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An Overview of Autosegmental Phonology*

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Since the subject of linguistics is the relation between sound and meaning, we must ask what the nature and form of the phonetic and semantic levels are. For a generative linguistic system, this task begins with hypotheses about the type of formal representation that counts as a faithful rendering of the phonetic or the semantic aspects of a word, sentence, discourse, and so forth.

Autosegmental phonology is an attempt to provide a more adequate understanding of the phonetic side of the linguistic representation. Viewed in this light, this is a proposal at the same logical level as the proposal that a phonetic representation is a linear sequence of atomic units—call them segments; it is at the same level as the suggestion that these atomic units are cross-classified by distinctive features. Autosegmental phonology constitutes a particular claim, then, about the *geometry* of phonetic representations; it suggests that the phonetic representation is composed of a set of several simultaneous sequences of these segments, with certain elementary constraints on how the various levels of sequences can be interrelated or "associated."

To say that autosegmental phonology is a hypothesis about the geometry of phonetic, and ultimately phonological, representations is rather abstract at best. From a more down-to-earth vantage point, autosegmental phonology is a theory of how the various components of the articulatory apparatus, i.e., the tongue, the lips, the larynx, the velum, are coordinated. At the most superficial, observable level the linguistic signal is split up into a large number of separate information channels. Viewed from the production side, this consists of the specific commands to the larynx, the velum, the tongue, and so on, or perhaps the patterns which each channel then attempts to attain. At an "abstract" level, this information comes about from splitting up a

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more unified representation. Let us clarify this with an example. Suppose we utter the word "pin". As the orthography suggests, the linguistic representation of the word consists of three segments linearly ordered, as in (1).

(1)

'p'	'i'	'n'
+conson	+syllabic	+conson
-nasal	-nasal	+nasal
+labial	-labial	-labial
-coronal	-coronal	+coronal
.	.	.
.	.	.
.	.	.

The production of this word, however, involves separate, though coordinated, activity by the velum, the lips, and so forth, expressed roughly in (2).

(2) A Score for the Orchestration of <u>Pin</u>

```
Lips:     ...Close up....open.....................
Tongue:   ...High and front..........touch the palate
Velum:    ..Raise.............lower.................
```

The standard assumption regarding the nature of phonological representations—that they look much like (1)—implies that the process of language acquisition includes the development of the ability to take a representation much like (2) and slice it vertically into columns, assigning the appropriate feature specifications to each column, ultimately deriving a representation like (1): P–I–N. In short, the normal assumption about phonological representations implies that in processing a signal, we learn to shift around slightly the horizontal alignment of the commands in (2). We "justify" it and patch it up so that it may be sliced up vertically into the phonologically, and hence psychologically, real segments. Let us call this assumption the "Absolute Slicing Hypothesis."

In the example we considered, saying *pin* as in (2), the process described above is essentially correct. The Absolute Slicing Hypothesis is then adequate to the level of detail we have considered in (2). Suppose, however, that we add to the orchestral score in (2) the activity of the larynx that gives rise to pitch. If we utter this word *pin*

in isolation, and if we disregard the actual sluggishness of the vocal folds for the nonce, the syllable will be uttered at a rapidly falling pitch. For reasons that will be developed in Section 1.2 and Ref. 6 I will represent the Falling pitch as the sequence of a High pitch and a Low pitch. A more faithful orchestral score for *pin* would be (3).

(3) A Revised Orchestral Score for <u>Pin</u>

```
Lips:     ...Close up....open......................
Tongue:   ...High and front.............touch the palate
Velum:    ..Raise.............lower.................
Larynx:   ...High pitch.....Low pitch...............
```

The assumption of the Absolute Slicing Hypothesis fails now, and this failure is in no sense a trivial one. The laryngeal pitch specifications are, we shall argue below, (and in detail in [6]), not the result of specification of any of the segments in (1), the phonological representation. The falling pitch of this utterance is not part of the phonological segments in the same sense that the other commands are, as in (3) (those for the lips, the tongue, or the velum).

The speaker of English thus factors out the pitch, and does not attempt to include the pitch features in the huge musical score which is sliced up into the more abstract segments as in (1). In this sense, then, the Absolute Slicing Hypothesis fails; the slicing is not absolute or complete, but rather may exclude some parts of the linguistic signal.

This failure of the Absolute Slicing Hypothesis is nontrivial in two separate, important senses. First, it is only an accident about English that the laryngeal pitch features are excluded from the great slicing. Other languages may well include pitch as a part of the signal which is sliced up into successive segments. Conversely, a language may exclude some features from the great slicing that English happens to include. Guarani, as we shall see in Section 5, happens to exclude the nasalization feature, while English includes it. Whether a particular channel of articulation is included cannot be specified universally once and for all.

The second sense in which the Absolute Slicing Hypothesis fails nontrivially will be the key to the successful formulation of its successor. The articulatory levels that are excluded—in the present example, pitch—are themselves susceptible to a slicing or segmentation. Thus, while the laryngeal pitch commands in (3) do not correspond to the standard phonological representation in (1), they do in fact correspond to a more abstract segmented level, as follows:

(4) $\overset{*}{\mathrm{H}}$ L where H=High and L=Low

In the present example, of course, the empirical significance of the representation in (4), including the meaning of the star∗, remains open for the present. The important point is however: while a language may exclude an articulatory level from the great slicing that leads to the principal segmentation (corresponding to P–I–N in (1)), the excluded articulatory levels themselves form segmented domains, domains in which the segments are linearly ordered, and where the segments are cross-classified by feature-specifications. In general, the formal properties of the "phonological" representation, as in (1), will be mirrored on each level. Just as (1) corresponded to (2), then, the revised and now autosegmental representation given as (5) corresponds to (3), the more adequate orchestral score. And (5), we see, is a synthesis of (1) and (4). The precise significance of the "association lines" linking the tonological and the phonological levels will become clearer shortly.

```
(5)
                   [ +conson  ] [ +syllabic ] [ +conson  ]
 phonological:     [ -nasal   ] [ -nasal    ] [ +nasal   ]
                   [ +labial  ] [ -labial   ] [ -labial  ]
                   [ -coronal ] [ -coronal  ] [ +coronal ]
                   [    .     ] [    .      ] [    .     ]
                   [    .     ] [    .      ] [    .     ]
                   [    .     ] [    .      ] [    .     ]
                             * /          \
 tonological:          [ +high ]      [ -high ]
                       [ -low  ]      [ +low  ]
```

To develop this idea, however, let us turn our attention from these rather general comments on the nature of phonological segmentation to some more pressing problems in generative phonology. A proposed theoretical revision must in general be shown to resolve a dilemma in the standard theory; we shall therefore proceed to several general types of phenomena that are all difficult or impossible to account for in the standard framework, which incorporates only one string of segments in a phonological representation. We shall show how each phenomenon of this type individually leads to the same solution, an autosegmental solution. In the course of doing so, we shall see that these phenomena in general, though not invariably, cluster together,

as predicted by the autosegmental solution. We shall consider the following:

A. The existence of contour-valued features, such as rising or falling tones on vowels, or prenasalized stops, such as ^{n}d, ^{m}b, etc. Here the argument must be made that in some languages, short vowels[1] bear these dynamic or contour tones, and that furthermore such a contour tone is linguistically the concatenation of two level tones, rather than being an atomic unit itself. The existence of short vowels with contour-tones has been argued for recently by a number of linguists, most forcefully by Leben [10]. No satisfactory alternative theoretical account has been given, however.

B. The phenomenon of "stability." This is the tendency of a feature value to persist despite the erasure of the major segment (generally, vowel) which appeared to have borne that feature. Roughly we find in tone languages that when a tone-bearing vowel is deleted by a phonological rule, the accompanying tone does not also delete, but rather shows up elsewhere on a neighboring syllable.

C. *Melody levels* in the grammar. These are linguistically significant levels in the grammar which refer to just one or two features in the utterance. We have already seen a foreshadowing of this phenomenon in the discussion of the difference between the pitch features in English and the other features. If we view the musical scoring for the utterance *pin* as in (3), and many more like it, we will notice a difference in the different lines (or "voices", in the musical sense). Some, like the line of instructions to the velum legislating nasality, will appear rather uninteresting when viewed alone. No generalizations can be made by looking at nasalization alone in English. In other areas—such as the level of instructions for pitch—there are linguistic generalizations to be gained by restricting our attention to just those features. There are, thus, strictly pitch-feature regularities, which is not to deny that further insight is to be gained by observing how the pitch-level is coordinated with the other levels, of course. However, the point is that certain subsequences of features *do* form linguistically significant melody levels, while others do not.

