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Tone Feature Geometry

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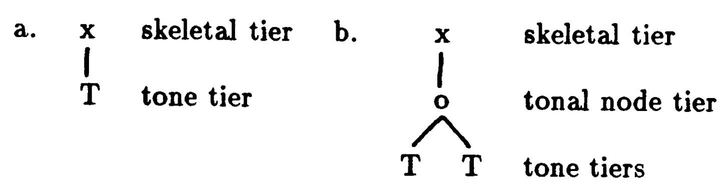
1. A three-dimensional model of tone

A number of recent studies have shown the need for a model of tone which is richer than that developed in early work on autosegmental phonology (e.g. Goldsmith 1976). Shown on the left in (1), the original model incorporates a single tonal tier containing a binary-valued tone feature, whose values are referred to as High and Low. In this paper I will argue for one particular alternative model, the one shown on the right in (1). This model incorporates not one but two tonal tiers, a move first suggested by Yip 1980; moreover, it connects those tiers to an intermediate level in the representation, the tier of tonal nodes. In line with the proposals of Clements 1985 for incorporating all phonological features in a single hierarchy, tonal nodes encode not only the connections holding between different tone features but also the correspondence between those tone features and the skeletal units on which they are phonetically realized.

(1)



2. Differences between the models

A. Number of tones. The two tiered model is able to encode a larger number of tonal contrasts than the single tiered model. Without tabulating the exact number of tonal configurations derivable in each (such a tabulation would depend on assumptions which are irrelevant here), it is clear that languages with five or six phonological tones simply can not be accommodated on a model such as that in (1a). And such languages do exist (e.g. Ngamambo, Chaga, certain dialects of Chinese). Work on these complex tonal systems has led to the postulation of two tone features, as in the work of Yip 1980, Clements 1981, Hyman 1985, 1986, and Inkelas 1987, among others. Because this point is rather well-accepted, I will not return to it in the paper. We will concentrate instead on the other two sorts of arguments for the proposed model.

B. Arrangement of tone features. Another source of differences between the models in (1) lies in the in the locality of the tone features with respect to one another — that is, in the geometries of the two different models. To illustrate this difference we will look at the phenomenon of downstep, which must be represented as a sequence of tones on the single tiered model. On the two-tiered model, however, downstep can be handled as a single, complex tone (Hyman 1985). The difference between these models will be examined with special reference to Tiv.

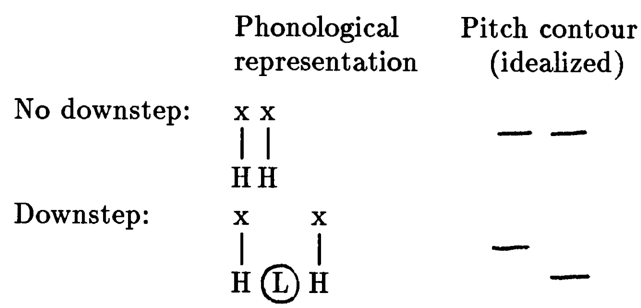
C. Presence of tonal nodes. Third, the models differ with respect to the presence of the tonal node tier. Building on the organizational use several recent analyses have found for a tier of tonal nodes intermediating between two tone tiers (see e.g. Archangeli and Pulleyblank 1986, Hyman and Pulleyblank 1987, Yip 1987), I will argue that tonal nodes can actually function as contrastive entities in the phonology. In Margi, where I will argue that only one tone tier is present in the lexicon, the presence of a tonal node is sufficient to distinguish tone-bearing from non-tone-bearing vowels. In Zulu as well, presence versus absence of tonal nodes is contrastive, and the model in (a), which lacks those nodes, is not sufficiently powerful to handle the data. The most important result of recognizing tonal nodes as contrastive is that doing so provides a way out of the theoretically undesirable but seemingly unavoidable need to posit ternary contrasts on binary-valued tone tiers in certain two-tone languages like Margi.

In this paper I will develop arguments (B) and (C) by focusing on cases where argument (A) is not a factor; that is, on languages whose actual number of tones is not so overwhelmingly large that model (1a) is incapable of handling them. The aim is to show that even with a small number of tones, languages still require the added flexibility of model (1b).

