The Phonology of Tone

The Representation of Tonal Register

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Mouton de Gruyter
Berlin · New York 1993

Issues in the Representation of Tonal Register

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1. Introduction*

Given that the majority of the world's languages is tonal, it is incumbent upon phonologists to strive towards the development of phonological theories which provide an adequate formal account of tonal phenomena. Efforts to this end have been many but the issues involved remain far from settled. In part, this is due to one aspect peculiar to tone, the fact that tonal oppositions are relative in nature; e.g., a phonetic Low tone can often be differentiated from a phonetic High tone only by comparing the two in a specific environment. This would be comparable to analyzing a vowel system in which a morpheme ending in [i] could be differentiated from one ending in [a] only by comparing each with a postposition that begins with a vowel of known quality.

The problem of establishing contrasts between elements which are only relative in nature is further compounded by the fact that there appear to be registers involved. Clements (1990:59) defines "register" as the "frequency band internal to the speaker's range, which determines the highest and lowest frequency within which tones can be realized at any given point in an utterance". Under certain conditions, this register can be shifted upward or downward, and this shift in register then re-establishes the fundamental frequencies at which the various affected tones are phonetically realized.

The present chapter includes a presentation of some major problems involved in formally representing tonal register phenomena. It also provides a discussion of various attempts to overcome these problems, and concludes with a summary of the proposals which form the content of the subsequent chapters in this book.

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* We thank Larry Hyman, Victor Manfredi, and Jeroen van de Weijer for giving comments on an earlier version of this paper. We also thank all contributors to this volume for their help in writing section 3.

2. Problems in representing tonal register

In this section, we wish to outline some of the major problems to be confronted in the representation of tonal phenomena. Although we focus on issues relating to register, our perspective is slightly broader than that. We first deal with the question how many *tone heights* must be distinguished. We next look at the matter of *contour tones* and, finally, we consider the problems involved in formally representing *shifts in tonal register*.

2.1. Multiple tone heights

Perhaps the most basic problem which confronts the tonologist is how to formally represent multiple tone heights, both in underlying and in derived representations. Here we specifically talk about *level* tones, i.e. tones which, from a phonological point of view, are not considered to be contours. It seems that at least four discrete levels of height need to be accounted for. In a paper devoted to this subject, Hyman (1986) lists Igede as having four underlying and four surface levels, Gwari as having three underlying but four surface levels (cf. Hyman and Magaji 1970), and Kagwe as having four underlying but three surface levels (cf. Koopman and Sportiche 1982). There are a few studies, however which report five discrete levels. One of the earliest and most convincing descriptions of such tone systems is that of the San Andres Chicahuaxtla dialect of Trique (Longacre 1952). Five levels are also assumed in the Copala dialect of Trique (Hollenbach 1984 and 1988), Miao-Yao (Chang 1953), Dan (Bearth and Zemp 1967 and Flik 1977), and Bencnon (Wedekind 1983). Cf. Anderson (1978) and Maddieson (1978) for general discussions of tonal systems.

Accounting for four discrete levels of tone can be optimally accomplished by assuming two binary features. One of the earliest proposals along this line was that of Gruber (1964), which appears in (1). This proposal shows resemblance to the more recent autosegmental approaches to tone, which we will discuss below. (1 is highest and 4, lowest):

(1)

	High	High2
1	+	+
2	+	−
3	−	+
4	−	−

This and other (early) proposals for representing tone are discussed elsewhere in the literature. We refer the interested reader to Stahlke (1977), Anderson (1978), Clements (1979, 1981, 1983), and Snider (1988).

A system using [±High] and [±Low] can only deal with a three-tone system, since [+High, +Low] is excluded. But even accounting for three levels poses problems for a two-feature system, when one considers the natural classes needed to account for the various types of assimilation in different languages. In some three-tone systems, for instance, the Mid tone seems to be more closely associated with the Low tone than with the High tone. One example of this is Ga'anda (Newman 1971) in which both Low tones and Mid tones cause following High tones to be downstepped. In other three-tone systems such as that of Moba (Russell 1986), the Mid tone is more closely associated with the High tone, and this may be seen in that the Mid tone, like the High tone, is downstepped following a Low tone.

(2)

	Ga'anda		*Moba*
High	Can be downstepped	High	Can be downstepped
Mid	Causes downstep	Mid	Can be downstepped
Low	Causes downstep	Low	Causes downstep

Cross-linguistic evidence of this type indicates that we need to be able to distinguish two different representations for the Mid tone and thus four different tone levels. A system as in (1), which is capable of generating the four-way distinction, is therefore strongly favoured.

Accounting for five discrete levels of tone is more problematical than accounting for four. It is clear that a third feature of tone must be added to the system. One of the earliest proposals which involves three features is that of Wang (1967):

(3)

	High	Central	Mid
1	+	−	−
2	+	+	−
3	−	+	+
4	−	+	−
5	−	−	−

By adding a third tone feature, however, the classic problem of overgeneration manifests itself, since three binary features allow for up to eight levels of tone. While languages with five discrete levels have been argued to exist, those with eight have not. A further problem which arises with feature systems of this nature is that there is no clear indication of how languages with fewer discrete levels should be described. As noted by Clements (1983:146–7), "a language with two tone levels can be described in ten different ways" using three binary features. We will not go into the question how a five-level system can be characterized in a principled way, although we believe that an extra feature is not called for.

2.2. *The representation of contour tones*

The problem of formally representing contour tones played a key role in the development of autosegmental theory. Prior to the appearance of Woo (1969), contour tones were widely perceived to be the result of some sort of modification of level tones; e.g. high-rising or high-falling (cf. Pike 1948). Woo's proposal for tone features was similar to Wang's in that she also used three binary features to account for multiple tone heights. A crucial difference, however, lies in their proposals for handling tonal contours. Whereas Wang proposed the additional binary features of [Rising] and [Falling], Woo claimed that contour tones are actually sequences of level tones. Working in pre-autosegmental times, she was then forced to conclude that contours could not occur on short vowels, but necessarily only occur over two or more segments or *tone bearing units*. The reason for this was that a single matrix could not contain a sequence of two tone features in SPE.

