kɔnni, basic nouns (i.e. excluding compounds) must end with one of three tonal patterns:

(29)


This is equivalent to saying that the last tonal complex must be aligned with the end of the noun, with the core High also as close to the end as possible. (29a) is permitted because it allows the final L to have its own syllable; (29b) arises just in case the configuration in (29a) is ruled out by other factors.

As we will see later on, this same idea about targeted output structures can help explain cases in which tonal features "polarize" in some morphological contexts.

4.1 The facts of Kɔnni tone

We begin by presenting the facts of Kɔnni tone. All the data discussed here are from Cahill's (1999) detailed and insightful description of the language. We differ from Cahill's interpretation and analysis of the data in significant respects, as we will show. Kɔnni nouns exhibit tonal contrasts; but verbs have no lexical tone, their tonal is dependent on aspect. Our focus here will therefore be on nouns.

4.1.1 Nouns

Following Cahill's description, Kɔnni has **High** and **Low** basic tones, and a downstepped High tone which occurs after a High. The tonal contrast is visible in the monosyllabic nouns in (30) and disyllabic nouns in (31). Each of following monosyllabic nouns ends in the word-final singular suffix *-ŋ́*, so an LH monosyllabic noun is actually a Low tone stem and a High tone suffix. The disyllabic H$^{\downarrow}$H nouns in (31) are HL stem nouns followed by the singular suffix *-ŋ́*.

(30) Monosyllabic nouns

LH (rising) vs. H			
kʊ̀áŋ	'back'	kʊ́áŋ	'farm'
dàáŋ	'stick, day'	dááŋ	'alcoholic drink'
ɲɪ̌ŋ	'bush partridge'	ɲɪ́ŋ	'tooth'
ɲʊ̌ŋ	'market'	ɲʊ́ŋ	'yam'
H vs. H$^{\downarrow}$H			
chɪ́ɪ́ŋ	'moon, month'	chɪ́$^{\downarrow}$ɪ́ŋ	'squirrel'
gbɪ́ɪ́ŋ	'catfish'	gbɪ́$^{\downarrow}$ɪ́ŋ	'sleep'
HL vs. LH			
chɪ́àŋ	'chair'	chɪ̀áŋ	'bottom, waist'

mîɪ	‘older sibling’ (same sex))	mɪ̀ŕŋ	‘biting ant’

(31) Disyllabic nouns

LH vs. HH

kpìbíŋ	‘louse’	kpíbíŋ	‘shea nut’
nʊ̀àmíŋ	‘floor pounder’	nʊ́ámíŋ	‘scorpion’
yìsíŋ	‘duiker antelope’	yísíŋ	‘sheep’

LH vs. H$^{\downarrow}$H

hààríŋ	‘tree (sp.)’	háá$^{\downarrow}$ríŋ	‘boat’
kpɪ̀ɪlíŋ	‘thigh’	kpíɪ$^{\downarrow}$líŋ	‘hawk (sp.)’
tʊ̀ʊlíŋ	‘headpad’	tʊ́ʊ$^{\downarrow}$líŋ	‘heat’

LLH vs. HH

nànjʊ̀ʊŋ	‘pepper’	nánjʊ́ʊŋ	‘fly’

In spite of the apparent tonal contrasts in (30) and (31), there are significant restrictions on tonal occurrence. The broad facts can be stated as follows.

(32) The broad facts of Kɔnni tone

(i) There are no LL nouns. No noun, or other word in Kɔnni, is pronounced with all Low tones in isolation (regardless of the number of syllables) (Cahill 1999: 372). It is instructive to note that **Moore**, **Dagaare** and **Tem** (see section 6) (three other Gur languages) have similar surface tone patterns: in disyllabic nouns, HH, HL, and LH are attested, but not LL (Kenstowicz, Nikiema, & Ourso 1988; Anttila & Bodomo 1997, 2002; Anttila 2001; Tchagbale 2002).

(ii) In Kɔnni, an “utterance” must have a High tone somewhere. If there is none present underlyingly, one is inserted (Cahill1999: 372). Though Cahill uses the word “utterance”, our focus is on nouns and we will restrict the domain of this restriction to N^0, a bare noun.

(iii) There is no HLH sequence phonetically within a word, and only rarely across words. An underlying HLH sequence is realized as H$^{\downarrow}$HH on the surface. (Cahill 1999: 340, etc.)[14]

(33) *zàsíŋ* ‘fish’ *ŋ̀ wó$^{\downarrow}$zásíŋ* ‘I lack fish’

[14] Cahill regards H$^{\downarrow}$H as a falling tone, and he notes that it also occurs only on bimoraic syllables, such as a long vowel or a closed syllable.