3. Geometry of tone features: Downstep

Downstep, often referred to as non-automatic downstep, is the lowering of a High tone (or sequence of High tones) which cannot be attributed to the more general process of downdrift. Downstep has traditionally been assumed to include two features: that belonging to the High tone which is lowered, and that of the element which performs the lowering. Working within a single-feature model of tone, many have proposed that the trigger of downstep is a floating Low tone which immediately precedes the downstepped High (Clements and Ford 1979, Clements 1981, Pulleyblank 1983, 1986).[1] The effect of this floating Low is to trigger a phonetic rule of lowering which causes the following High to be lower than it would be if no floating Low preceded. The contrast between downstepped and non-downstepped High is illustrated in (2).

(2)



To that same language-particular phonetic rule of lowering is often attributed the closely related process of automatic 'downdrift'[2], according to whose dictates a linked Low tone lowers the pitch register for all following Highs.

On this single-feature model, the two features composing a downstepped tone are ordered sequentially on the tonal tier. But in Clements 1981, Pulleyblank 1983, 1986, Hyman 1985, 1986, and Inkelas 1987, an alternative proposal has been made using the two-tiered model of tone. There, downstep is not a sequence of features but rather a single, complex tone, incorporating the High aspect of downstep as a High feature on one tier, and encoding the fact that it is a lowered High by connecting it with a Low specification on a different tier.[3]

I will assume the features used in Hyman 1985, where the tonal tier containing the Low part of a downstepped High is a register tier. Features on that tier modify, by raising or lowering, the pitch register on which features on the other tier, the 'primary' tier, are realized. Thus instead of being a sequence of primary tones, downstep is represented as a complex tone, as shown on the right, below. Tonal nodes are added in conformity with the model in (1b).

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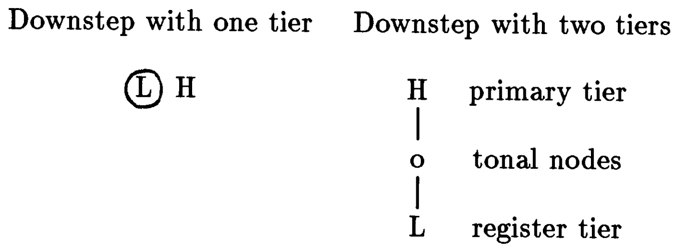
[1] Earlier analyses, e.g. Clements 1979, Hyman 1979, Stewart 1981, conceived of downstep as a phonological entity, but did not equate it with a Low tone.

[2] The idea that downstep and downdrift (also called 'catathesis', e.g. in Poser 1984) are the same process at some level is quite longstanding; recent works in which it is explictly mentioned include, for example, Clements and Ford 1979, Hyman 1985, Pulleyblank 1986, and Inkelas 1987.

[3] Clements does not actually propose separate tiers for these two features, treating them instead as belonging to a single feature matrix associated with one skeletal slot.

(3)

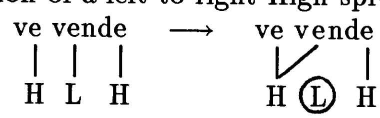


A glance at (3) suggests that the locality relations obtaining between the downstep marker and the primary tones surrounding the downstepped High will be radically different in the two models. Hyman 1985 uses this difference to argue for the two-tiered model in Dschang, where a register Low is shown to downstep the primary High to the right under certain morphological conditions, but the tone to the left under other conditions. This account would be impossible using only one tier but is straightforward under the richer model.