Woo's claim that contour tones are confined to sequences of tone bearing units has since been demonstrated not to be true, as argued by Leben (1971 and 1973) and Williams (1976) (but see Duanmu 1990). Initial steps were taken by Leben and Williams towards giving adequate representation to single segments which bear sequences of level tones. Following these steps, Goldsmith (1976) worked out a detailed alternative to the phonological model of Chomsky and Halle (1968), viz. *autosegmental phonology*.

In autosegmental phonology, the speech signal is not only "chopped" vertically into segments, but is also "sliced" horizontally into autosegmental sequences of features which represent some part of the speech signal. For example, one sequence would represent tonal features, whereas another sequence would represent, say, the rest. Each sequence is referred to as a *tier*, and matrices on each tier as *autosegments*. Coordination between two tiers is achieved by sets of *association lines* which appropriately "connect" autosegments of one tier with autosegments of another tier. The advantage of this approach, of course, is that it allows for "many-to-one" mappings, e.g. two or more tonal matrices can be associated with one single unit on the tier that represents the tone bearing unit, and vice versa.

Not only has autosegmental phonology proven valuable in the analysis of tone systems, but by assuming that other than tonal features also occupy separate autosegmental tiers, it has offered solutions to problems involving such things as nasalization and various types of vowel harmony. A logical extreme of autosegmental phonology is that every feature is represented on a separate tier. This view necessitates the postulation of a "central" tier to which all features characterizing one position in the syllable structure associate. This tier is referred to as the skeletal tier and its units are usually represented by Xs. Autosegmental phonology, then, resolves the problems raised by Woo and Leben by allowing representations of the following kind:

(4) [+High] [-High] Tonal Tier

X Skeletal Tier

Structures such as that of (4) account for the contours found in African languages remarkably well. This success may be attributed to the fact that, for the most part, contours in African languages tend to occur more on the edges of morphemes and words than in the middle of such units. If tonal contours are in fact just a linear sequence of two different level tones which come to be associated with one tone-bearing unit (TBU), we then have a reasonable explanation for their predominant occurrence in edge environments. It is precisely at the edges of domains where we expect to find contours, either through the addition or spreading of a tone from a neighbouring morpheme or word to the peripheral TBU of an adjacent morpheme or word, or through the deletion of an initial or final vowel, in a sandhi context. If the tones remain while their TBU is deleted, they can associate to, for example, the TBU that caused the deletion.

While early autosegmental phonology provides a reasonable account of contour tones in African languages, problems arise when one tries to account for the contours of many East Asian languages. In an article devoted to the subject of contour tones, Yip (1989) points out that the contours of these languages are often *unitary contours*. Unitary contours differ from what we will call *composite contours* (or *tone clusters*) significantly in two ways. As units in their own right, they are realized on any TBU as freely as are level tones, thus differing from composite contours which are realized mainly on edges. (In as far as unitary contours occur in languages which favour monosyllabic words, this difference may be difficult to establish in all cases.) The second way unitary contours differ from composite contours is that unlike composite contours, which spread or reduplicate only one or the other of their composite parts, unitary contours have been claimed to spread or reduplicate as a unit (Chan forth.). While early autosegmental phonology provides a reasonable account for composite contour tones, the problem of providing a model which accounts (in a satisfactory manner) for both composite and unitary contour tones did not arise until later.

One of the important developments leading to a solution to the problem of representing unitary contour tones was the work of Yip (1980). Yip claimed that there are actually two tonal tiers associated with TBUs—a Tone Tier, and a Register Tier. Recognizing that tonal systems with five levels of height are somewhat special, she proposed that two binary features, [High] and [Upper], occupy two independent tiers that are associated with TBUs. Together, these features define four discrete levels of pitch as in (5) (cf. the proposal in 1).

(5)

	Tone Tier	*Register Tier*
1	+High (H)	+Upper
2	−High (L)	+Upper
3	+High (H)	−Upper
4	−High (L)	−Upper

Structurally, the features from each tier are associated directly with the TBUs (taken to be matrices containing all non-tonal features; the skeleton had not been developed in 1980). In (6), we illustrate a falling tone (taken from Yip 1980:32).

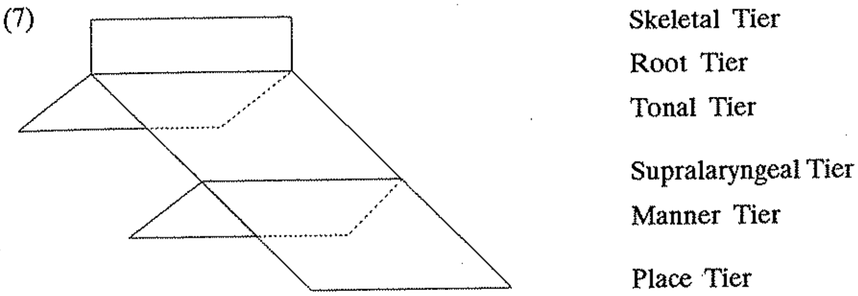
(6)

[−Upper]
|
peʔ
H L

While Yip (1980) was an important development in tone theory, it still left unsolved the adequate representation of *both* composite and unitary contours. It was not until after the advent of feature geometry that further progress was made in this area.

Feature geometry refers to a claim worked out in detail in Clements (1985) and Sagey (1986) that the autosegmental tiers are not all linked to the skeletal tier directly. Rather, there is a hierarchical arrangement involved in the sense that autosegments on tiers which constitute a class (e.g. all tone features, all place features, etc.) associate to a tier intermediate between these autosegments and the skeletal tier. The units on tiers which merely group other tiers that bear features are called *class nodes*.