Within a word, sequences of two or more L syllables between H syllables appear never to occur: *HLLH, *HLLLH, etc.

(iv) In CV syllables, only the HL falling tone is attested. LH rising does not occur on a CV syllable, they occur only on bimoraic syllables, such as a long vowel or a closed syllable.

In the following discussion we link ALL of the above restrictions, as well as the occurrence of tone polarization, to the formation of *tonal complexes* (the structured combination of tones).

4.2 An explanation of the Kɔnni facts

The above tonal facts can be accounted for by assuming that a tonal complex must be formed at end of every minimal N^0 in Kɔnni. This includes a noun stem with a number suffix, or a bare noun stem in a compound construction. It does NOT include a noun followed by a determiner, which is logically a structure at a higher phrasal level of the syntactic hierarchy, such as N^1 or DP.

This observation can be captured with a constraint like ALIGN-TC (or a constraint like ALLTCR in parallel to foot formation):

(34) TC Alignment
ALIGN-TC: The right edge of every tonal complex must be aligned with the right edge of a minimal N^0.

In many cases, the final tonal complex is the only tonal marking of a Kɔnni noun.[15] In other cases (those with internal downsteps) there are several tonal complexes (because two H tones separated by an L tone cannot parse into a single tonal complex). As far as we can tell, these forms are always morphologically complex, so perhaps a simple noun stem in Kɔnni must always have exactly one tonal complex. However, this is not crucial to our analysis.

Note that L tones in Kɔnni nouns are treated in three different ways from the point of view of alignment. At the beginning of a noun, an arbitrary number of L syllables is allowed.

(35) zàsíŋ ‘fish’
nʊ̀àmíŋ ‘floor pounder’
nànjʊ̀ʊ́ŋ ‘pepper’

It is natural to treat these as multiple linkage of an (optional) initial L. Internally in a noun (i.e. between H tones) only individual L tones are allowed underlyingly, and

[15] The constraint ALIGN-TC in combination with another (such as PARSE-TONE), which ensures are parsed into tonal complexes will enforce this.

these do not surface phonetically, appearing only as downsteps in a sequence of H tones. At the end of a noun, at most one L syllable is permitted (and a final HL contour is also permitted). If we leave the internal (downstep-inducing) L's in place, and apply the OCP (in Leben's original sense), so that any sequence of like-toned syllables is treated as multiple linkage of a single tone, then the permitted tonal sequences in Kɔnni nouns are like those shown in (36):

(36) H, HL, LH, LHL, LHLHL, LHLH, HLH, HLHL, etc.

These are all and only the alternating patterns that contain at least one H tone. They are also isomorphic to the CV patterns of a language in which onsets are obligatory except in word-initial position, and codas are forbidden except in word-final position. Note however that this must be construed as the opposite of syllable structure, because the preferred tonal complex here is (HL). Thus initial L-tones of a tonal complex are forbidden except in absolute word initial position.

To get the surface tonal patterns of Kɔnni, we must

(37) (a) allow the initial L to spread to multiple syllables;
(b) allow all H's to spread to multiple syllables;
(c) turn each medial L into ꜜH
(d) assign the final L to the final syllable (which may or may not also be linked to the preceding H).

The result is the observed syllable-by-syllable pattern of surface tones Kɔnni nouns, such as

(38) HHL, HHH, LLH, LLHHL, etc.

Our argument is that the emergence of the patterns in (36) and (38) are not accidental conspiracies of lexical specification and morpho-tonological rules, but rather are targeted outcomes roughly in the way that surface syllable structures are, with an extra wrinkle imposed by constraints on the alignment of tonal and segmental structures.

Informally, we propose that the following general constraints explain the surface tonal outputs in Kɔnni, in addition to those already seen earlier. As we shall show in the following sections these constraints are so broad that they explain most of Gur tone and beyond.

(39) Additional constraints:
(a) Tonal complexes are headed.
(b) Heads must be H tones.
(c) There is only one tonal complex per domain.

We are now in a position to offer an explanation of the broad facts of Kɔnni tone stated in (32).

(a) Lack of LL nouns, and H insertion: The absence of LL sequence, and the mandatory insertion of an H on the surface even when there is none in the input.

We propose that both facts follow from the fact that each noun must have a tonal complex and the kind of tonal complexes allowed, as seen above. Taking a surface form like **hɔ̀gú** 'woman' (LH) as an example, Cahill (1999: 368, 479) argues that the underlying tonal representation is Ø (i.e. underlyingly toneless). His argument is based on the following paradigm, in which the form takes a different tonal pattern (LH, HH, or HL) depending on the context.