3.1. Tiv

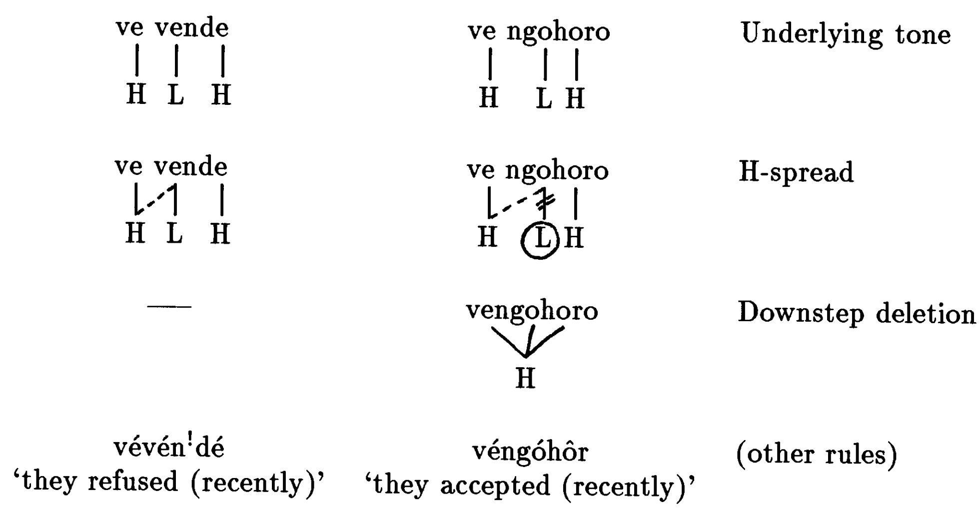
A different kind of locality problem is demonstrated by downstep in Tiv, another language supporting the register Low treatment of downstep. As shown in Pulleyblank 1986, linked Low tones in Tiv verbs are systematically set afloat by the application of a left-to-right High spreading rule.

(4)



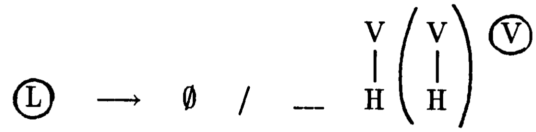
The primary High following the floating Low surfaces as downstepped, as we might expect — *except* under one specific condition: If the syllable following the downstepped High is not linked to any tone, then the downstep is deleted. This is illustrated in (5), where downstep deletion applies to the verb on the right but not to that on the left (examples from Pulleyblank 1987).

(5)



While the phenomenon is straightforward, the analysis is not. In fact, as Pulleyblank 1987 argues, the rule in (6) — the only formal way to state the facts just described in a single-tiered model of tone — violates well-motivated constraints on phonological rules.

(6) !-deletion:

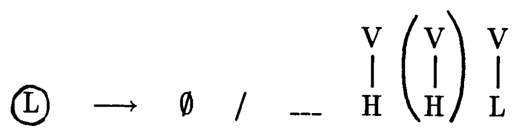


(Pulleyblank 1986)

Pulleyblank 1987 rejects this rule on the basis of constraints on phonological rules motivated in Archangeli and Pulleyblank 1986, which make it impossible for a rule to refer to an empty skeletal slot unless the rule is inserting or spreading a feature onto that slot. The obligatorily toneless V slot in the environment of (6) is thus sufficient to invalidate the rule.

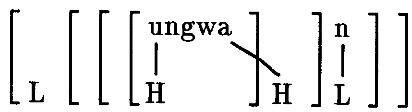
It appears that this particular objection to the rule can be circumvented, however. Because of an independently motivated default Low insertion rule, toneless vowels eventually surface as Low. With this in mind, we can replace the empty V slot in (6) with a Low tone.

(7) !-deletion (revised):



Pulleyblank 1986 considers this alternative and rejects it (p. 148) because the language has a Low-toned suffix — *-n*, the Habitual 1 — which, when it occurs in the position that would be occupied by the final Low tone in (7), crucially fails to trigger downstep deletion.

(8)



⟶ !úngwáǹ (*úngwáǹ)

However, this example alone will not invalidate the revised !-deletion rule in (7), for the following reasons. Pulleyblank makes a convincing argument elsewhere (p. 217) that syllables are never closed by consonants in the lexicon in Tiv, and to maintain this constraint when analyzing (8) we will have to assume that the consonant suffix is not in the rime of a syllable.[4] As consonants not in the rime can never be tone-bearing, the *-n* suffix cannot possibly be linked to the Low tone with which it is underlyingly affiliated. Rather, that Low must be floating. And since floating tones are irrelevant to !-deletion as formulated in (7), the rule can thus be upheld for the moment.

But not for a very long moment. A much more serious threat to this rule is brought by locality considerations. Observe that the focus of !-deletion (the Ⓛ) is not adjacent to one of the determinants (the final V linked to L). According to Poser

[4] Another equally plausible possibility is to treat the suffix as extrametrical.

1985 rules containing a non-adjacent determinant and focus are overly powerful than is justified by natural language data and have no place in phonological theory. There is no way to save the !-deletion rule from this locality violation.