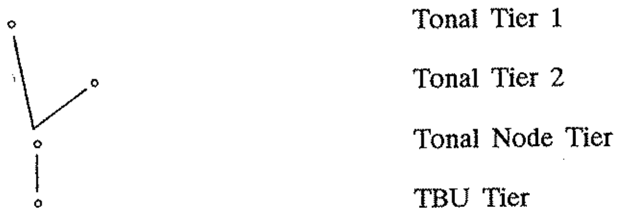
(7)



Except for the case of tonal features, we will not concern ourselves here with all the details of hierarchical arrangements of features and tiers. Detailed discussion of proposals on feature hierarchy can be found in Den Dikken and Van der Hulst (1988) and McCarthy (1988).

Adopting the notions of two tonal tiers (from Yip), and of feature geometry (from Clements and Sagey), several linguists (many independently of one another) have made proposals using the geometric structure of (8).

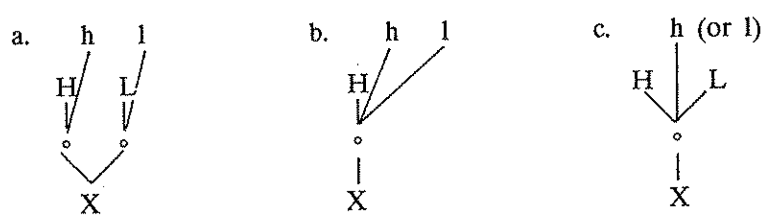
(8)



Proposals along the lines of (8) have included Archangeli and Pulleyblank (1986), Hyman (this volume), Hyman and Pulleyblank (1988), Inkelas (1987, 1989), Inkelas and Leben (1990), Snider (1988, 1990) and Yip (this volume). It is not always clear whether the TBU tier is the root tier or the skeletal tier in these proposals, but we ignore that issue here.

Exploiting the feature geometry of (8), one can represent, say, a *composite* falling tone as in (9a), and a unitary falling tone as in (9b) or (9c), depending on whether or not the fall involves a change in register.

(9)



The dual representation of unitary contours forms a less secure aspect of this approach; perhaps contours never involve a register shift. Another question regards the composite contours. Formally, we could also have both parts sharing the same register feature. Such issues need attention, but we will not go into them here (cf. Yip, this vol. for some discussion).

2.3. *The representation of register shifts*

As stated in the introduction to this chapter, the tonal register of an utterance, i.e. the frequencies at which, say, the High tones and the Low tones are realized, can be shifted downwards, as well as upwards. In many African tone languages, the presence of a Low tone between two High tones triggers a downward shift in tonal register. This register shift then re-establishes at a lower level the phonetic pitch at which all following tones in the utterance are phonetically realized. Such phonetic sequences are frequently represented as in (10).

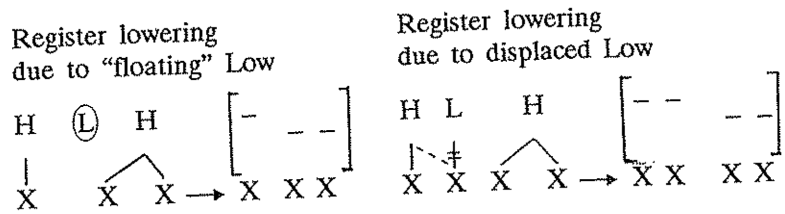
(10) [H L H H L L H L H H]

Observe that the lowering effect can take place an unlimited number of times, in principle, thereby allowing an indefinite number of pitch values for high and low tones. High tones later in the utterance may, in fact, have a lower pitch than low tones early on.

When register lowering occurs as in (10), the phenomenon is often called *downdrift*—not to be confused with *declination* which refers to the slight general decline in pitch which is found over most utterances in perhaps all languages (even when they consist of a span of like tones).

In some languages, register lowering occurs even when there is no overt indication of a Low tone, and this has most often been called *downstep*. In such cases, the presence is assumed of a Low tone which has lost its tone-bearing support. This is most usually due to either (a) the tone-bearing unit of the Low tone was lost historically (due, perhaps, to apocope) but the Low tone has survived, i.e. it is "floating"; or (b) the Low tone was displaced by another tone (due, perhaps, to the rightward spreading of the High tone immediately to its left) but, again, the Low tone has survived and has the effect of shifting the register ("key lowering") of the next H(s). In (11), below, the two sources of downstep are demonstrated. TBUs are represented by Xs:

(11)



From the above description of downdrift and downstep, it is obvious that they are the same process, their differences merely mirroring their different derivations. In order to capture this fact, but at the same time to differentiate the two, Stewart (1965) proposed the terms *automatic downstep* to refer to the former (i.e. downdrift) and *nonautomatic downstep* to refer to the latter. Throughout this article we shall use the term *downstep* to refer to the phenomenon as a whole.

In Llogoori, a Bantu language, downstep occurs at the new occurrence of a H tone (cf. Clements 1990:66ff), i.e., there is no need for a preceding low tone. This looks like automatic downstep even though there are no overt Ls to trigger the process.

There are a number of problems associated with all these forms of downstep. Should shifts in register be accounted for in the phonological component or the phonetic component? Should a downstepped High tone be formally equated with a Mid tone in those languages where phonetic equivalence is demonstrated? Perhaps the most difficult problem concerns the cumulative nature of the shifts, i.e. the fact that successive occurrences of downstep result in ever lower levels of pitch. An additional problem comes up in Krachi, a Kwa language spoken in Ghana, where a register difference between two TBUs which are associated with one underlying tone is demonstrated to occur (Snider 1990). How should this be accounted for? These and other problems have prompted a number of proposals in the past including: Winston (1960), Schachter (1961), Pike (1966), Stewart (1971), Welmers (1973), Clements (1976, 1979, 1981, 1983), Hyman (1979, 1986), Pierrehumbert (1980), Yip (1980), Pulleyblank (1986), Inkelas (1987), and Snider (1988, 1990).