D. The heuristic notion of "floating tone," which can be rigorously defended in autosegmental terms. The floating tone has served

[1] The requirement of "short" here is meant to avoid the possibility that a long vowel might actually be two successive short vowels, each with a level tone. This, of course, does happen frequently; it is, however, irrelevant in the present context. The situation is much the same for prenasalized stops: in some languages, these stops are clearly *one* segment, even though they have two successive feature-specifications for nasality.

well in practical terms for linguists dealing with tone languages; it has, however, had a tainted reputation because of its apparent anomalous nature within the current theoretical framework.

E. Finally, we will consider some processes of automatic spreading of features, both to the left and right, over segments unspecified for those features. The accepted notation for phonological rules implicitly predicts that spreading should be simpler if it occurs only to the left or only to the right; we find, however, many cases of bidirectional spreading. When viewed from an autosegmental perspective, the reasons become clear.

This is, perhaps, an appropriate moment at which to point out some differences and similarities between autosegmental phonology and other treatments of what have been called suprasegmentals. Much of what is covered in this present analysis would be called suprasegmental by the criteria implicit in the literature. What is suggested by the term "suprasegmental"? Two things, I would submit, which are entirely different but which have been continually confused in the recent linguistic tradition.[2]

Calling tone "suprasegmental" immediately distinguishes it from the "segmental," correctly viewing pitch as different from and not part of the phonological segmentation as in (1), the segmentation into phonemes. But this first observation has led to the false assumption that "suprasegmentals" could not be segmental in their own right—the second, more fundamental, sense of "segmental", which is overlooked by the term "suprasegmental." If the "suprasegmental" of pitch, does by itself form a sequence of tonal segments, then "suprasegmental" is a misleading label. A more accurate picture we suggest is parallel sequences of segments, none of which "depend" or "ride on" the others. Each is independent in its own right; hence the name, *auto*segmental level.

1. CONTOUR TONES

Let us proceed to particular problems within the theory of phonology. Our first task is to make quite clear why having two tonal specifications on a single vowel is incontrovertibly in contradiction

[2] For example, "Suprasegmental tones are by definition independent of any segments—rather than being expressed as features on segments, they are features on larger linguistic units." [10:26]

with the standard theory. I shall first sketch the argument heuristically, and then redo it in more technical language.

Suppose we analyze the tonal workings of a language and decide that where contour tones occur, they are really the concatenation of level tones.[3] That is, Rising tones are actually composed of the sequence Low tone and High tone; Falling tones are composed of High tone and Low tone. Suppose further that such contour tones occur on short vowels. We shall consider several actual examples shortly. A long vowel may be analyzed as a sequence of two short vowels, but a short vowel has no such analysis. How can we represent the contour tone of the short vowel?

Our conclusion will be simply that we cannot represent it if we stay within the assumptions of the standard theory. Let us assume, for purpose of exposition, that tone can be represented in terms of binary features[4] (although the assumption of the binary nature is not relevant at this point). Suppose, then, we try to represent *a* with a Falling tone, that is, *â* as in (6). This Falling tone, as we have said, is the combination of a High tone and a Low tone.

[3] One could, in this regard, accept the suggestion of Woo [17] that *all* contour tones are necessarily such concatenations. The logic of the situation would not be much changed; we would simply not need to investigate the particular language in question to come to the conclusion mentioned in the text.

[4] We shall, for the sake of definiteness, assume a theory of tonal features that is defended at more length in [7]. We adopt two binary pitch features: ± Highpitch and ± Lowpitch.

$$\begin{bmatrix} +\text{Highpitch} \\ -\text{Lowpitch} \end{bmatrix} = \text{High tone (H)}$$

$$\begin{bmatrix} -\text{Highpitch} \\ +\text{Lowpitch} \end{bmatrix} = \text{Low tone (L)}$$

$$\begin{bmatrix} -\text{Highpitch} \\ -\text{Lowpitch} \end{bmatrix} = \text{Mid tone (M)}$$

the fourth possible combination

$$\begin{bmatrix} +\text{Highpitch} \\ +\text{Lowpitch} \end{bmatrix}$$

will tentatively be excluded by a universal principle. The distinction between tone and pitch is drawn in Chapter 2 of [7].

(6)
$$
\begin{array}{r}
\\ \\ \\ \\ \\ \\ \\ \\
a\left\{\begin{array}{l}\\ \\ \end{array}\right. \\
b\left\{\begin{array}{l}\\ \\ \end{array}\right.
\end{array}
\left[\begin{array}{l}
+\ \text{syllabic} \\
+\ \text{constricted} \\
\quad \text{pharynx} \\
-\ \text{high} \\
-\ \text{round} \\
\quad \cdot \\
\quad \cdot \\
\quad \cdot \\
+\ \text{Highpitch} \\
-\ \text{Lowpitch} \\
-\ \text{Highpitch} \\
+\ \text{Lowpitch}
\end{array}\right]
$$

Now this clearly will not do. This curious segment (6) is both +Highpitch and −Highpitch; is both +Lowpitch and −Lowpitch. The features in the part labeled (a) seem to indicate a High tone; those in (b) seem to indicate a Low tone. But putting one on top of another does not order them, as we require. In particular, we must distinguish a Falling tone from a Rising tone; but to do so, a new and theoretically momentous set of conventions must be introduced in order to make *vertical* ordering of features within a segment play the role of left-to-right (temporal) ordering of segments elsewhere.

Or one could attempt an equally radical revision of the notion of segment with the introduction of a notation as in (7).

(7)
$$
\left[\begin{array}{c}
\begin{array}{l}
+\ \text{syllabic} \\
+\ \text{constricted} \\
\quad \text{pharynx} \\
-\ \text{high} \\
-\ \text{round} \\
\quad \vdots
\end{array} \\
\\
{}_{A}\!\left[\begin{array}{l} +\ \text{Highpitch} \\ -\ \text{Lowpitch} \end{array}\right]_{A}
{}_{B}\!\left[\begin{array}{l} -\ \text{Highpitch} \\ +\ \text{Lowpitch} \end{array}\right]_{B}
\end{array}\right]
$$

One has here, however, what is to all appearance a category error. The nontonal features have one relationship to the entire segment; they are, let us say, "features-of it." The tonal features are features of a subsegment (there are two subsegments here, A and B); and the subsegments bear some entirely other relationship to the entire

segment: they "subcompose" it, let us say. Consequently, tonal features are "features-of a segment which subcomposes" the entire segment; in particular, the tonal features are no longer features-of the segment. Here, too, is a radical suggestion intended to make possible the representation of a contour tone.

Now these two attempts, the second of which is rather a commonplace in the literature, are not misguided; quite the contrary, even though both are wrong. They recognize that the existence of contour tones is a *problem* for the standard representation. Our task is to outline a third proposal, one which is conceptually simpler and which has a number of direct empirical consequences: autosegmental representation. First, let us review in more technical terms the argument that demonstrates the dilemma of the standard theory.

Segments are atomic elements ordered linearly left to right; this simple and elegant hypothesis is at the foundation of standard phonology. A feature-specification of a segment is, then, a property or an attribute of the segment. The property of being voiceless "belongs" to the first segment in *pin*, just as the property of being "front" belongs to the second segment. More technically, we would say that *pin* has a representation at the phonological level as in (8).

(8) $S_{75}\ S_{31}\ S_{33}$

The subscripts indicate nothing but that these are primitive elements in the phonological vocabulary. We would further specify that there are various "feature-projection" maps—characteristic functions, in mathematicians' language—that tell us what the feature specifications for each segment are. For example, there is an F_{voice} function which maps S_{75} in the present example to − (minus). $F_{voice}(S_{75}) = -$. This says that the first segment in the representation of *pin* in (8) is voiceless.

Having made precise our notions of segment and feature-specification (following essentially Chomsky's *Logical Structure of Linguistic Theory*). it is clear that there is no way that a segment can be specified both + and − for some particular feature. In particular, no single segment can be both [+Highpitch] and [−Highpitch]; therefore no single segment can be High-Low in pitch, and therefore no single segment can be contour-toned unless there is a single feature which is "Falling" or "Rising", contrary to hypothesis. If a single segment were both +Highpitch and −Highpitch, then $F_{highpitch}$ would not be a function, again contrary to assumption, since it would be two-valued.

If we wished to resolve this formal conflict by saying that there were two separate characteristic functions associated with each phonological feature, one mapping to the specification + (plus) and the other to the specification – (minus), we would avoid the immediate contradiction, but lose the formal representation of the fact that the two values are values of the *same* feature; such an approach would clearly lead in the wrong direction.

The correct position to take is that the formalism demands that no segment may be doubly specified for a feature. If tones are features of the vowel segment, then there may be no Low-High sequence on a single vowel. Some other basic axiom must be abandoned.