How, then, are we to express the deletion of downsteps in Tiv? Fortunately, this seemingly intractable problem obtains a simple solution on the register tier. As mentioned earlier, Hyman 1985 proposes that in Bamileke Dschang downstep is not a floating primary Low but rather a register Low tone, which we may construe as occupying an a separate, autosegmental register tier. From there it is linked, via a tonal node, to the primary High whose pitch it lowers. The example below is constructed from Hyman 1985 (pp. 68, 71), and reformulated according to the model in (1b). The three-dimensional representation required by the proposal model is here depicted in two planes; the top contains skeletal tier and tonal nodes, while the bottom shows tonal nodes and the tonal tiers with which they are linked.

(9)

```
alɔʔ    skeletal tier     àꜝlɔ́ʔ 'country'
| |
o o     tonal nodes

L H     primary tier
| |
o o     tonal nodes
  |
  L     register tier
```

Hyman 1985, and later Inkelas et al. 1987, make a similar proposal for the representation of downdrift, illustrated in (10) by an example from Hausa. Here again, a register Low is responsible for why each primary High tone is lower than its predecessor.

(10)

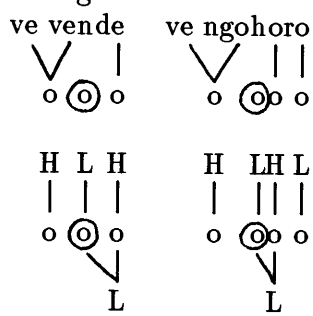
```
rigar Ali    skeletal tier     rìgár Àlí 'shirt of Ali'
| |   | |
o o   o o    tonal nodes

L H   L H    primary tier
| |   | |
o o   o o    tonal nodes
|/    |/
L     L      register tier
```

The two-tiered representation of registral lowering effects retains the insight that downstep and downdrift are related phenomena.[5] And this distinction is essential to understanding downstep in Tiv.

[5] Inkelas 1987 argues for this position on the basis of data from Chaga, a language with both downstep and downdrift, factoring apart the source of lowering (in many cases, a primary Low tone) from its ultimate representation (a register Low).

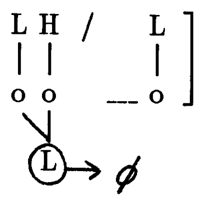
Under a register treatment of downstep like that shown above, those Tiv words shown earlier in (5) obtain the representation given in (11). Notice that when downstep is represented on the register tier, the downstep marker — the register Low — is clearly adjacent to the empty V slot which later conditions its loss in the word on the right.[6]

(11)



We are now able to write a downstep deletion rule which, in removing register Low tones, does not violate adjacency conditions.

(12) Register Low deletion:



According to this formulation of the rule, only a register Low linked simultaneously to primary Low and primary High will be deleted, which is exactly what we need to say if we are to explain why downsteps introduced by the General Past morpheme fail to disappear.

(13) ꜜúngwà (*úngwà) 'heard Gen.Past'

As Pulleyblank 1986 notes (p. 37), there are no alternations in the General Past between the downstep (which is the only marker of the morpheme) and a Low tone; thus, we can say quite simply that the morpheme consists only of a register Low. The Low links directly to the first primary High-toned tonal node, and the Register Low deletion rule is oblivious to it.

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6 This is not the account given by Pulleyblank, who invokes the Morpheme Tier Hypothesis (see e.g. McCarthy 1981) in order to locate the floating Low downstep marker on a different tier from the High which it downsteps. His analysis works quite nicely given the assumptions he makes, but it requires the powerful machinery of the Morpheme Tier Hypothesis, while the one proposed here makes use of a simple phonological notion which is needed for quite a large number of languages.

```
(14)    ungwa
        |   |
        o   o

        H   L
        |   |
        o   o
        |
        L
```

On an approach where downstep — and the General Past morpheme — is simply a floating primary Low, one is forced to stipulate that the General Past is an exception to !-deletion.

4. Tonal Nodes

The downstep facts seen above support the two-tiered model over a single-tiered one. In this section we will see independent evidence for the richer model, showing that the power of allowing tonal nodes to be contrastive is required in languages. The first example, Margi, will be a case where register tones are not needed, so that the only relevant difference between the two models is the absence versus presence of the tonal node tier. This is shown below.

```
(15)
     a.  x   skeletal tier             b.  x   skeletal tier
         |                                 |
         T   (primary) tone tier           o   tonal node tier
                                           |
                                           T   (primary) tone tier
```

4.1. Margi

Margi has only two surface tones (High and Low), but a richer inventory of tonal configurations in the lexicon, where it distinguishes among High, Low and ∅. This tripartite contrast is illustrated below by verbs which, as shown by Pulleyblank 1986, are affiliated in underlying representation with High, or Low, or both, or no tone at all.