When one considers the cumulative nature of downstep, it becomes clear that any attempt to account for successive occurrences of downstep is doomed to failure with phonological rules which use binary features in the traditional manner. A number of linguists have therefore abandoned the idea that shifts in tonal register should be accounted for in the phonological component. They have, in turn, provided various accounts which assign gradient pitch values by means of left-to-right implementation rules in a phonetic component (cf. Johnson 1972; Peters 1973; Pulleyblank 1986; Pierrehumbert 1980; and Pierrehumbert and Beckman (1989).

Snider (1990) discusses some points which argue against handling register shifts in the phonetic component:

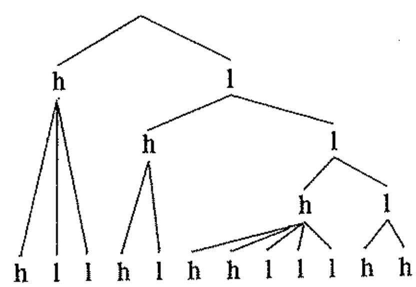
I. In many African languages, downstep is phonemic; that is, its occurrence is the sole indicator that two utterances are distinct. "To account not only for the degree of downstep, but also for the fact of downstep in a nonphonological component would imply the claim that a native speaker's recognition of an emic distinction can be triggered *solely* by the implementation of a distinctive feature in the phonetic component. This would greatly increase the power of the phonetic component" (p. 469).

II. So far as is known, in languages in which downstep and upstep both play a role, the degree of register shift is the same in both cases. This should be coincidental in models that account for these phenomena with phonetic pitch implementation rules.

III. In many three-tone languages that also have downstep, a downstepped High tone is phonetically equivalent to a Mid tone. If downstep should indeed be accounted for in the phonetic component, any equivalence between a phonemic difference, on the one hand, and a "phonetic" difference, on the other hand, should be purely coincidental.

Not all linguists have abandoned the idea of handling register shifts in the phonological component. Huang (1980), Clements (1981, reprinted as Clements 1983), and Hyman (1986) are notable examples which have made use of hierarchical structures. In Clements (1983:155), for example, language-specific algorithms are used to construct tree-like structures above underlying tones.

(12)



(lexical tones)

A structure like (12) is phonetically interpreted in such a manner that all features which dominate any given underlying tone are grouped into a "feature bundle" or matrix. Thus a Low tone dominated by, for instance, two l's would be phonetically realized at a lower pitch than one dominated by only one l.

Models which employ hierarchical structures like that of (12) are limited in that they are unable to account for changes in register which occur over two TBUs that are dominated by a single tone. Snider (1990:471) exemplifies this with data from Krachi, like (13).

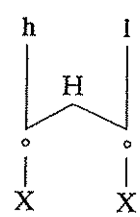
(13) LH L H

/alɪ kɔtʊna/ ⟶ **[alɪ kɔtʊna]** 'our mat'

In (13), the difference in pitch between the last and the penultimate TBU is demonstrated to be attributable to a difference in register, despite the fact that underlyingly, both TBUs are associated with the same High tone. The problem with hierarchical structures like that of (12) is that, regardless of how one constructs the tree, the pitch levels of the two final TBUs in (13) are going to be identical, which, of course, is incorrect. Such upsteps are non-local in effect since the final TBU is realized on the same pitch as the second and the third, instead of being lower. This prevents a treatment of such cases in terms of the local F0 adjustments (cf. Clements 1990:66).

Snider (1988, 1990) proposed a model incorporating the geometry in (8) which we will briefly discuss here as a contribution to the issues raised in the present volume. In this model (hereafter called the register tier model) upper case letters designate features on a Modal, or Tonal Tier, and lower case letters designate features on a Register Tier. Features from both tiers are associated with structural nodes on a Tonal Node Tier. The two feature tiers form different geometric planes with respect to the Tonal Node Tier.

(14)

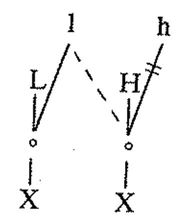


The structure in (14), then, forms an adequate representation of the final two TBUs in (13). In (14), both TBUs are associated with a single High tone and the second TBU is downstepped in relation to the first, since it is (indirectly) associated with a lower register feature on the Register Tier.

A similar proposal occurs in Inkelas (1987, 1989), but the unique aspect of the register tier model is how the cumulative nature of register shifts is handled. In this model, features on the Register Tier "are represented by **l** (one step lower than the preceding register) and **h** (one step higher than the preceding register)" (Snider 1990:461). This contrasts with other models which make use of the same geometry in that h and l are given a "relative" interpretation (i.e. lower and higher), as opposed to the more conventional "static" interpretation of features. The Modal Tier also contrasts with the Register Tier in this respect. By using this relative interpretation of the register features, the cumulative nature of register shifts can receive satisfactory treatment. Thus while two consecutive Ls on the Modal Tier would not indicate any phonetic difference, two consecutive l's on the Register Tier would indicate that the TBU (indirectly) associated with the second l would be realized at a lower pitch level than a TBU associated with the first (assuming, of course, that the OCP did not collapse the two l's).

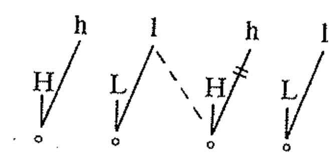
In environments in which downstepping typically occurs, what happens is that a High tone which follows a Low tone shares the lower register of the preceding Low tone. In the register tier model, this is represented by the spreading of the lower register of the preceding Low tone to the tonal node associated with the following High tone. In this process, the higher register of the High tone is delinked. This rule of "l-Spread" can thus be represented as in (15).