Note: Cahill proposes that associative constructions, and his/her constructions have a floating H tone. (kàànɪ́ 'one')

(40) hɔ̀gú 'woman'
Ø

hɔ̀gú wún↓ná	'this is a woman'	hɔ̀gú ↓káánɪ́	'one woman'
ŋ̀ wó ↓hɔ́gú	'I lack a woman'	ù hɔ́gù	'his/her woman'

In isolation, if a completely toneless form must have a tonal complex and if the tonal complex must be headed by a high tone, then one has to be inserted. If the head of the tonal complex must be as close to the right edge as possible, then the high tone must be inserted on the last syllable. Low tones are inserted on the initial syllable(s) because this is the less marked tone. Finally, TC-initial tones are permitted only if they occur at absolute word initial position, hence insertion initially. Therefore an underlyingly "toneless" form like **hɔ̀gú** 'woman', surfaces (LH).

(b) There is no surface HLH: Our explanation of this fact is as follows:
First, HLH cannot constitute only one tonal complex (just as VCV cannot form a single syllable). Secondly, we must assume that in an H↓H sequence there are two tonal complexes, built around the two H tones. This is forced by the need not to delete any tones. Finally, TC-initial Ls are only allowed in absolute word initial position, and single Ls are permitted only word finally. As we will see later in this paper, languages allow different ways of resolving HLH sequences within a single domain, depending on the overall constraint-ranking preferences of the language.

Taking a form like **tá↓síŋ** 'headpan', as an example, the input form is HL+H, the final H coming from the singular suffix *-ɲ́*. In this case, the output *must* violate the constraint on having only one tonal complex per domain, because HLH cannot be parsed into one tonal complex. The least offensive interpretation for Kɔnni is H↓H as two tonal complexes.

4.3 Tone Polarization in Kɔnni nouns

As Cahill notes, an overwhelming majority of nouns, whether singulars or plurals, definite or not, end with a High tone. The high tone can be either a downstepped High or a 'plain' High. The examples in (41) show that this high tone derives from one of the many high toned nominal suffixes. The exceptions to this generalization are some plurals in Classes 1 and 3, and a few singulars in Class 3 and 5. We return to the plural classes in the next section.

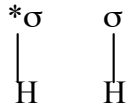
(41) Tones in nominal suffixes (Cahill 1999:345-346)

Nouns	Singular	Sg.+ Art	Plural	Pl.+ Art
Noun Class 1	/-ŋ́/	/-rÍ/	/-A/	/-A-hÁ/
stone	tǎŋ	tànní	tàná	tànáhá
chest	ɲúúŋ	ɲúúrí	ɲúrà	ɲú↓ráhá
nail	yí↓íŋ	yíí↓rí	yíímà	yíí↓máhá
bee	síébíŋ	síébírí	síébíè	síébié↓hé
breast	bɪ̀ɪ̀síŋ	bɪ̀ɪ̀sɪ̀rí	bɪ̀ɪ̀sá	bɪ̀ɪ̀sáhá
Noun Class 2	/-ŋ́/	/-kÚ/	/-tÍ/	/-tÍ-tÍ/
courtyard	gbàáŋ	gbàákú	gbàátí	gbàátítí
farm	kúáŋ	kúákú	kúátí	kúátítí
hawk	kpíí↓líŋ	kpíí↓líkú	kpíí↓lítí	kpíí↓lítítí
Noun Class 3	/-ŋ́/	/-kÁ/	/-sÍ/	/-sÍ-sÍ/
person	vúóŋ	vúóké	vúósí	vúósísí
dawadawa tree	dùúŋ	dùùká	dùùsí	dùùsísí
axe	lí↓áŋ	líá↓ká	líásɪ̂	líá↓sísí
fly	nánjúŋ	nánjúká	nánjúsí	nánjúsísí
man	dèmbíŋ	dèmbìké	dèmbìsí	dèmbìsísí
headpan	tá↓síŋ	tásí↓ká	tásísɪ̂	tásí↓sísí
Noun Class 4	/-ŋ́/	/-bÚ/	/-tÍ/	/-tÍ-tÍ/
water	ɲááŋ	ɲáábú	ɲáátí	ɲáátítí
meat	nɔ̌ŋ	nɔ̀mbú	nɔntí	nɔntítí
sleep	gbí↓íŋ	gbíí↓bú	gbíí↓tí	gbíí↓títí
peanut	sɪ̀ŋkpááŋ	sɪ̀ŋkpáábú	sɪ̀ŋkpáátí	sɪ̀ŋkpáátítí
ash	táɲéé↓líŋ	táɲéé↓líbú		
Noun Class 5	/-Ø/	/-wÁ/	irreg.	irreg.
child	bùá	bùàwá	bàllí	bàllílí

woman	hɔ̀gʊ́	hɔ̀wwá	hʊ̀áŋ	hʊ̀àbá
sister	táà	táá↓wá	táá↓líŋ	táálí↓bá

With the systematic exception of the plurals [-a/-e] in Noun Class 1, all the suffixes are High-toned. As the examples in (38) show, this High tone does not alternate (even after High toned stems (síébíŋ 'bee'; kʊ́áŋ 'farm'). This is an apparent violation of the Obligatory Contour Principle (Leben 1973, Goldsmith 1976, McCarthy 1986, Yip 1988, Myers 1997, and others), stated in (42).