(16) Verb stems:

H	L	LH	∅
shíná 'change'	tsə̀dzù̥ 'shake'	mbìɗú̥ 'blow'	pə̀tlù̥ / pə́tlú̥ 'break'
tsá 'beat'	ŋkà 'refuse'	hǔ̥ 'grow up'	ìɗà / íɗá 'rot'
ndáɓía 'feel'	ntə̀l 'lack'	mbǔ̥ 'get better'	hyà / hyá 'start'
dzə́bá 'measure'	kùtù̥ 'see'	fǐ 'swell'	hù̥ / hú̥ 'take'

Although all tone-bearing units eventually end up linked to one of the two surface tones, underlyingly toneless verb stems can be distinguished from those affiliated underlyingly with High or Low in that only the former will typically assume the tone of the nearest affix. In this vein, both possible realizations for toneless stems are given above. Toneless stems which do not abut other tones will receive Lows by default (Pulleyblank 1986).

To handle the phonological contrast between toneless elements and those marked for either High or Low tone, we will thus need the following three configurations in the lexical rules:

```
(17)    V  V  V
        |  |
        H  L
```

But this is a serious problem for the integrity of binary-valued features. The ternary use of a binary-valued feature has been frowned on ever since Stanley 1967, and the creation of three tonal configurations in (17) would seem to cry out for reanalysis. An interesting move in that direction is made by Pulleyblank 1986. To avoid ternary contrasts on the primary tier in Margi, he proposes to expand the number of tone features, placing the lexical specification corresponding to High on the [upper] tier, and that corresponding to Low on the [raised] tier. Each tier thus has only binary contrasts.

However, distributional facts about Margi tone strongly suggest that High and Low must be on the same tonal tier in the lexicon. Below I present the evidence for this position.

A. Co-occurrence restrictions. High and Low are in complementary distribution in the lexicon: no vowel is specified for both tones underlyingly. Although a class of verbs is affiliated with two tones (the LH class), these tones never link to the same vowel except under one condition: if, at the end of the word, the number of tones exceeds the number of tone-bearing units, the extra tones will bunch up on the final TBU.

```
(18)     fi  'swell'
        / \
        L H
```

Co-occurrence restrictions of this sort are exactly what we would expect of two specifications on the same tier; High and Low, as complementary values for the same feature, cannot normally be combined. However, it would require stipulation to achieve the same result for features on independent autosegmental tiers.

B. Contours but no complex segments. When High and Low do occur on the same vowel, they form a contour — not a complex melody. (As noted earlier, contours arise when rules apply to link floating tones at the end of the domain.) What this fact shows is that even when forced by rule to occupy the same vowel, High and Low remain linearly ordered. And this obligatory sequencing is explained only if they are on the same autosegmental tier.

By contrast, we would expect features on independent tiers to form a complex segment when linked to the same skeletal position — for example, a Mid tone would be the logical result of combining High and Low. Mid tones are in fact exactly what we find in languages like Yoruba which *do* require two tone features in the lexicon (Pulleyblank 1986), but they do not play a role in Margi.

C. Ordering floating features. Pulleyblank argues compellingly that a large class of verbs are affiliated underlyingly with a floating LH melody. Its realization is totally predictable from left-to-right, one-to-one mapping, and there is thus no reason to prelink these tones underlyingly.

Given the fact that floating High and Low must, as components of a well-defined melody, be ordered with respect to one another, we have yet another piece of evidence that they are on the same tier. Floating features on independent tiers cannot be ordered under current formulations of autosegmental phonology. We can look elsewhere to plenty of examples where floating features on different tiers can both be mapped to the same vowel on the first iteration of left-to-right, one-to-one mapping — but this is not the case for floating features on the same tier, and it is not the case in Margi.

4.2. Solution

If High and Low are represented on the same tier in Margi, then how are we to deal with the fact that the language appears to require a ternary tonal contrast in the lexicon, which is resolved into a binary contrast on the surface?