(15)

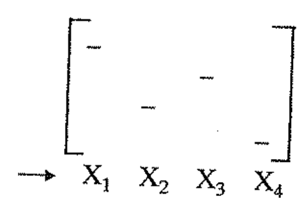


The operation of (15) may be seen in sequences like (16). In the utterance of (16) there are two occurrences of downstep, and these are discussed below.

(16)



	X_1	X_2	X_3	X_4
R.	0	1	1	2
M.	0	1	0	1
total	0	2	1	3



In (16), X2 is realized on both a lower mode and a lower register than X1. Let us assume that the phonetic difference attributable to the difference between l and h is equivalent to that between L and H. This is true for some languages, but not for all. Let us further assume that this difference has a phonetic value of 1 degree. With these assumptions, X2 is realized 2 degrees lower than X1. X3 is realized 1 degree higher than X2 since, while it shares the lower register of X2, it is realized on the high mode, which is 1 degree higher than the low mode of X2. X3 is also realized 1 degree lower than X1. In this case X3 is realized on the high mode, the same as X1; it is 1 degree lower, however, since it is associated with l, which is "one step lower than the preceding register" (i.e. 1 degree). This is the first instance of downstep in this sequence. The phonetic value of X4 is 2 degrees lower than the value for X3. One degree of this difference is accounted for in that X4 is realized on the low mode, which is 1 degree lower than the high mode of X3. The second degree of difference is accounted for in that, while both TBUs are associated with an l, the l of X4 is interpreted as "one step lower than the preceding register" (i.e. 1 degree). The presence of the floating h from X3 blocks the OCP from collapsing the l's from X2 and X4, and downstep (the second instance of downstep) is effected between these TBUs.

To make these calculations explicit, we have added three rows of integers. The row labeled R gives integers from zero going up by 1 with every occurrence of l (and down with every occurrence of h). The row labeled M gives 0 for H and 1 for L. The row called *total* adds up the integers on the M and R row.

We turn our attention at this point to the matter of upstep. As pointed out by different linguists, upstep is related to downstep in that both seem to have their origin in floating Low tones. It is also often the case that languages with upstep also have downstep, albeit the two are in complementary distribution. Consider upstep in Zulu, as described in Cope (1970), and also discussed in Clements (1981, 1983).

Zulu has a highly productive rule of High tone spread in which a High tone spreads rightward onto, and displaces a following Low tone from, a following syllable. This only happens, however, when the Low tone syllable is nonfinal and does not begin with a "depressor" consonant. Thus when High-Spread occurs, a floating Low is created. If the tone that follows the now floating Low is High, one of two things happens. If this High tone is associated with the penultimate syllable of the utterance, downstep occurs. If it is associated elsewhere, upstep occurs. In (17), the underlying tones are placed below each utterance, and the surface realizations are indicated above. The symbols ꜝ and ꜛ indicate downstep and upstep, respectively.

(17) a. *Downstep*

aɓayiboni 'they did not see it'
L H L H L

aɓafana 'boys'
H LH L

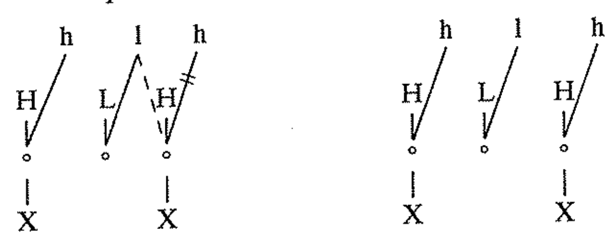
b. *Upstep*

sibala incwadi 'we write a letter'
LHLH LH

aɓafanyana 'small boys'
H LH L L

The fact that these two (seemingly opposite) phenomena are conditioned by almost identical environments receives a straightforward explanation in the register tier model.

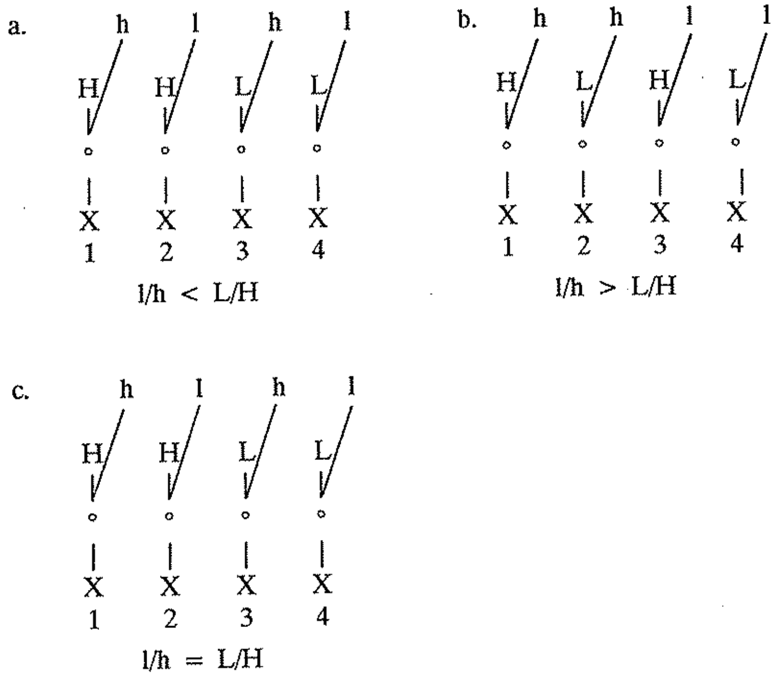
(18) a. *Downstep* b. *Upstep*



In both (18a) and (18b), the Low tone is unassociated, i.e., it is floating. In (18a), l-Spread has occurred and so the second High tone is downstepped in relation to the first High tone since it shares the lower register of the floating Low tone. In (18b), l-Spread has failed to occur and so the second High tone is upstepped in relation to the first High tone. This is due to the fact that the second TBU is associated with the higher register of the second High tone and so is "one step higher than the preceding register". Because the Low tone is floating, it is unable to have any direct influence on the surface realization. What its presence does do, however, is block the application of the OCP on the Register Tier, thereby preventing the two h's from collapsing into one. The model therefore reduces the difference between upstep and downstep in this type of environment to a single parameter choice; l-Spread, yes or no.