(42) The Obligatory Contour Principle (OCP):
Adjacent identical elements are prohibited (on the same tier).



The question that arises here is whether the OCP is relevant in the noun-suffix domain in Kɔnni. There are two possible answers to this question. The first obvious answer is to say no, because a High tone suffix can follow a High tone stem. Cahill (1999) for example argues that the OCP is totally absent (or violated) in Kɔnni because two High tones can follow each other as shown by the surface contrast in the examples in (43). His argument is that there are two High tones in the first form "shade", and they are not fused, resulting in a falling tone in the plural noun "shades"; whereas the form "river" has a single high tone and hence there is no falling tone in the plural "rivers".

(43)	*jágíŋ*	*jág-â*	'shade(s)' (HH input)
	múgúŋ	*múg-à*	'river(s)' (H input)

One possible way of accounting for the difference in the plural forms in (43) is to say that the form "shade" includes a "floating" H tone, which is absent in "river". Support for this hypothesis comes from another class 1 (possibly related) noun "place". Compare the paradigms for "shade", "place", and "river" in (44) (from Cahill 1999:483).

(44)	Singular	Sing. + Art.	Plural	Plu. + Art.	Gloss
	já́gɪ́ŋ	já́gɪ́rɪ́	já́gâ	já́gá↓há	shade
	jíǵíŋ	jíǵírí	jíǵê	---	place
	mʊ́gʊ́ŋ	mʊ́gʊ́rɪ́	mʊ́gà	mʊ́↓gáhá	river

The idea is that in both "shade" and "place" the second high vowel is underlying, and its deletion leads to a floating H tone, whereas in "river" the second high vowel is epenthetic, to break the cluster created by the final singular suffix *-ŋ́*. Notice crucially that the downstepped high tone in the Plu. + Art. forms comes after the first syllable in "river", the only underlying H of the stem, but after the second syllable of "shade". If we assume that the OCP forbids two associated H tones (and applies to surface forms), then the problem is solved, and we do not have to assume that the OCP is absent in Kɔnni.

The second possible view, and the one that we will assume here, is that the noun-suffix domain is indeed an OCP domain in Kɔnni. The forms in (41) with two High tones can be accounted for by assuming that the suffixal High tone *fuses* with the stem High tone, respecting the OCP.

If this assumption is true, then how is it that some suffixal tones are High and others (the [a]/[e] Class 1 plurals) polarize, within the same domain? We turn to these polarizing suffixes immediately below.

4.3.1 The Noun Class 1 Plurals

The Kɔnni noun class 1 suffixes are realized as either *-a* or *-e,* depending on vowel harmony. It is *–a* after [-ATR] stem vowels and *–e* after [+ATR] stem vowels. This suffix exhibits tonal polarity, surfacing with a tone opposite to the preceding stem tone. As the examples in (45) show it is realized with a High tone after Low tone noun stems and with a Low tone after High tone stems. The first three examples in (45) illustrate monosyllabic noun stems while the remaining four illustrate disyllabic noun stems. The last example, sìkpárà "hearts" shows that it is H after an LH stem.

(45)

singular	plural	root tone	pl.suffix tone	gloss
tǎŋ	tàná	L	H	'stone/s'
síŋ	síà	H	L	'fish/es (sp.)'
wíŋ	wíè	H	L	'face mark/s'
bɪ̀ɪsíŋ	bɪ̀ɪsá	L	H	'breast/s'
yìsíŋ	yìsé	L	H	'antelope'
tígíŋ	tígè	H	L	'house/s'
sìkpááŋ	sìkpárà	LH	L	'heart/s'

The class 1 plural suffix however shows a level of complication that suggests this is not a simple case of tone polarization. If the root is HL, the plural **does not** surface as HLH, as would be expected. Rather, the pluralized noun surfaces as **HL**. The singular citation forms in (46) show that the nouns have input HL tones on the stem, because they surface as H$^{\downarrow}$H in combination with the singular suffix.