The approach we will take toward a resolution of this problem is to deny that tonal features are features of the vowel in the case of the problematic contour tone. Rather, the tonal features are properties of another level; feature specifications on the other level constitute segments, but their relation to the vowels with which they are associated is merely one of simultaneity in time. We represent this dynamic element by association lines. The Falling-toned *â*, then, is represented as in (9).

```
(9)      [+syllabic     ]            a
         [+constricted  ]           / \
         [  pharynx     ]   or     H   L
         [-high         ]
         [ . . .        ]
              /   \
   [+highpitch] [-highpitch]
   [-lowpitch ] [+lowpitch ]
```

A more complex example, like the word *àkálă* would be represented as in (10).

```
(10)  a k a l a
      |   |   |\
      L   H   L H
```

Before proceeding with the development of this notation, let us turn to an example from a tone language.

1.1 IGBO

Our first example is from Uhuhu Igbo, as described in [8]. (These facts are discussed in much greater detail in Chapter 2 of [7].) For the

present we will content ourselves with finding a contour tone on a single segment, and showing that it is indeed the concatenation of two tones; we shall then see why the notation in (9) or (10) does more than describe these facts, but predicts and explains the intuitively clear sense of left-to-right order of tones that is revealed inside of contour tones by the tonological rules.

There is a simple tone rule that occurs in the "I Main" form. Throughout the Igbo language, the particular tone of the verb stem, suffixes, and prefixes is determined by the "form" of the clause. We may reserve our attention here to I Main form, in which the verb-stem is Low-toned, in unexceptional cases. Consider, for example, a simple sentence in the I Main form where the subject is a pronoun:[5]

(11)

I Main form

(a) ó cì àkhwá 'He must carry some eggs.' or
he carry eggs 'He was carrying some eggs.'

(b) ó zà úlò 'He must sweep the house.'
he sweep house

(c) Ḿ cì ánú 'I was carrying meat.'
I carry meat

We see that in the I, Main form, the pronominal subjects are High in tone, and the verb stem is uniformly Low in tone. When the subject noun phrase (NP) ends in a Low tone, the tone pattern of the sentence is just what we would expect on the basis of the sentences in (11). The verb stem is Low; the subject bears its inherent (isolation) tones.

(12)

Ézè cì àkhwá 'The chief was carrying eggs.'
Chief carry eggs Ézè 'chief' (HL)

Ùwà cì àkhwá 'Uwa was carrying eggs.'
Uwa carry eggs Ùwà (a name) (LL)

[5] In the present example I shall consider forms with no suffixes on the verb for simplicity of presentation. More extensive data are discussed in [7].

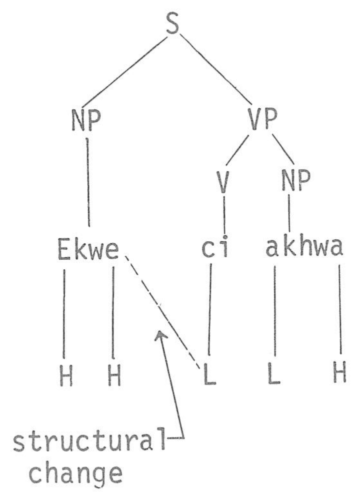
However, when the subject NP would normally (i.e., in isolation) end in a High tone, here it undergoes a slight tonal change. As we see in (14), the final H becomes a Falling tone.

(13) Ékwê cì àkhwá 'Ekwe was carrying eggs.'
Ékwé (a name) (HH)

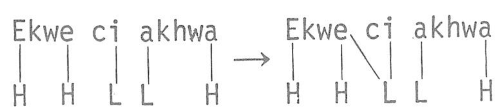
Àdhâ cì àkhwá 'Adha was carrying eggs.'
Àdhá (a name) (LH)

What is happening is clear if we observe the tonal melody. In (13), the drop from the High on the last syllable of the subject NP to the Low of the verb stem is shifted leftward, or "anticipated" on the last syllable of the subject. Using the autosegmental notation, this change is represented as in (14), where the dotted line indicates that the association line was added. The process (15) separates the before and after stages; it says the same thing as (14) in more familiar but less perspicuous notation.

(14)



(15)



The point to observe is that the final syllable in *Ekwe* is associated with two tones—H and L—in the derived structures; this is what is identified as a contour tone.

Before proceeding to the behavior of the irregular verbs in the I Main form, let us see what this autosegmental notation has provided us with. By setting the tonal segments or tonemes off on a separate autosegmental level, we were forced to introduce "association lines" to coordinate the two levels in time. We hoped, thereby, to represent contour tones, which is *prima facie* a phenomenon purely internal to the vowel in question. The notation captures precisely, however, the fact that the tone associated with a vowel on the right—here, the verb stem—may associate with a vowel neighboring on the left, causing a change in the righthand side of the latter vowel. Thus we find processes like (16a), but not as in (16b), just as the notation predicts.

(16) a. V́ V̀ ⟶ V̂ V̀

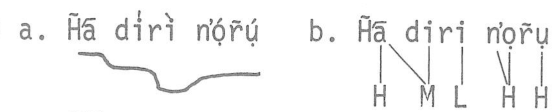
b. V́ V̀ ⟶ V̌ V̀

The difference between two such rules is intuitively plausible, and in fact borne out in empirical work in tone languages throughout the world. Process (16a) is in some sense a proper "assimilation"; (16b) is not. The representation in (14) makes clear what that sense is; alternative proposals, such as (6) or (7), do not.

Having called the tonal phenomenon in (13) an assimilation, and having characterized it as a "flop" rule as in (14), we have committed ourselves to a view with certain predictions. If the verb stem should be on a Mid tone, for whatever reason, then the falling tone of the subject's final syllable must fall to Mid, rather than to Low. This is in fact true, and is borne out in three separate cases, discussed in [7].

For example, a Low-toned suffix immediately following the stem causes the stem to raise to Mid, as in (17a). The pitch of the utterance is as drawn; the autosegmental representation is as in (17b).

(17)



'They were at farm.'

where the accent over *a* means "High vowel falling to a Mid which is level with the following vowel, which must be Mid." The reason for this complicated statement lies in the nature of Downstepping tonemes (the Mid here is one); these are discussed in Section 3 below and in [7].

1.2 English

The next example is drawn from English, where the neutral intonation pattern is HL, with a star * over the H, indicating that the High tone is associated with the accented syllable.

Consider a polysyllabic word like *archipelago*. It has a tone pattern as in (18).

```
          *               *
(18)  archipelago    archipelago
                      \ |/  /
                       \|/ /
                        *
                        H  L
```

This is derived by linking the starred elements in either level. The Well-formedness Condition of autosegmental theory then comes into play and does the rest. Thus we start with a representation as in (19), with no linkage between the levels; then rule (20) comes into play, creating (21a). The Well-formedness Condition derives (21b) from (21a).

```
           *                  *
(19)  archipelago      (20)   V
                              .
         *                    .
         H L                  .
                              *
                              T
```

In (20), as elsewhere, T stands for any arbitrary toneme, and V for any arbitrary vowel; a dotted association line indicates that the rule adds that line.

```
              *                  *
(21) a. archipelago     b. archipelago
             /              \  |/  |/
            *                \ *   /
            H   L              H  L
```

(22)

<u>Well-formedness Condition</u> (initial statement)

(a) All vowels are associated with at least one tone
    All tones are associated with at least one vowel

(b) Association lines do not cross.

Note that the Well-formedness Condition is in the indicative, not the imperative. A derivation containing a representation that violates it is not thereby marked as ill-formed; rather, the condition is interpreted so as to change the representation minimally by addition or deletion of association lines so as to meet the condition maximally. In the case at hand, (21a) is changed to (21b) minimally by addition of four association lines.

Holding aside one or two small points (cf. the discussion in [7]), the description just given accounts accurately for the assignment of neutral intonation to English words. So far no contour tones have been encountered, but that is because the accented syllable was not final in the example considered. If we consider a word like *balloon*, we get a structure as in (23), corrected to (24) by the Well-formedness Condition.

```
           *                  *
(23)  balloon        (24)  balloon
         /                   \/\
        *                     * \
        H  L                  H  L
```

What the theory predicts about English is somewhat reminiscent of tone languages: nonfinal accent is realized as a High tone (as in (22)); final accent is realized as a Falling tone.