I propose to use the insight of Pulleyblank that this contrast can be handled by appealing to a second autosegmental tier — but, instead of positing a new tonal tier, I will make use of one already in use in the representation: that of tonal nodes.

If we suppose, as suggested earlier, that the presence or absence of a tonal node is manipulable by phonological rules, then we can use this potential contrast to distinguish tone-bearing vowels from non-tone-bearing ones. High and Low vowels stems must have a tonal node in our model — it is a necessary part of associating a tone with a timing slot — and we need only separate out vowels with tonal nodes from those without to get the one additional contrast required by the language. Toneless vowels are simply those which lack a tonal node at a particular stage in the lexicon.

```
(19)    V V V
        | |
        o o
        | |
        H L
```

We have thus factored a three-way, + vs. − vs. ∅, contrast on one tier into two binary contrasts: + vs. − on the tonal tier, and presence vs. absence on the tonal node tier. The fact that we must specify both values of the tone feature in the lexicon is not a drawback; Margi and other languages with floating tone melodies are simply not candidates for the radical underspecification that is possible when features are underlyingly linked to segments.[7]

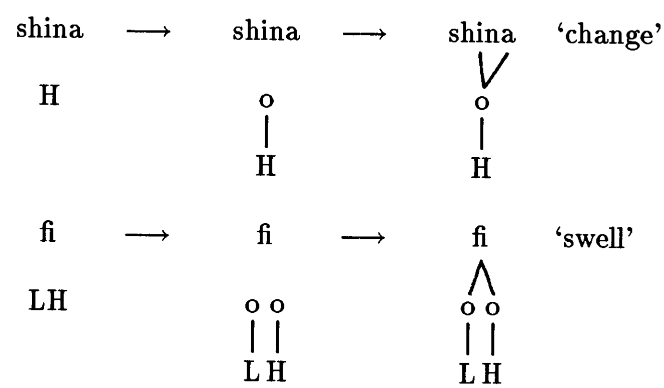
To make the proposal work, we need some method of introducing tonal nodes into the representation, and as a first approximation I offer this algorithm:

(20) Tonal Node Insertion:

a. Attach a tonal node to each floating tone.

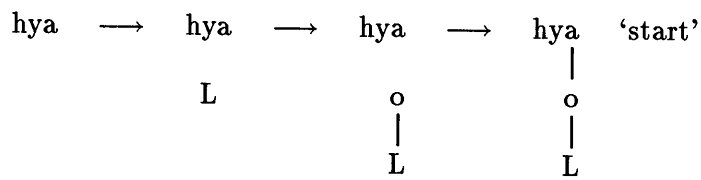
b. Map floating tonal nodes to tone-bearing units from left-to-right.

(21)



Post-lexically, the default rule allotting floating Low tones to words without any tonal specification will precede Tonal Node Insertion.

(22)



The algorithm successfully prohibits the possibility that a tone-bearing unit might be linked to a tonal node but not to a tone in Margi, and this is exactly what we need to ensure that our ternary contrast will not expand to a quaternary one.

This deceptively simple solution, which is available only in the richer model of tone advocated here, makes it possible to maintain the intuitive, single-feature

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[7] For example, if we were to mark the location of each High tone underlyingly, we would not need to mark Lows in the lexicon at all. But since the location of Highs is so predictable, this method would be terribly redundant, and it is thus preferable to posit both floating Highs and Lows.

analysis of Margi tone while still obeying the well-motivated injunction against the ternary use of a binary feature. Of course, what remains to be worked out in order to give this solution real explanatory power is a theory of under what circumstances the presence or absence of tonal nodes is contrastive, and we must look to future work for such a theory.

5. Zulu

In Tiv we argued for the addition into the phonological representation of register tone; in Margi, for the phonological status of tonal nodes. Zulu depressor consonants provide a case where both aspects of the model interact.

A language with a High vs. Low tonal contrast in the lexicon, Zulu contains certain consonants — the so-called depressors — which have the effect of lowering the pitch register on which an adjacent vowel is realized. (The data presented here are from Laughren 1984.)

For example, the /z/ in *ìzìhlâ:lò* 'seats' (23) is a depressor consonant, and lowers the F∅ of the surrounding vowels with respect to their realization in the word *ìsíhlâ:lò* 'seat', which has, on Laughren's account, the identical LHL basic tone pattern — but no depressor consonants. Surface pitch levels are represented above each word, following the impressionistic transcription of Doke (1926:245). The highest is 1, the lowest 9; depressor consonants and depressed vowels are underlined.