(46)

yí$^{\downarrow}$íŋ	'arrow'	*yíímà*	'arrows'	(cf. **yíí$^{\downarrow}$má*)	*yíí$^{\downarrow}$rí*	'the arrow'
bítí$^{\downarrow}$éŋ	'chin'	*bítíè*	'chins'	(cf. **bítí$^{\downarrow}$*é)	*bítié$^{\downarrow}$rí*	'the chin'

The data in (46) raises an important question: what is the underlying tone of the Noun Class 1 plural suffix, since as we have seen, it sometimes polarizes and other times

it does not? The underlying tone of the suffix cannot be High, because High tone suffixes do not alternate (i.e. polarize), as the singular suffix [-*íj*] shows.

Again, there are two possible answers to this question. The first, and probably most obvious answer is to assume that the suffix is *toneless*. Thus it takes the tone opposite to the tone of the preceding noun stem. The second answer is to assume that the suffix is Low toned. It dissimilates to the preceding tone when the preceding tone is Low. We argue here that the plural suffix is indeed **Low** toned.[16]

At first look, one could see the tone dissimilation in the plural class 1 suffix as an OCP effect: a Low tone suffix dissimilates to a preceding Low. But there are several issues in the analysis of Kɔnni tone facts, which are beyond the OCP.

(47) Issues beyond the OCP
(i) Why is an H tone required in a word?
(ii) Why is an OCP violation resolved by H tone fusion in the H suffixes, and by dissimilation in the L tone suffixes?
(iii) Why does the L tone suffix not dissimilate to H after an HL stem in the examples in (45)?

The first question has already been addressed above. We propose that the answer to the last two questions lies again in the formation of *tonal complexes*, and we now proceed to show how.

4.3.2 The low tone suffix

We can re-state the second question as follows: **why is there "polarization" in only one suffix?** The answer to this is that the so-called polarizing suffix is the only suffix that is Low toned. As we have suggested above, H tones are analogous to vowels. Therefore, H tones can independently form a tonal complex or join with an L, just as vowels can independently form syllables or join with consonants. L tones are like consonants; hence they (prefer to) form tonal complexes with H's.

The majority of Kɔnni suffixes are H toned, as in the singular suffix [-*íj*]. They can join with a preceding L to form a final (LH) complex, and they can also merge with the preceding H to respect the OCP, as they do after H tone noun stems.

The plural class 1 suffix, being L toned, **must** form a tonal complex with a preceding stem. It dissimilates to H after an L toned root to form a complex with it (forming an (LH) complex), because it cannot form a complex by itself. It remains L after an H stem because a (HL) complex is possible. If the preceding stem tone is (LH), it remains L. In this case it joins with the preceding LH, forming a maximal complex

[16] Note that Cahill (1999) argues that the plural class 1 suffix cannot be L toned because "this runs into problems in the case of *tànáhá* 'the stones.' This word is divided into morphemes as *tàn-á-há*. If the plural suffix *-a* is underlyingly Low-toned, there is now no motivation for it to change to High, since a High is already present in the definite suffix *-há.*"

(LHL) (sort of like CVC syllable). As we have already shown with the account of general tone distribution an initial L is allowed if the L aligns with the beginning of the domain, and a final L is allowed if the L aligns with the end of the domain. No internal Ls are allowed.

In a simple form like yìsé 'antelopes', the general idea is that since tones must be parsed into tonal complexes, and since the L tone suffix must form a tonal complex with the preceding noun root, and since an L tone cannot head a complex in Kɔnni, dissimilation is compelled.

To ensure that this happens, in addition to the assumptions in (39) we must ensure that:

(48) i. Root tones do not change.
ii Tones are not deleted.

A form like *jág-â* 'shade(s)' (HH input), illustrates a case in which there is already H in the noun root, and so dissimilation is unnecessary to achieve a well-formed tonal complex, and so the L of the plural suffix simply stays unchanged, resulting in (HL) complex.[17]

4.3.3 An Explanation for the HL Root Complication

If the noun root is underlyingly HL, the plural **does not** surface as HLH or H$^{\downarrow}$HH as may be expected from simple dissimilation of the suffixal L tone. Rather, the suffixed noun surfaces as HL. We repeat the examples from (46) as (49) below.

(49)

yí$^{\downarrow}$íŋ	'arrow'	*yíímà*	'arrows'	(cf. **yíí$^{\downarrow}$má*)	*yíí$^{\downarrow}$rí*	'the arrow'
bítí$^{\downarrow}$éŋ	'chin'	*bítíè*	'chins'	(cf. **bítí!*é)	*bítié$^{\downarrow}$rí*	'the chin'

The question is, why is the surface output HL better than the surface output H$^{\downarrow}$HH? One obvious difference is that it is one tonal complex rather than two. This might be preferable in and of itself, or it might be preferable because in the two-tonal-complex case, the first tonal complex is quite non-final.