This conclusion is also true independent of the length of the final vowel; our search for contour tones on short vowels has led us to English with a clear example. Examples are provided in (25) (the reader will recall that were the final vowels in (25) long, they would undergo diphthongization and Vowel Shift).

```
          *      *     *     *      *
(25)  Japan    hat   pin   pun   Japan
         /\     /\    /\    /\     \/\
        *  \   *  \  *  \  *  \     * \
        H  L   H  L  H  L  H  L     H  L
```

1.3 Excursus on Formalism

With the initial statement of the Well-formedness Condition (22) for tones given, the central aspects of the autosegmental theory are clear. In this excursus, I would like to formally restate some of these provisions. A formalization of these ideas is simple, almost too simple in that it requires a certain amount of familiarity with the concepts involved before the axiomatization makes as much sense as the simple diagram notation.

Each autosegmental tier is a totally ordered sequence of elements, a_j^i: this is the jth element on the ith level. Call the set of segments on the ith level L^i. For now we shall restrict our attention to the case with two levels. Thus we have:

$$a_1^1 a_2^1 a_3^1 a_4^1 a_5^1$$
$$a_1^2 a_2^2 a_3^2 a_4^2$$

In addition to these two sequence of segments, there is a totally ordered sequence of pairs—essentially the association lines—from the geometric point of view.

$$(a_1^1, a_1^2) \quad (a_2^1, a_2^2) \quad (a_3^1, a_2^2) \ldots$$

Call the sequence of these pairs A.

It is clear that A organizes the other levels. Define projection π_1 from 2^A (the set of subsets of A) to 2^{L^1} (the set of subsets of L^1) in the natural way:

$$\pi_1(\{(a_j^1, a_k^2), (a_l^1, a_m^2), (a_n^1, a_p^2), \ldots\}) = \{a_j^1, a_l^1, a_n^1, \ldots\}$$

That is, the first projection π_1 picks out the set of first elements of the pairs. Likewise, the second projection π_2 picks out the second element of each pair, and so forth. Define the inverse of these projections: π_1^{-1} may be defined as follows (or any other way that makes clear that π_1^{-1} is the inverse of π_1 in the natural sense):

$$\pi_1^{-1}\text{ (a) is the largest subset } \alpha \text{ of A such that } \pi_1(\alpha) = \text{a}.$$

Then the Well-formedness Condition is:

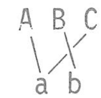
(WFC) π_1 and π_1^{-1} preserve connectedness.

Recall that we have a notion of connected already defined on each level L^i and A since we assumed they were linearly ordered. This ordering naturally induces a connectedness in which the set circled in (26) is connected, but the one in (27) is not, and so forth.

(26) a b c d e f (27) a b c d e f

I will briefly run through why the statement WFC above has the effect of the Well-formedness Condition in (22).

Suppose we have a situation as in (28):

(28) 

This violates (22b); we shall see that its corresponding formal representation does not have a proper projection operator preserving connectedness.

L^1 for (28) is, evidently, $A\ B\ C$. There are, rather trivially, seven connected subsets: $\emptyset$, A, B, C, AB, BC, and ABC.

Similarly, L^2 is $a\ b$, with four connected subsets: $\emptyset$, a, b, and ab. We will see that there is no formulation of the set A with the correct properties; there are only two candidates: (29) and (30). Consider (29) first:

(29) $(A, a) \quad (B, b) \quad (C, a)$

Since $\{a\}$ is a connected set, $\pi_2^{-1}(\{a\})$ should be connected. $\pi_2^{-1}(\{a\}) = \{(A, a), (C, a)\}$, which is not connected in (29). Thus, a contradiction.

If we try (30), we get a similar result:

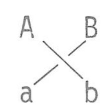
(30) $(A, a) \quad (C, a) \quad (B, b)$

Now $\pi_2^{-1}(a) = \{(A, a), (C, a)\}$ *is* connected.

However, in (30) $\{(A, a), (C, a)\}$ is connected, so $\pi_1(\{(A, a), (C, a)\}) = \{A, C\}$ should be connected, i.e., A and C should be neighboring. But they are not; thus, a contradiction.

Therefore, any situation like (28) where lines cross must be ill-formed; and so (22b) is derived.[6] Similarly in (31), which violates the

[6] Strictly speaking this is not true: the one case we cannot rule out is essentially:



There are, however, good reasons not to want to rule this out, for if we could rule it out we would have given an inherent sense to each level, not just total ordering. In fact, in every possible linguistic case, there will be linked boundary segments on the extremes, and there WFC works correctly.

first part (22a) of the Well-formedness Condition, we find WFC violated also.

```
(31)  A B C   L¹
       \ /
       a b    L²
```

If π_2^{-1} and π_1 preserve connectedness, then $\pi_1 \circ \pi_2^{-1}$ must preserve connectedness too. But $\pi_1 \circ \pi_2^{-1}(ab) = AC$, which is not connected (although ab is); thus a contradiction. The same argument holds if $a = b$. Thus WFC implies (22a).[7]

2. STABILITY

The second type of phenomenon we shall consider in motivating autosegmental representation is what I have named "stability."[8] In tone languages we find that when a vowel desyllabifies or is deleted by some phonological rule, the tone it bore does not disappear; rather, it shifts its location and shows up on some other vowel. The toneme or tone melody has a stability which is maintained independently of the other aspects of the signal, and thus is preserved despite modifications to the syllabic structure.

Reference to this type of phenomenon in the literature has generally been associated with the notion of "conspiracy" or derivational constraint: in this case, a derivational constraint or conspiracy to move around the tonal specifications from vowel to vowel in order to find on the surface the underlying tone melody. This is not to say that there are no tonal rules that delete or modify the tone melody: certainly there are such rules. But the normal case is where the tone melody survives the effects of phonological rules.

[7] Again a proviso must be made. Example (i) is not in violation of WFC; in general, we find, when we inspect the definitions provided here, that if segments on the end of some L^1 are not associated, WFC is not violated. In fact, this odd formal characteristic appears to be reflected correctly in the behavior of certain floating tones. That is, to the extent that WFC differs from (22) above—WFC making curious predictions—WFC is more correct.

```
(i)  Q   A   B
      \   \
       b   a
```

[8] This phenomenon of stability is the subject of [5] from which this section draws heavily; further examples not mentioned here are treated there.

If the tone of a vowel is specified by its features, then the pitch of a vowel is just like any other of its characteristics, such as its tenseness or roundedness. If a phonological rule should delete that vowel, then its tonal specifications are deleted along with all other properties. For example, suppose we have a phonological rule deleting a vowel as in (32).

(32) $V \rightarrow \emptyset$ / —— V   V-Deletion

(A common Bantu rule; see e.g. [16:78, rule (32)].) However, we need to save the tonal information of the deleted vowel, because it shows up on the surface. Looking at tone as a feature of the vowel, we could do this in one of two ways, both similar in intent.

Solution 1. We could posit a special "Tone Copy" rule which copies the tone of the to-be-deleted vowel onto its neighbor. We could do this, I should add, if we permit two tonal feature-specifications inside a single vowel segment, the position I have argued against in section 1. But in order to consider the logic of stability independently of that of "contour specifications," let us permit the latter for the moment to be expressed as in (33) below.

(33) Tone copy

$$\begin{bmatrix} V \\ \alpha\text{high} \\ \beta\text{low} \end{bmatrix} \begin{bmatrix} V \\ \gamma\text{high} \\ \delta\text{low} \end{bmatrix} \rightarrow \begin{bmatrix} V \\ \alpha\text{high} \\ \beta\text{low} \end{bmatrix} \begin{bmatrix} & V & \\ \begin{bmatrix} \alpha\text{high} \\ \beta\text{low} \end{bmatrix} & & \begin{bmatrix} \gamma\text{high} \\ \delta\text{low} \end{bmatrix} \end{bmatrix}$$

A typical derivation applying Tone Copy and V-Deletion would be as in (34).

```
(34)  ... à í ...
      ... à ǐ ...   Tone copy
      ...   ǐ ...   V-Deletion
```

Solution 2. Second, we could posit a general "derivational constraint" to apply to *all* tonal rules—this is, the approach Spa takes in his grammar of Enya, a Bantu language. He suggests, "when a segment carrying a High tone is deleted or becomes incapable of carrying a tone, the High tone is transferred to the nearest syllabic segment . . . [This constraint] applies each time any rule meets its structural description'' [16:139 passim]. In fact, the correct statement of his derivational constraint should apply to preserve equally both High and Low tones. This modification both simplifies his phonological system and generalizes the derivational constraint.