Like Yip (1980), Snider (1990) considers languages with more than four underlying levels of tone height (extremely rare) to be somehow special. The problem is important, however, and dealing with it is a matter of current investigation. The feature system of the register tier model therefore accommodates up to four underlying levels of tone. The different possibilities are set out in (19).

(19)



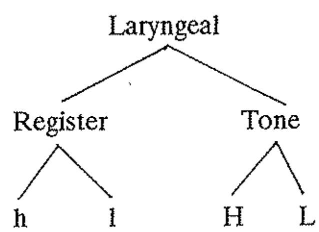
Let us assume that the phonetic difference attributable to the difference between l and h (register) is less than that attributable to the difference between L and H (mode). A language with these phonological characteristics could have up to four discrete levels of height, and its underlying tones would have the representations of (19a). A language with these same phonological characteristics reversed could also have up to four discrete levels of height, and its underlying tones would have the representations of (19b). A number of languages also have the phonological characteristics of (19c), in which the phonetic differences attributable to register are equivalent to those attributable to mode. Kagwe, mentioned above as having four underlying levels but only three surface levels (cf. Koopman and Sportiche 1982) would fit into this category. Many two-tone languages in Africa, including Krachi (discussed above), also have the phonological characteristics of (19c).

One thing which the register tier model has in common with other models that handle shifts of register in the phonological component concerns the relationship between downstepped High tones and underlying Mid tones. If upstep and downstep are dealt with in the phonological component, then it follows that an underlying High tone that has been downstepped will be phonologically nondistinct from one of the (potentially two) middle tones. This is because the same feature representation is being used for both.

Given the discussion immediately above, the Mid tone of a three tone system could have one of two feature characterizations: either (a) H mode and l register, or (b) L mode and h register. For those languages with three discrete levels of tone in which the Mid tone has the characterization of (a), this Mid tone will be phonologically and phonetically nondistinct from a downstepped High tone. And in a language with four underlying levels of tone, one of the two middle tones will be nondistinct from a downstepped High tone.

Two recent studies of tone provide overviews and critical discussions of both traditional and geometrical proposals for the representation of tonal phenomena (Bao 1990; Duanmu 1990). These proposals take up earlier ideas presented in Halle and Stevens (1971), in which a set of features is developed which generalize over tone and (most of the) phonation distinctions that seem relevant in natural languages. A similar undertaking can be found in Van der Hulst (1990/1991). All three proposals rigorously locate tonal distinctions under the laryngeal group of features in the following way:

(20)



Bao (1990) and Duanmu (1990) use different feature names and there are a number of other differences that we will not discuss here. The importance of these proposals lies in the fact that an explicit connection is made between the tonal interpretation of the laryngeal features and the phonatory, especially voice (quality) interpretation of h and l. In her contribution to this volume, Yip also deals with such relations.

We feel that such proposals are compatible with the relative interpretation for register features proposed in the model of Snider (1990) but here we will not explore this point nor discuss how phonatory constriction features such as [Constricted] and [Spread] relate to the features in (20).

3. The contributions to this volume

In this section we will briefly outline the content and essential claims of the contributions to this volume.

3.1. Mary Clark: Representation of downstep in Dschang Bamileke

This paper is a follow-up to Clark (1990), in which it is argued that register-lowering (downstep/downdrift) can be predicted from the tonal representation alone, with no need for a special "register" tier or metrical tree. In languages like Igbo, which have downstep between adjacent high tones and downdrift between high and low, register lowering can be accounted for by a phonetic-interpretation rule which lowers the pitch standard for high (and low) tones at the boundary between a high ([+UPPER]) tone and any following tone (T):

(21) $X^{i} \longrightarrow X^{i+1}$ / [+UPPER] ___ T

(where X^{n} is the pitch standard for [+UPPER] tones at point *n* in the phonological representation; see Liberman and Pierrehumbert 1984 and Beckman and Pierrehumbert 1986).

Rule (21) applies, for example, at the points indicated by a raised exclamation point in the Igbo words below:

(22) **á$^{!}$kàbó** 'hedgehog' (H L H) **é$^{!}$gó** 'coin' (H H) (cf. **ewu** 'goat' (H))

This analysis closely follows the proposals of Odden (1982) for Ki-Shambaa and Carlson (1983) for Supyire; in these analyses, the OCP is regarded not as a universal convention, but as a markedness condition which must be implemented by language-specific rules. Thus sequences of identical tonal features do occur, under some circumstances, and are realized with an intervening downstep, as in **é$^{!}$gó** 'coin'.

In her article, Clark shows that an analysis along these lines can be applied, with good results, to Dschang Bamileke, which has downstep between high and low tones, but no downdrift:

(23) a. **tɔ́ŋɔ́** [— —] 'call (imperative)' vs. **tɔ́$^{!}$ŋɔ́** [— —] 'reimburse (imperative)'

b. **èfɔ̀ mə̀ndzwì** [_ _ _ _] 'chief of leopards'

vs. **àzɔ̀bɔ̀ mə̀n$^{!}$dzwì** [_ _ _ _ _] 'song of leopards'

Languages of this sort have a register-lowering rule which applies at the boundary between identical tonal features, as follows:

(24) $X^{i} \longrightarrow X^{i+1}$ /[αT] ___ [αT], where 'T' is a tonal feature.