Note that the primary goal appears to be that the surface tonal structure in the noun+suffix domain forms a tonal complex. The input structure HL can already form a complex by itself, so there is no need for the suffixal L tone "dissimilate" to supply an H. Therefore the L of the suffix simply fuses with the final L in any HL noun, hence the apparent conspiracy.

[17] Notice that if the suffix [a] is indeed toneless as Cahill (1999) proposes there is no reason why the output of this form is not *[já́gá́], since he also assumes that this form has two H tones in the stem, and the second H is available to link.

The above solution unifies what happens in the H tone suffix after H tone stems, namely nothing. The H tone suffix must be assumed to "fuse" with the H of the stem. After L tone stems they don't "polarize" because they can form tonal complexes with the preceding Ls. (It also provides support for our position that the plural suffix must be L.)

Essentially, the generalization is that a suffix tone does not "polarize" unless there is the need to form a tonal complex. If one can be formed without polarization, then nothing happens. A straight OCP or dissimilation approach cannot explain this fact.

Finally, a form like *bítíè* 'chins' (singular bítí́ḛ́ŋ) can be explained by assuming that the final [e] of the root, and the [e] of the suffix fuse. The H tones of the root also fuse (by OCP) on the surface.

One result of the approach proposed here is that there are no constraints like **POLARIZE**. Tone dissimilation or polarization occurs simply to satisfy a higher prosodic demand: the demand that tones form tonal complexes, the structured combination of tones. If tonal complexes can be formed without dissimilation, then nothing happens.

Thus the three intriguing properties of this language -- the lack of LL nouns, the presence of H in every noun, and polarity/dissimilation in just one suffix -- all immediately follow from the need to form tonal complexes of a restricted kind.

The facts of Dagaare, another Gur language (Anttila and Bodomo 1997, 2002, and Anttila 2001), are close to those of Kɔnni. Like Kɔnni, there are no LL nouns in Dagaare. Also like Kɔnni there must be an H in a word. The basic tonal differences between Kɔnni and Dagaare are the following:

(50) (a) The number suffixes (singular and plural) are High toned.
(Dagaare does not have a Low tone suffix like Kɔnni.)

(b) The number H-tone suffix polarizes in Dagaare, unlike Kɔnni.

(c) In trisyllabic nouns of the form HØ + H, that is, a disyllabic noun plus a number suffix, the H tone suffix does not polarize.[18]

These Dagaare facts can be handled by assumptions close to those proposed for Kɔnni above. Dagaare has the same requirement of a tonal complex within a minimal N^0 as Kɔnni, and Dagaare has the same tonal complexes as Kɔnni. Tone polarization takes place in the number suffix in Dagaare because the language prefers tone change to tone merger. That is, as long as the requirements of having a tonal complex and satisfying the OCP are met, Dagaare chooses feature change over feature merger in the number suffixes.

[18] We will account for the first two differences, since Anttila (citing Kennedy 1966) notes that the trisyllabic nouns may be compounds.

5. Tonal conspiracies in Lokaa and Tem

Our experience is that nearly every system of tonal morphophonology is substantially simplified, at least in some respects, when analyzed in terms of tonal complexes; and that intricate and seemingly arbitrary patterns often turn out to be the direct consequence of simple constraints on the formation and alignment of such tonal structures. Our detailed discussion of Yoruba and Kɔnni illustrates these points; we have prepared re-analyses in similar depth of a number of other languages, which must be published separately for reasons of length, where similar results arise.

Just as important, we find evidence that the typological implications of these ideas are realized in practice. If we consider the obvious ways in which such structures and constraints might plausibly interact, we find the corresponding patterns instantiated in particular languages. This idea is analogous to the famous "factorial typology" of syllable structure proposed by McCarthy and Prince (1993). Unfortunately, the basic facts of syllable structure and its interactions with word formation processes are more widely documented and more familiar to readers than the analogous tonal facts are, so that it is not as easy to cover a wide range of tonal cases so quickly. However, we want to sketch at least one example of each of the four cases that we cited in the introduction. We've covered tone polarization and polarized tone epenthesis in Yoruba and Kɔnni at some length; we will now close with a much shorter discussion of H tone insertion and tonal metathesis in Lokaa and Tem. Lokaa is treated in more detail in Iwara, Akinlabi and Truckenbrodt (2003) and Iwara (2004), while a detailed analysis of Tem has been split out into a companion paper to this one (Akinlabi and Liberman, in prep).