Solution 2 is explicitly global, and therefore suspect within received generative theory: a theory countenancing global rules approaches vacuity. This solution introduces a general global condition on vowel-affecting rules, and while this seems like an improvement, in that it is a generalization, it is nonetheless worse theoretically because we now permit not only global rules, but a whole new kind of object which is global and applies anywhere in the course of a derivation, outside the set of ordered rules. Only solution 1 holds promise, and yet what we find in actual work is that for every case of vowel-deletion or desyllabification, we must set up another case of tone-copying, and thus we have missed a generalization. But the generalization is precisely solution 2, the general derivation constraint. A paradoxical situation: to effect a satisfactory linguistic solution, we need to state a generalization; but inclusion of this generalization within the standard theory amounts to a serious weakening of the theory of phonology. We have reached a crisis point.

We might note that even if we did include the derivational constraint, in the belief that constraining a theory must always take a back seat to stating a generalization, three important questions would be left unanswered: first, why are tonal features copied, but not the other features? What makes them special? Second, what is meant by a representation with two feature specifications inside a single vowel (the issue pursued in Section 1)? Is there a connection between the fact that there can be contour tones and the phenomenon of stability—apparently so different? Third, and most telling, the ''conspiracy'' to preserve tonal melodies extends past a derivational constraint that whisks the tone off of a sinking vowel. In fact, in a tone language where the Derivational Constraint seems to generally hold, what we find is that vowel assimilation rules such as (35) copy all vowel features up to, but *not* including, tone features.

(35) $$\mathrm{V} \longrightarrow \begin{bmatrix} \alpha\,\mathrm{High} \\ \beta\,\mathrm{Back} \\ \gamma\,\mathrm{Round} \\ \delta\,\mathrm{ATR} \\ \ldots \end{bmatrix} \;/\; \text{—} \begin{bmatrix} \alpha\,\mathrm{High} \\ \beta\,\mathrm{Back} \\ \gamma\,\mathrm{Round} \\ \delta\,\mathrm{ATR} \\ \ldots \end{bmatrix}$$

A rule like (35) certainly exists in Igbo and Yoruba, and in Enya according to Spa [16:47, 57]. So if two vowels come together, each with its own tone, then either one vowel is deleted and its tone is retained, as in (32), or one assimilates in quality in every regard save tone. The only empirical difference lies in the length and syllable quality of the remaining vowel(s). From the point of view of tone and its conspiracies the same fate has come to pass. Yet the derivational constraint speaks only to the case with deletion, not the case of nearly complete assimilation: thus missing the generalization.

This is the logic of the situation. Let us look at some actual cases in more detail.

Consider two articles by Julie Lovins [11] on Lomongo, whose tonological rules, she suggests, ''conspire, individually or in concert, to derive surface tone patterns on words and phrases without changing the underlying melody.'' Central to the analysis is what Lovins calls ''tone composition,'' in which ''the tones stay where they are when segmentals are deleted.'' She continues with an example, ''if two vowels are juxtaposed, within a word or across word boundary, it is usual for the first vowel to be elided. Its tone remains and combines with that of the following vowel.'' For example,

(36)	bàlóngó bǎkáé	→	bàlóngǎ̂káé	'his book'
	bánà bǎmǒ	→	bánǎmǒ	'other children'
	bọ̌mọ̌ bòtámbá	→	bǒmǒ̂támbá	'another tree'
	bǎtswá là èmí	→	bǎtswêmí	'you who lead me away'

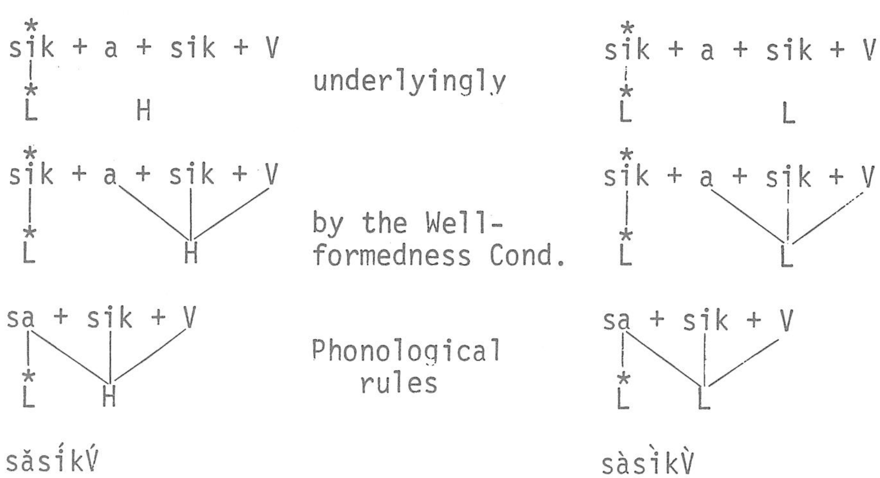
With a number of similar examples, Lovins concludes, ''The only derived forms that occur are the ones that preserve the underlying melody . . . and the only way to get these derived forms is to posit a species of rule application that many linguists find objectionable.'' She is certainly correct, given the standard framework; and she is exceptional among writers on this subject in recognizing the implications for phonological theory of the type of rule she posits.

The existence of the tone melody's ''stability'' is our concern: how can it be that a tone refuses to be deleted when its vowel is deleted? In autosegmental formalism, this is precisely what is predicted. In any theory of generative phonology, a deletion rule deletes a *segment*. Now, if a rule—(32) for example, V-Deletion—should delete a vowel, it does not delete any of the tone segments that the vowel is associated with, since those tone segments are separate segments. The worst that can happen is that the tone segments will be left "orphaned" or free, without a vowel associated with it. That will be the interesting case to look at in detail.

The point we have just seen should be emphasized: the stability phenomenon, formerly paradoxical, is a natural consequence of the autosegmental system—not by proposing a constraint on rules, but rather by proposing in effect a new geometrical shape (in a somewhat abstract sense) for formal representations.

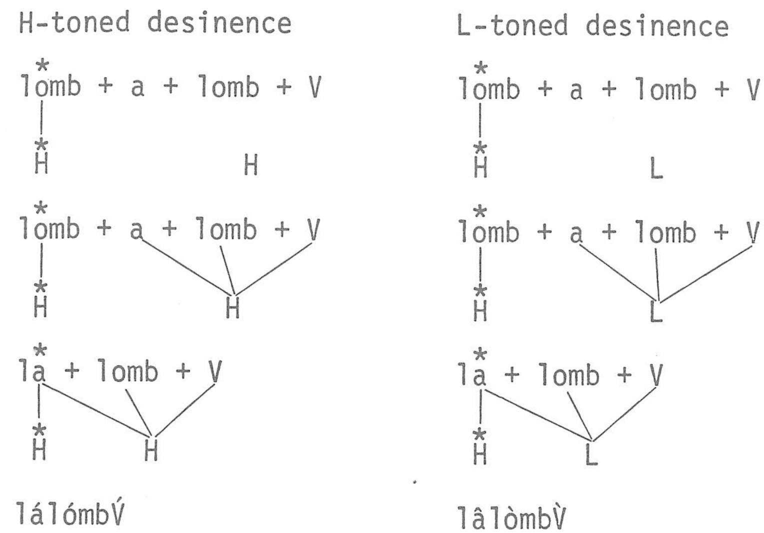
Let us consider in more detail the reduplication treated in Lovins papers. Verbs are lexically marked for tone, H or L; the stem is reduplicated and an /a/ infix is added between the two copies of the stem. A L or H desinence then follows.

(37) L-toned stem <u>sik</u> 'stop'



The last stage is reached by pure phonological rules: $k \rightarrow \emptyset$ and $ia \rightarrow a$.

(38) H-toned stem <u>lomb</u> 'be shy'



In short, from the notation we get the "conspiratorial" results automatically by keeping the syllabic and the tonal levels formally separate. It may be noted that we get the desinence-tone spreading automatically,[9] as well as a formal understanding of the notion "contour tone." Furthermore, the process of total vowel assimilation—construed as, e.g., (39)—has the desired property of copying all features up to, but not including tone features since tone features are not features of vowels.

(39) X . +syllabic . +syllabic . Y

SD:	1	2	3	4 →
SC:	1	3	3	4

The resolution of the paradox in tonal stability was derived from viewing tones as segments on an equal rank with "phonological" segments. This parallelism can be pursued; in fact, we find in general perfect formal symmetry between the two levels. The "dual," then, of vowel deletion would be tone-deletion, followed by reassociation to another tone by the vowel that had been associated with the

[9] A discussion of this general type of phenomenon is the content of Section 5 below.

deleted tone. This in fact occurs; see the discussion of the II Main form in Igbo in [7], and Sanskrit [13].

3. MELODY LEVELS

The third type of argument for autosegmental theory is motivated by the existence of "melody levels." As explained above, these are linguistically significant levels in the grammar which refer to just one or two features in the utterance. *Faute de mieux*, this has been taken sometimes to indicate tone features as "features of an entire morpheme," in some unexplained sense.