The "downstepped high" tone which follows a low tone, as in **mə́mꜜbhʉ́** 'dogs', must be treated as a mid tone, as proposed by Hyman (1985), with the features [+UPPER,−RAISED]. In other words, both tonal features—[UPPER] and [RAISED]—are employed in Dschang. This has interesting consequences for the downstep rule, in that the downstep environment (24) may occur on either tonal tier (the [UPPER] tier or the [RAISED] tier), or on both tiers at once, creating a double downstep, as in the form **à kè ꜜkɔ́ŋɔ́ ꜜꜜ mɔ́** 'He liked a child (yesterday)', whose representation is given below, with the feature [+UPPER] abbreviated as H/L, and the feature [+RAISED] as h/l:

(25)

```
   h        l      l
  / \      / \     |
 à  kè  ꜜkɔ́ŋɔ́  ꜜꜜ mɔ́
  \ /      \ /     |
   L        H      H
```

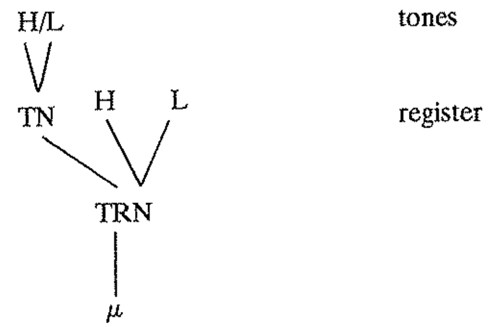
site of double downstep

The discussion of Dschang downstep is couched within a complete analysis of the associative construction, which improves on previous treatments of this construction, in that it avoids the metathesis rule of Pulleyblank (1986), and the "tier-hopping" and re-structuring rules of Hyman (1985).

3.2. Larry Hyman: Register tones and tonal geometry

In this volume, Hyman proposes a geometry for tonal features which recognizes two structural nodes, a tonal node (TN) and a tonal root node (TRN). There are two features, privative H and L which may associate to the tonal node or to the tonal root node. In the former case these features characterize tone levels, whereas in the latter case they characterize register distinctions. If H and L both associate to the tonal node, a mid tone is the result.

(25)



There are nine distinct representations:

(26)

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
T-plane:	H	L	LH	H	L	LH	H	L	LH
R-plane:	∅	∅	∅	L	L	L	H	H	H
TONE:	H	L	M	ꜜH	ꜜL	ꜜM	↑H	↑L	↑M

Note that in the model discussed in the previous section, the occurrence of both H and L (or h and l) does not produce a mid tone but rather a contour tone.

Hyman's model allows a wider variety of tonal assimilation processes than most other current proposals and Hyman briefly refers to suitable candidates for most of the logical possibilities. His system makes available a number of raised tones (↑L, ↑M and ↑H). The use of the first two is less obvious, but raised H can be identified as an upstepped H tone. Hyman then offers a discussion of upstep in three languages: Engenni, Mankon and Kirimi. In all cases we find an upstepping process by which a H tone is raised before a L. Hyman proposes that high tone raising results from assigning a floating L as a register specification to a following H or sequence of Hs. Then a single H is raised (this is accomplished by a H register specification which is inserted for this purpose) before a L, provided that this H tone is itself not associated to a L register feature by the first-mentioned rule. Hyman argues that the need for a register H feature can be demonstrated independently.

3.3. Bob Ladd: In defense of a metrical theory of intonational downstep

This paper defends the proposal in Ladd (1990) that register shifts in English and other intonation languages are controlled by "register trees" —abstract prosodic structures in which the relative height of prosodic constituents is specified—rather than being the result of a phonetic realization rule affecting sequences of abstract tones (as proposed by Pierrehumbert 1980, Clark this volume, and others). The motivation for this proposal is that it allows a common phonological representation for all downstepping contours without running into the difficulties of the "feature" notation proposed by Ladd (1983). An equally important advantage is that it provides a natural representation for the widely observed "nesting" of downstep (accent-to-accent, phrase-to-phrase) in utterances with fairly deep surface syntactic structure.

Ladd argues that the apparent attractiveness of Pierrehumbert's proposal depends crucially on doubtful assumptions about (a) the distinction between linguistic and paralinguistic functions of pitch phenomena, (b) the phonetic modelling of pitch range, and (c) prosodic structure.

Specifically, he claims that:

(a) Pierrehumbert is forced to treat phrase-level downstep as "paralinguistic", though the independent motivation for this is not convincing; conversely, she is forced to ignore the fact that overall modification of pitch range ("raising the voice") seems to work independently of phrase level downstep, though the two are treated identically in their model.

(b) Pierrehumbert is led, by the distinction between accent-level and phrase-level downstep, to treat the former as a narrowing of pitch range and the latter as a lowering, though this will make it impossible to model downstep in true tone languages (like Yoruba) in a unified way.

(c) She is forced to treat list intonation (in the Liberman and Pierrehumbert experiment on the quantitative invariance of downstep) as *not* involving phrase boundaries between the elements of the list, since those would block downstep in their model.

A discussion of Ladd's model is found in Clements (1990).

3.4. Victor Manfredi: Spreading and downstep: prosodic government in tone languages

Manfredi expresses a critical view on many influential studies of Benue-Kwa tone systems in the 1970's and 1980's.

He adopts and extends Bamba's (1984) proposal regarding the relationship between tone and metrical structure. This proposal replaces the "register tone" theory propounded by Manfredi (1979), Huang (1980), Clements (1981), Inkelas et al. (1987). He accepts and follows Kaye, Lowenstamm and Vergnaud (1987) and Charette (1988) with respect to phonological licensing in a constraint-and-principles based framework. His approach accounts for a wide range of tone systems in the typological space of the Benue-Kwa languages. The position of true mid tones in this typology is problematic, but Manfredi suggests that there is evidence that three-tone systems respect the same basic principles as two-tone systems. The fact that both H and L spread in Yorùbá (a three-tone system) suggests that both H and L can be strong only if there is a third possibility which is always weak (cf. Láníràn 1991).