5.1 Lokaa

In Lokaa, an Upper Cross language of Nigeria (Faraclas 1988), verbs must have at least one high tone in isolation. A verb which has no underlyingly H tone must have one inserted. However, if there is a High tone clitic or prefix preceding the verb, H tone insertion is blocked.

A less commonplace fact about Lokaa is that a noun-plus-clitic unit cannot have two high tones separated by a L tone (i.e. HLH). If cliticization creates such a sequence, it metathesizes to create a HHL sequence.

The same sort of tonal metathesis occurs in several other contexts in Lokaa: associative constructions, relative clauses and questions.

In Lokaa associative constructions, an associative marker [Cə́] occurs between Noun1 and Noun2. The consonant varies depending on the noun class of the first noun, which we refer to as N1. The vowel of the associative marker is invariably [ə́]. The associative marker is underlyingly H. The underlying tonal structure of the preceding N1 is never altered, but the tonal structure of N2 is often modified by the H tone of the associative marker, in a way that is not affected by the underlying tone of N1.

In this construction, when N2 is HH or HL, its tone is unchanged. When N2 is LL, the associative H onto the first L, making it a falling HL; this is basically just as in Yoruba. When N2 is LH, however, it surfaces as HL.

Schematically, XX + H + **LH** becomes XX + H + **HL**. That is, a potential HLH sequence is reversed to HHL. Exactly the same pattern of tonal effects can be found in Lokaa questions and relative clauses, where there is an overt H-toned "relator" or question morpheme at the start of the clause.

Lokaa combines one formal property each from the languages we have previously examined. As in the Gur languages, the domain of the tonal complex is a prosodic word. Like Yoruba, an L can be the head of (and in fact the entire) tonal complex when nouns are pronounced in isolation. And like Kɔnni, Lokaa permits the maximal tonal complex (LHL) within a tonal domain.

A key difference, however, is that Lokaa is willing to abandon the underlying order of tones in order to repair a violation of its desire to have "exactly one tonal complex per phonological word," so that a derived HLH sequence becomes HHL.

5.2 Tem

Tem is a central Gur language of Togo and Benin (pop. 300,000; SIL 1987). The tonal system of Tem involves another conspiracy, this time between H tone insertion noun roots and tone polarization in nominal suffixes, both of which take place only when the obligatory "gender" suffixes are added to the noun roots. These two processes conspire to limit the surface tonal pattern on Tem bisyllabic nouns to LH and HL. We argue that both processes are the result of satisfying constraints on tonal complexes. The discussion in this section is restricted to the pitch phenomena in nouns. It is further restricted to alternations in root + suffix contexts. (See Tchagbale 1973, 1976, 2002, and Akinlabi and Liberman (in preparation) for further details. We are indebted to Dr. Tchagbale for data provided in personal communications.)

The intricacy of the pitch system of Tem has often resulted in different characterizations at different times. For example Tem has been variously analyzed as an accentual system (Tchagbale 1973), a tone system (Tchagbale 1976), and a tonal accent system (Tchagbale 2002).

The basic tonal facts of Tem, according to Tchagbale 2002, are that

(51) (a) Monosyllabic nouns can only be H toned on the surface.

(b) Bisyllabic nouns, which in general consist of a monosyllabic root and suffix, can only be HL or LH.

(c) Trisyllabic nouns (root + suffix) cannot have the tone pattern HLH. The most common patterns are LHL and LLH; a few cases of HHH occur.[19]

[19] Tchagbale (2002) has two nouns of the form prefix + root + suffix, which have the LLL pattern.
ɖi̩ - ɲin - ɖe̩ "mad"

(d) HLH across morphemes often changes to HHH.

Tem has nine plural suffixes, divided among five "genders" or noun classes (one of the classes, for mass nouns, has no plural). In Tchagbale's analysis, five of the suffixes have L tone; one has H tone, and three have polarizing tone.

If we assume that monosyllabic roots can be underlyingly H or L, then there should in principle be six ways to make a bisyllabic noun from a monosyllabic root and a monosyllabic suffix: H or L for the root, and H, L or P(olarizing) for the suffix. How are these six options mapped to the three possible surface outcomes HL and LH?

H+L and L+H emerge unchanged as HL and LH respectively. H+P and L+P by definition emerge as HL and LH. All Tem roots end in a vowel, and the only H-toned affix is /a/, which coalesces with a H-toned root to form a monomoraic H-toned output.

The new case is L+L, which emerges as HL. This outcome is a tonal dissimilation of a familiar sort, except that it changes the root tone rather than the suffix tone, which we have not seen before.