Let us begin with an example from Mende, a Mande tone language. The analysis is due to Leben [10].

On short vowels in Mende, we can find Low, High, Rising, Falling, or Rising-Falling tones. Morphemes are one to three syllables long, and if the distribution of tones over these syllables were random, we would expect to find five tonal classes of 1-syllable words, 5^2 or 25 classes of 2-syllable words, and 5^3 or 125 classes of 3-syllable words: 155 types in all. In fact, there are 5 classes for each, not 5^n, and they are of a very particular sort. Leben explains this by proposing that there are only 5 available underlying melodies in Mende, and that the melody is mapped from left to right onto the word. The five possibilities are:

(40)	H	pẹ́lẹ́, kọ́
	L	bẹ̀lẹ̀, kpà
	HL	kényà, mbû
	LH	nìká, nàvó, mbǎ
	LHL	nìkílì, nyàhâ, mbǎ̂

Such an analysis, we might note, supports the contention that contour tones are the concatenation of level tones, and that short vowels (and these in (40) are) may bear several ordered level tones.

3.1 TIV VERBAL SYSTEM

The next example is somewhat more complex and more interesting. The Tiv verbal system has been the subject of a sequence of more and

more refined analyses, including Arnott's exposition [1], McCawley's reanalysis [14] and Leben's proposal [10]. The present reanalysis departs from Leben's in one particular way; I shall indicate that the inclusion of Leben's principle (which I shall call the Obligatory Contour Principle) leads to unnecessary complications, and that it should be abandoned. This leads to certain particulars that are different than their counterparts in Leben's analysis; it should be kept in mind that although I am using autosegmental notation here, the principal empirical differences between Leben's analysis and mine result from the inclusion or rejection of the "Obligatory Contour Principle," which may be stated as:

> *Obligatory Contour Principle* (Leben): At the melodic level of the grammar, any two adjacent tonemes must be distinct. Thus HHL is not a possible melodic pattern; it automatically simplifies to HL.

As I say, I shall argue against the inclusion of such a principle within phonological theory at the phonological or tonological level.[10] In describing the Tiv verbal system, Arnott begins by explaining that the tonal pattern for each tense need only be illustrated by a small number of examples: six, to be exact. There are twelve "tenses": General Past, Future, Imperative, Habitual 1, 2, 3 and 4, Recent Past A and B, Subjunctive, Continuous, and Past Habitual. The verb stem can in general be one, two, or three syllables long; and—it is important to note—for each length there are at most two (generally two) possible tone patterns. Thus, for example, the General Past is illustrated as in (41).

(41)	ve 'they'	General Past	
	High	Low	! = Drop; see text
	vé ! vá	vé dzà	
	vé ! úngwà	vé vèndè	
	vé ! yévèsè	vé ngòhòr̀	

[10] In particular, I claim that it is not true at levels in the grammar where phonological and tonological rules apply. Leben's system requires there to be sequences of identically-toned vowels (CV́CV́CV́) after his "tone mapping"; thus, for him, the Obligatory Contour Principle holds in the abstract levels but not at the superficial levels. In Chapter 4 of [7], I argue that the opposite holds.

(As of yet, the reason for calling the first column "High" and the second "Low" is unexplained.) Normally two successive High tones are the same pitch; sometimes, however, there is a "Drop" of one or two semitones between the successive Highs. This drop is indicated by the raised exclamation point (!).

The point has been emphasized (in the three analyses cited above and elsewhere) that the six tonal melodies in (41) are not unrelated—that the language learner need not memorize six separate patterns for each tense. While this is true and important, we should emphasize equally the following point: whether the speaker knows six formulas for the General Past or just one, these are melodies *of* the General Past, not of the word. For each tense, there is a corresponding chart as in (41), and from tense to tense the particular tone pattern on a particular verb varies wildly. However, all verbs of the same syllabic structure have the same tonal pattern in a particular tense. The conclusion is that there is a level in the grammar which contains as entries in its various melodic patterns independent of the words or vowels; these entries can be assigned to particular tenses.

Here is the argument for autosegmental representation: the tonal pattern found on each verb is linked in the lexicon not with the verb but with the verb tense; thus the melody must be a separate entity in the lexicon. The only system capable of merging into one simultaneous utterance two lexical (phonological) entries is autosegmental phonology.[11]

We might then conclude that for each tense, the speaker of Tiv has learned six tonal melodies, two for verbs of one syllable, two for those of two syllables, and two for those of three syllables, as in (42). Which of the two possibilities a particular verb selects must be arbitrarily marked in the lexical entry of the verb.

(42) General Past

1 syllable	!H	L
2 syllable	!HL	LL
3 syllable	!HLL	LLL

[11] One could imagine logically the position that each verb has its tone marked on it in the lexicon, arbitrarily selecting one of the tenses' tonal patterns as the underlying one; the other tonal patterns might then be derived by tonological rules sensitive to the semantic mood and tense of the clause. While not impossible within current phonological theory, such an approach does not in fact work.

Such a tentative conclusion is implausible, for the six forms in (42) have too much in common for it to be an accident. Arnott points out that a "drop !" is imperceptible before L; one could as well say that the drop ! occurs before all forms, and lessen the amount of arbitrariness in the tone formulas.

Similarly, Arnott points out, it is only the first syllable whose tone must be arbitrarily memorized, the distinction being between H and L. Modifying Arnott's notation slightly, we could summarize both 2-syllable tone patterns as *!BL*. *B* here is a variable that ranges over H and L. Thus the abbreviation stands for !HL, or !LL, which is indistinguishable from LL.

If we adopt this formula for the 2-syllable forms, the Well-formedness Condition accounts for the tones of the 3-syllable verbs starting with the same formula. That is, if the first two syllables of *yévèsè* were treated as a bisyllabic verb, the third syllable would automatically become L (see 43).

```
(43)    y e v e s e
          |   | /
      !   H   L
```

Through the use of the B variable, we can generalize across the L and H tonal forms (as Arnott points out); through the use of the Well-formedness Condition, we can generalize over the 2- and 3-syllable cases. One would hope that the 1-syllable forms would be expressible by means of the same formula, for then we could conclude that the Tiv speaker need memorize only one tonal formula for the General Past.

The formula !BL works, we observe, for the L-verb, since LL = L in effect; however, for the H-verbs this formula predicts !HL (i.e., Falling) rather than !H, the correct form. In a sense, the difficulty has been created by the Well-formedness Condition, which causes the L to associate with the single vowel.

```
(44)    va
         |\
      !  H L
```

The theory now requires us to set up a language-particular rule to delete the L in this context.

There are two reasons to believe that this is, in fact, a language-particular rule and not a shortcoming of the theory. First, recall that in the preceding example from Mende, the same melody HL does in fact map onto a monosyllable as HL; thus the simplification to H is certainly not universal. In fact, we have seen the same thing in English ((25) above) where HL does not automatically simplify.

Secondly, we need a process to delete the L toneme in (44) anyway, assuming that !BL is the correct formula. Arnott suggests and McCawley argues that the Drop ! is really a Low toneme. Independently of whether such a claim is true in all cases, it is superficially true that a pitch drop does occur on the second of two H's when they are separated by a L. Thus an unattached L (diagram (44) if the dotted line were not present) should cause a drop in the pitch of the next tone if that tone is an H. In fact, no such drop occurs; therefore the L has been deleted. In sum, the fact that the Well-formedness Condition in this case forces us to draw the association line in (44) is not unfortunate in any sense, for we need a rule to delete the L here independently of any conventions like the Well-formedness Condition. In fact, it is the inclusion of the Well-formedness Condition that makes the Deletion rule simple to state, as we shall see.

Our rule, then, will tentatively be (45), Fall-Simplification.

```
(45)  V                         V      V
     /\    which abbreviates   /\  →   |
    H (L) → Ø                  H L     H
```

With the inclusion of this rule, all the forms in (41) or (42) fall under the single formula !BL.

Our formula needs one more modification before it can be adopted finally. Within a theory of downstep as described in Chapter 2 of [7], we expect a downstep of Drop toneme that has the properties of the sequence "!H" (we have already illustrated this briefly in figure (17) above). If we call this toneme "Drop" or D, then the formula written !BL actually stands for *DL* (when B = High) and *LL* (when B = Low); again using a suggestion of Arnott's, we summarize these two formulas as *B*L*, which now replaces the formula *!BL*.

To repeat: B is a variable that ranges over H and L; B* is a variable that ranges over D and L; in particular, B* = D if B = H.