(23)

3 2 2-8 9	6 6 3-8 9
ìsíhlâ:lò	ìzìhlâ:lò
'seat'	'seats'

Depressor consonants have the following three properties (Laughren 1984):

(24)

a. Depressor consonants do not participate in or affect the process by which underlying tone melodies are associated with vowels.

b. A consonant will depress the pitch of surrounding vowels only if one of those adjacent vowels bears a Low tone (p. 219), as shown in (25).

c. If a depressor consonant gets deleted in the lexical rules, its lowering effect will persist (p. 218), as shown in (26).

(25)

No adjacent L's		Adjacent L's	
úḿ!fází	'woman'	ìzìhlâ:lò	'seats'
í!nkúnzí	'bull'	ízìfú:ndò	'lessons'
úbú!hlúngú	'pain'	àmá:ndlà	'it is strength'

(26) ízìngănè ⟶ î:ngă:nè

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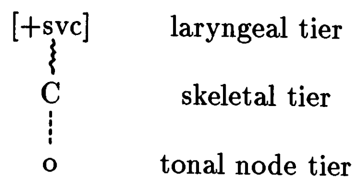
I propose that all of these facts can be accounted for using exactly the entities we have established so far — tonal nodes, register tone, and primary tone. My analysis owes a number of insights to that of Laughren 1984, who was working in a different framework (one without register tone).

Essentially, I analyze the 'depression' effect as the linking of a register Low tone to the depressed elements. Further, I propose that depressor consonants are distinguished from non-depressor consonants by the presence of a tonal node in the lexicon. That is, in Zulu as in Margi the presence or absence of tonal nodes is phonological.

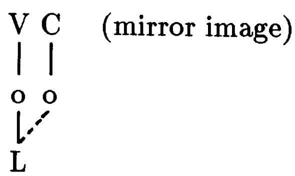
Laughren has proposed [+slack vocal cords] as a characteristic feature of depressors, and we may use that feature as the trigger of the tonal node insertion rule:

(27)



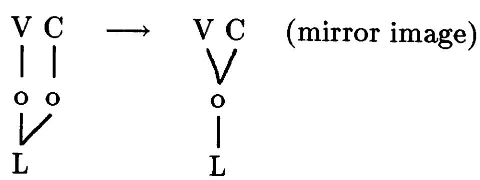
Next, a simple spreading rule spreads a neighboring Low tone onto the new tonal node:

(28)



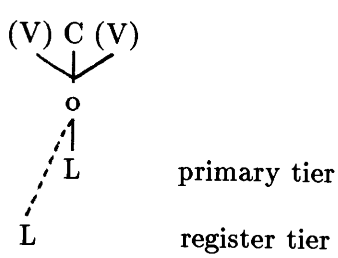
The tonal nodes linked to primary Low are collapsed by the OCP (Leben 1978):

(29)



Last, register Low is inserted into the configuration, rendering the primary Low tone and all elements it attaches to 'depressed'.

(30)



We now can explain all of the facts listed in (24).

Because rule (27) applies after tone assignment takes place, we account for why depressor consonants — though linked to a tonal node — do not acquire pieces of underlying tone melodies through normal left-to-right, one-to-one association principles, explaining fact (24a).

The reason the depressing effect of consonants can remain even after the depressor consonant is deleted (fact (24b)) is that the consonant is merely the source for — not the actual representation of — F∅ depression. The phonological entity corresponding to register lowering is the register Low tone, which remains in the representation even after its source has disappeared.

Fact (24c), that depressor consonants do not depress when surrounded by High tone, falls out from the inapplicability of rule (28) in that environment. The depressor consonant is thus deprived of the primary Low needed to trigger the ultimate insertion of register Low.

6. Conclusion

Besides being more powerful than a single-feature model of tone, the proposed model is also more restrictive, in that using mechanisms independently needed to handle the facts of different languages, we can dispense with various diacritics which have been proposed to deal with phenomena that a two-tiered model cannot accommodate. By proposing that tonal nodes, the mechanism needed independently to organize the two tonal tiers, are phonologically contrastive, we can solve the rather general problem of how to represent apparent three-way tonal contrasts in languages with only two surface tones.

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