Thus among bisyllabic bimoraic nouns there are only two tonal possibilities, HL and LH, since HH nouns become monomoraic H. We propose that this is not a accident, but another logical result of the organization of tones into tonal complexes.

In Tem, and the H "nucleus" is obligatory. Tem enforces this by making L roots H if an affix does not supply an H, which will be true for L roots followed by a L affix as well as in the case of monosyllabic nouns, where no affix is present. The H tone is inserted on the last tone-bearing unit of the noun root rather than the suffix, because of a preference for the H (the peak) to be aligned with the root, other things equal.

Finally, there is an additional parallel to some of the other cases discussed earlier. There are no HLH trisyllabic or trimoraic nouns, though LHL is possible on these nouns. We propose that this results from the fact that the root plus suffix domain is *strictly* a one tonal complex domain. HLH is avoided on nouns and elsewhere because this creates two tonal complexes in a domain where only one is permitted. Within the noun plus suffix domain, Tem turns HLH sequences to HHH

6. Other approaches to tonal organization

Several recent studies have proposed different approaches to tone organization. The most similar approach to the one advanced in this study is the "tonal foot" (Bamba 1991; Leben 1997, 2002; Manfredi 1995; Zec 1999; Yip 1996; and others).

In his discussion of the tone system of Maninka, Bamba (1991) posits a metrical structure with strong and weak nodes as the basis for the surface tones. Zec (1999)

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kɛ̀ - sɛ̀n - kà [kɛ̀sɛ̀ŋà] "soul"
Our focus here is going to be on the root+suffix domain.

employs tonal feet to analyze the tone-stress interactions in the pitch-accent system of Serbo-Croatian described by Inkelas and Zec (1988). In an approach similar to Bamba (1991), Manfredi (1995) proposes a metrical analysis of Yoruba tone; and Yip (1996, 2002) also proposes tonal feet in Chinese, citing work by Shih 1986 and Duanmu 1995). More recently, Leben (2002) suggests that the key to explaining the distribution of tone in Bambara trisyllables is to divide them exhaustively into maximally binary feet, and to associate each foot with one of two possible tonal patterns. Furthermore, he uses that idea of tonal feet to account for the tone pattern of Hausa borrowed words.

Representative of the idea of tonal foot is Leben (2002). Leben proposes that a tonal foot structure could refer to prosodic structure on the segmental tier, or on both the segmental and tonal tiers, but never the tonal tier alone (Leben 2002:30-31). There are similarities and differences between the ideas proposed in this work, and the idea of a tonal foot. First, in both works the tonal tier is organized into "prosodic units". Secondly, in both works, the tonal organization has some connection with the segmental tier. Finally, in both works an HLH sequence cannot form a unit.

However, there are significant differences. In the proposals made here tonal complexes structure features or segments on the tonal tier rather than the "segmental" one. The connections to the segmental tier are established by constraints on the domains of tonal complexes or their alignment with segmental entities. Secondly, a sequence of LHL can represent a single tonal complex (the maximal unit); as we have seen in Kɔnni, Lokaa and Tem. Such sequences are usually broken into two feet within the tonal foot theory. Finally, the H tone has no central role in the tonal foot theory. As we have suggested in this paper, H seems empirically to be the tone around which structural units are preferentially built. It seems to represent the "peak" of a tonal complex, like the vowel in a syllable, even though in some cases, tonal complexes of the form [L] or [LH] may be found.

7. Concluding remarks

In the foregoing sections we have proposed enriching tonal representations to include some simple kinds of structures to organize tones, which we call tonal complexes. These structures are analogous to the syllable-related structures that play such a central role in segmental phonology. The motivation for notions like mora, syllable and foot is that they are useful, again and again, in enabling simpler descriptions of complex phonological and morphological patterns, and therefore in helping us to understand how and why these patterns develop as they do. The motivation for tonal complexes is exactly the same.

Our examples have mainly been drawn from the Benue-Congo languages of West Africa, where tonal complexes play a central role in phenomena such as tone spreading; tone polarization and dissimilation; and tone deletion, epenthesis and metathesis. These phenomena typically organize themselves into "conspiracies" who effect is easy to state if we can make reference to surface patterns of tonal complexes, and difficult to state otherwise.

In many accentual languages (e.g. Japanese), the entities called "pitch accents" are in fact tonal complexes, and have both phonological and phonetic properties that are reminiscent of the derived tonal complexes in West Africa. Yip (2002:147) points out that "Asian languages treat [tonal] sequences in many ways as units," referring to a range of roles that tonal complexes may play in a very different set of tonal systems.

In summary, we feel that it is past time for phonologists working on tone to begin sharing some of the rewards that their segmental brothers and sisters have been enjoying for the past several decades.

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