Let us now look at the rest of the Tiv verbal tone patterns. It is not our intention to prove that in all tenses, the formulas reduce to one, as they do in the General Past. To succeed in doing so would, it appears now, require a fairly powerful set of rules, and to claim that the learner of Tiv prefers to learn (say) two basic formulas for a tense and stay with formally simple tonological rules permits us to posit an

evaluation metric with which we can come very close to our ultimate goal: that is, explaining why this particular solution was arrived at on the basis of the data.

For purposes of exposition, I shall give for each of the remaining tenses only the tonal patterns (as in (42)) rather than the actual spellings of the verbs with tones marked diacritically.

(46) Continuous

	High	Low
1 syllable	HL	HL
2 syllable	HLL	HLL
3 syllable	HLL	HLL

In the 1- and 2-syllable forms, a suffix is added to the stem, so two tones are indicated for the "1 syllable" forms, and three for the 2. But the conclusion is evident here: there is only one tone formula, HL.

(47) Future

	High	Low
1 syllable	D	L
2 syllable	HL	LL
3 syllable	HLL	LLL

On the basis of the 2- and 3-syllable forms, the tone formula should be *BL*; given this formula, in fact, the 2- and 3-syllable forms work exactly as expected, and so does the Low 1-syllable form. As in the General Past, the problematic form is the 1-syllable H form; here, the sequence $\widehat{\text{HL}}$ reduces to D.

But given the revision that the General Past formula for H-toned verbs is DL, the revised form of (45) is D L → D. Using the features suggested in Section 1 above (and identifying the Drop toneme D with Mid tone), we write the revised Fall Simplification rule (48).[12]

[12] It is not without interest to note that if instead of giving D the features [−High, −Low] as suggested here, we give it the features [+High, +Low], then rule (48) takes on a much more elegant shape:

$$\widehat{[+\text{High}]\ [+\text{Low}]} \rightarrow \begin{bmatrix} +\text{High} \\ +\text{Low} \end{bmatrix}$$

Whether this is more than an accident will require further research.

(48) Revised Fall Simplification Rule

$$\left\{\begin{matrix} D \\ H \end{matrix}\right\} L \longrightarrow D \quad \underline{\text{or}} \quad \widehat{[-\text{Low}]\ [+\text{Low}]} \longrightarrow \begin{bmatrix} -\text{Low} \\ -\text{High} \end{bmatrix}$$

Thus, having simplified the already needed rule of Fall Simplification (simplified in that one feature specification has been eliminated), we are left with *BL* as the Future tonal melody.

(49) Habitual 1

	High	Low
1 syllable	D	D
2 syllable	DH	LH
3 syllable	HHL	LHL

The 3-syllable forms reduce to one formula, utilizing the B-notation, BHL.[13] Maintaining left-to-right mapping as in Mende, the Low-toned 2-syllable verb works as expected, then LHL is mapped as

```
V V
| |\
L HL
```

The $\widehat{HL}$ contour is simplified to D, and, as we know, the sequence L D and L H are indistinguishable.

Nonetheless, this formula (BHL) does not work for the remaining cases, nor is there a simply formulatable rule that can derive the correct surface form from underlying BHL. Rather, we posit the melody B*H for the 1- and 2-syllable forms. This in turn requires positing a complementary contour simplification rule (50).

(50) LH Simplification

$$\widehat{L\ H} \longrightarrow D$$

Habitual 2

	High	Low
1 syllable	$D^!$	$D^!$
2 syllable	$DH^!$	$LH^!$
3 syllable	DHH	?

[13] Here is the first case where the Obligatory Contour Principle is violated, for HHL does not satisfy the principle.

Maintaining the same principles, we have seen so far, the tone formulas for this form are straightforward. Arnott notes that it is not clear whether there is, in fact, a 3-syllable Low form in the Habitual. The other trisyllabic form, inexplicably, does not have a following $^!$; aside from that curious feature, the five forms cited above reduce to the formula $B{*}H^!$. The reader will recall that for the Low-toned monosyllabic form, this formula gives $LH^!$ and that this reduces to $D^!$ by (50) LH Simplification. If, in fact, Arnott is correct about the absence of downstep following the trisyllabic form, then either a minor rule must be posited to delete the Drop there, or two formulas, $B{*}H^!$ and B*H, must be posited. At present, these two cannot be compared on empirical grounds, and our evaluation metric is not subtle enough to decide for us.

(51) Habitual 3

	High	Low
1 syllable	DH	DH
2 syllable	DHH	LHH
3 syllable	DHH	LHH

Again, as in the Continuous form above, the 1- and 2-syllable forms have a suffix, and so an extra tone-bearing element. With no further ado, this form simplifies to the melody B*H#H (see below).

(52) Habitual 4

	High	Low
1 syllable	H+L	H+L
2 syllable	HH+L	HH+L
3 syllable	HHH+L	HH(H)+L

In this form, the suffix *−n* appears to bring and bear its own tone: hence the + in the tonal formula. We find, then, forms like *vááǹ, dzááǹ, úngwáǹ, véndáǹ, yévéséǹ, ngóhóř*. I shall tentatively presume that the suffix, preceded by a phonological boundary (represented here by #) has a corresponding toneme (L) and the boundary on the phonological level is matched by one on the tonological level. Thus we get a pattern like:

(53)
```
yevese#n
 \|/   ||
  H    #L
```

But with this assumption the tonal formula for this form is just H#L.

(54) Past Habitual

	High	Low
1 syllable	D+L	D+L
2 syllable	DH+L	LH+L
3 syllable	DHH+L	LHH+L

In this form, we have the same appearance of a Low-toned suffix as in the form preceding. Again, with the set of simplification rules posited above, these six forms reduce to the formula B*H#L.

(55) Recent Past A

	High	Low
1 syllable	D	D
2 syllable	DH	LH
3 syllable	DHL	LHL

The 3-syllable forms, considered alone for the moment, reduce immediately to the familiar formula B*HL. This formula, however, does not apply to the 1- and 2-syllable forms, which derive from the formula B*H. We shall not posit an ad hoc rule to derive one from the other; such a move does not, in fact, seem possible in this case. Some sort of parenthesis notation may well be available for these lexical melodies; the two would then be expressed B*H(L)_3, where the subscript 3 indicates that the L is chosen when the word is trisyllabic.

The next two tenses have the same tonal melodies, a puzzling set of tones:

(56) Recent Past B/ Subjunctive

	High	Low
1 syllable	H	H
2 syllable	HH	HD
3 syllable	HHL	HHL

What strikes us as odd is that there is no tonal distinction between the two columns for the 3-syllable forms, as there is for the 2-syllable forms. On the basis of the 3-syllable forms, we would naturally expect a melody HHL; this generalizes correctly to the Low 2-syllable form,

but not to the High 2-syllable form or the 1-syllable forms. The 2-syllable forms, considered alone, would derive from only one of two possible melodies, given our assumptions: HHB or HBH. Neither of these, however, generalize naturally to the 1- or 3-syllable forms. By adopting the parenthesis notation that seemed plausible in the previous form (Recent Past A), we see that the melody HHB that is appropriate for the 2-syllable forms can reduce to the 1-syllable forms as:

(57) H H (B)_2

When the subscript option is not taken—that is, in the case of a 1-syllable stem—the formula is HH, which is the same as H on one vowel, as required.

Pursuing this analysis, we would attempt to see if formula (57) has any natural relation to the formula for the 3-syllable forms, HHL. The answer seems to be yes; the relationship may be stated as in (58).

(58) Recent Past B/Subjunctive

$$\text{H H} \begin{Bmatrix} \text{B}_{2\Sigma} \\ \text{L}_{3\Sigma} \end{Bmatrix}$$

This, then, is the formula we posit for the Recent Past B and the Subjunctive.

(59) Imperative

	High	Low
1 syllable	H	H
2 syllable	HL	LH
3 syllable	HHL	LHL

This is the last of the 12 tenses to be considered, and the one for which we can offer the least satisfactory explanation. Given our rules so far, the formulas underlying the 1- and 3-syllable forms is immediately dictated to us, fortunately: the 1-syllable forms are simply H (or conceivably HH, but there seems to be nothing supporting this); the 3-syllable forms are derived from the formula BHL.

The problematic forms are the 2-syllable forms. As Arnott points out, the generalization here, if there is one, is that the tone of the form is the "Base tone" (B) followed by its opposite—thus L follows

H, and H follows B. If we accept this proposal, then the 2-syllable formula is, in Arnott's terms, *B-opp(B)*.

This is not satisfactory for two reasons. First, it is the first and only time such a device, "Opposite," need be introduced in this statement of the Tiv tonal system. From this we could not conclude, of course, that a notion like "tonal opposite" does not occur in tone languages in general. But while it is not impossible as a solution, we would hope to see more motivation for the "opposite"-function in Tiv.