Contrary to Clark (this vol.), Manfredi supports a strong version of the OCP and provides analyses of the major nominal and verbal constructions of Igbo which account for the same facts which Clark (1990) analyzes in a model that suspends the OCP.

In both Igbo and ɣɔmaláʔ-Yamba, the reanalyses proposed in the article rely on specific syntactic analyses—information not directly accessed by the respective rule-based analyses of Clark (1990) and Hyman (1985). It is argued that this tight interface between syntax and prosody is desirable, within a cognitively based generative grammar. Most of the alternative "floating tone" analyses are claimed to require extremely abstract underlying forms, which are based mainly on historically reconstructed forms.

3.5. John Stewart: Dschang and Ebrié as Akan-type tonal downstep languages

Dschang, a language with overt downstep, but without the overt automatic downstep of the classic downstep languages, and Ebrié, a discrete level language with three discrete levels, the mid tones of which are analyzable as downstepped high tones (Kutsch Lojenga 1985), display remarkable resemblances. Stewart analyses both as having, on a separate tonal tier, not only the same two binary tone features [high] and [stepping] but also the same four tonal autosegments, namely the two [−stepping], or linking, tones L̲, H̲, which may be linked or unlinked but which are not realized unless they are linked, and the two [+stepping] tones l, h, which are never linked and which are realized as downstep and upstep respectively. Downstep, as in Stewart's (1983) analysis of Adioukrou and Akan, is total in the sense that it consists of a downward stepping of the tone level frame to the point at which a following $\underline{\mathrm{H}}$ would be level with a preceding $\underline{\mathrm{L}}$; upstep is similarly an upward stepping of the frame to the point at which a following $\underline{\mathrm{L}}$ would be level with a preceding $\underline{\mathrm{H}}$.

Dschang and Ebrié differ from Akan in a way that has not been recognized in any previous analysis of either language: they have a tonal autosegment that Akan lacks, namely the [+high, +stepping] segment h which is realized as upstep.

Dschang and Ebrié also resemble Akan in a way that has not been recognized in any previous analysis of either language: they have automatic downstep in the sense that they have $\underline{\mathrm{H}}\mathrm{l}\underline{\mathrm{L}}$ to the exclusion of $\underline{\mathrm{HL}}$. They further resemble Akan in that they eliminate inadmissible $\underline{\mathrm{HL}}$ sequences, arising at word boundaries for instance, mainly by means of a low tone stepping rule which changes $\underline{\mathrm{L}}$ to l after $\underline{\mathrm{H}}$.

Dschang and Ebrié have not only automatic downstep but also automatic upstep, or $\underline{\mathrm{L}}\mathrm{h}\underline{\mathrm{H}}$ to the exclusion of $\underline{\mathrm{LH}}$. In Ebrié, moreover, though not in Dschang, upstep, whether automatic or non-automatic, is balanced against downstep in such a way that the linking tones are realized on three discrete levels.

Now Akan, with its infinite number of surface levels, and Ebrié, with its three surface levels, are representative of the two most common types of tone language found among the Niger-Congo languages of West Africa. Stewart tentatively suggests that, historically, systems like that of Ebrié develop from systems like that of Akan by bringing in upstep to reduce the number of surface levels from infinity to three. This is particularly plausible if it is correct, as is commonly supposed, that systems like that of Akan themselves develop from simple two-tone systems by the introduction of downstep: the introduction of downstep creates a gap, and that gap is sometimes subsequently filled by the introduction of upstep.

3.6. Moria Yip: Tonal register in East Asian Languages

Yip distinguishes between three different uses of the term register:

1. tonal register, dividing the pitch of the voice into two ranges, called [+upper] and [−upper]

2. phonation register, giving laryngeal characteristics such as murmur and creaky voice
3. intonation register, determining the level on which a lexical tone is actually realized in an utterance

1. Tonal register
Four level tones are distinguished by two binary features, [upper] and [raised]. Contour tones hold the register feature [upper] constant, and have sequences of values for [raised]: for example, a high rising tone is [+upper], [−raised, +raised]. Yip offers two types of evidence for this representation. First, there are rules which delete the [raised] value(s), but leave [upper] intact, as in Taiwanese and Suzhou. Second, there are rules which spread register, but leave [raised] unaffected (e.g. Fuzhou).

2. Phonation register
In Shanghai and Tibetan, there is a close connection between phonation and pitch, such that [−upper] syllables have voiced murmured onsets, and low pitch. In certain contexts, all tonal contrasts and murmur disappear in Shanghai, suggesting that the feature responsible for murmur is a tonal feature. In Tibetan, on the other hand, all laryngeal contrasts and murmur disappear together, suggesting that the feature responsible for murmur is a laryngeal feature. It is suggested that the feature [murmur] requires domination by both laryngeal and tonal nodes, and that deletion of either of these nodes causes loss of murmur. This special behavior, Yip suggests, shows that [murmur] cannot be identified with the purely tonal register feature, [−upper].

3a. Intonation register
The interaction between tone and intonation in Hausa and Mandarin shows that intonation register is to be distinguished from tonal register and is instead a way of realizing a particular tone (with all its features) phonetically. Inkelas, Leben and Cobler's (1987) use of "register" for Hausa intonation differs from tonal register in Chinese in two striking ways. First, their register effects a permanent resetting of the pitch range for the remainder of the utterance, not just that syllable. Second, there is a close connection between lexical Ls and L register, and lexical Hs and H register, unlike the four possible combinations found within lexical tone in Chinese.

3b. Chinese intonation
In Mandarin, contrastive stress raises high tones, and leaves alone or lowers low ones. It is argued that the phonetic scaling operation (Shih 1988) must include as its input not just tonal register [upper], but also the other tonal feature, [raised].

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