Second (and leading out of the first point), all the other forms show some coherence among the 1-, 2-, and 3-syllable forms; the adoption of the "opposite" notation destroys this generalization.

The question, then, is to determine when a language-learner, presented with data as in (59), will memorize independent melodies for each syllabic structure (60), and when she or he will adopt a simpler melody supplemented by tonal adjustment rules. To the extent that the tonal adjustment rules necessary for the second approach seem very complex, the independent memorization position is supported; to the extent that they are fairly simple, the second, general melody approach is supported. However, the notion of "simple" is internal to a theory of tonological rules, not external to it, and so we shall not be able, at this early stage, to reach a conclusion about the actual form of the Imperative in Tiv.

(60) Tiv Imperative à la Memorization:

1 syllable	H	(essentially
2 syllable	B + opp(B)	Arnott's
3 syllable	BHL	solution)

If we attempt to fit all these patterns into one melody, we observe that the 3-syllable formula, BHL, predicts the correct form for the 2-syllable Low-toned verb, because the melody LHL spreads over a bisyllabic word as L $\widehat{HL}$, which becomes L D, which is (we have observed) indistinguishable from the reported LH. However, such an approach is not straightforward for the H-toned bisyllabic forms, for HHL would give HD, rather than the required HL. Suppose we could resolve this problem; the formula for the 1-syllable forms could (rather trivially) be derived from the 3-syllable formula with parenthesis notation, leaving us with the Imperative formula as in (61):

(61) Tiv Imperative with Readjustment Rule

$(B)_{2,3}$ H $(L)_{2,3}$

The readjustment rule that is necessary, as we have observed, is for the H-toned bisyllabic form, as in (62).

(62) Minor Rule for H-bisyllabic Imperative

```
V V
| |\
H H L
  ↓
  Ø
```

To repeat, the adoption of solution (60) or (61) or some intermediate solution must await further theoretical work. To sum up this section, we have considered in some detail the verb tone system of Tiv, an African tone language, indicating how the tonal melodies must be described at a particular tonological level in the grammar.

4. FLOATING TONES

Next we will consider the nature of "floating tones", a device that has proven useful in working with tone languages but whose theoretical status has always been suspect. A floating tone is, in essence, a segment specified only for tone which, at some point during the derivation, merges with some vowel, thus passing on its tonal specifications to that vowel. This is, in any event, the traditional view; and this traditional view, framed within the standard theory, fixes the floating tone as one of the segments, and therefore linearly ordered amongst all the other, more completely specified segments of the phonological representation.

Thus it has been suggested that certain affixes are purely tonal; Bird, for example, posits a floating L tone for the Bambara definite marker on nouns, cited in [10].

We shall say, and we shall see, that floating tones are melodic levels, much as in the previous section, that map onto the syllabic structure in a slightly more complex way than the Tiv forms. Often floating tones associate after some phonological/tonological rules have applied, though this is not always true.

Igbo presents several interesting cases of floating tones, analyzed in detail in Chapter 2 of [7]. For the present, let us consider the general outlines of their behavior.

We will look at the preverbal floating H tone, a mark of subordinate clauses. We will content ourselves here with observing its behavior, leaving aside the factors conditioning its presence. If a tone "floats" when it has no vowel associated with it, let us say that the process of associating a floating tone is "docking."

We shall see four separate cases of "docking" of this preverbal H tone, four kinds of docking that are predictable on autosegmental grounds, and on no other.

To describe these effects, we must review some of the basics of the structure of Igbo. It is a Subject-Verb-Object (SVO) language; singular subject pronouns (though not plural) have two forms, noncliticizing or Strong, and cliticizing or weak. The cliticization of the subject pronoun, however, includes a syntactic movement. In certain tenses, that is, the verb stem is normally preceded by the prefix *a*– when the subject is a noun phrase (NP). This *a* is realized as *e* when the verb stem is in the 'tense' vowel harmony class. Thus, if the subject is *ányì* ('we', not a clitic) and the stem is *za*, we find (63).

```
(63)  ányì  ázàá  àlà      za = sweep
      we    sweep floor    (stem followed by
                            suffix -a)
      'we swept the floor'
```

If the subject cliticizes, the prefix *a*– disappears, because, we shall see, the cliticization puts the clitic subject into the *a*-prefix position. Thus we get (64).

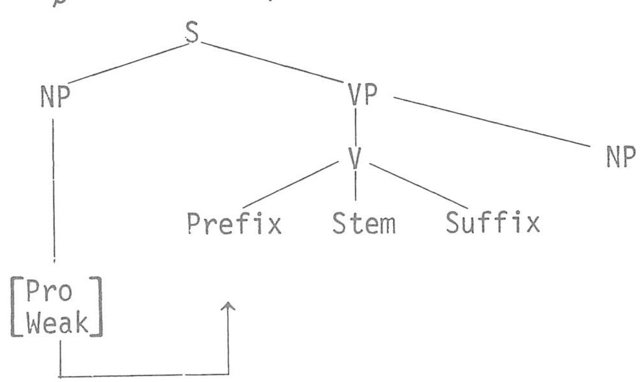
```
(64)  ó zàá àlà  'he swept the floor.  o = he, she
```

We may formalize this operation as (65), illustrated in (66).

```
(65)  [Pronoun]  [Verb  ]   Subject Cliticization
      [Weak   ]  [Prefix]

          1          2 →
          ∅          1
```

(66)

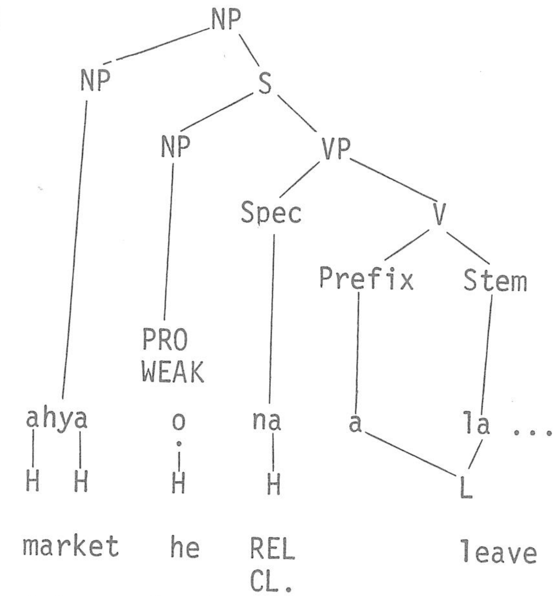


Such a rule must be a local rule, in Emonds' sense, given the general

structure-preserving framework (see [3]). Therefore, if any element could appear in between the Weak subject and the prefix position, it would block this cliticization process, and thus keep the *a* prefix from disappearing.

The *na* relative-clause marker does precisely that. In a structure such as in (67), the clitic subject stays where it starts, and it cooccurs with the *a* prefix.

(67)



'the market he should have left'

The picture in (67) is important; around it will revolve our argument. The tone attached there with the Relative Clause marker *na* is the floating tone H. We shall see that under other circumstances, that same H tone docks on other vowels, depending, we might say, on what is "closest" to it in derived structure.

We have seen first that the *na*, when present, is H-toned. The *na* may be *not* present for two reasons: first, in a relative clause, it is optional; thus we may simply delete it and see what the derived structure is. As we observed in Section 2, when we discussed tone stability, we expect the H tone to appear elsewhere. Second, and quite differently, while the *na* always marks a relative clause when it appears, the H-tone appears in other subordinate clauses indicating adverbial dependency (that is, in sentences translatable as "Lest X happen, . . ."). In this second case, the H tone is not a remnant of a deleted *na*, for the *na* could not have been there in the first place.

In both cases when the subject of the clause is a normal noun (noncliticizing, that is), the final tone of the subject is raised. For example, the noun *ọ̀nụ̀* (a type of yam) shows up as *ọ̀nụ̌* in the relative clause *ọ̀nụ̌ rèré èré*, 'the onu that is rotten' (*rèré èré* is a complex predicate meaning 'is rotten'). Here, as elsewhere in Igbo, the contour tone LH generally simplifies to what is called a Mid tone in Igbo, but which is precisely the same as the Drop tone (D) in Tiv. Its tone is slightly lower than the first preceding High tone. But since any High tone is slightly lower than a preceding High tone if the two are separated by a Low tone, High and Mid(or Drop) are indistinguishable after a Low tone. Thus in this position, LL nouns become L+Rising or L Mid; HL nouns become H+Rising, or more commonly H+Mid, as in (68).

(68) ázū rèré èré 'the fish that was rotten'
ázù 'fish'

Nouns that end in a High tone do not change; see (69).

(69) ánú rèré·èrú (ánú 'meat')

àkwhá rèré èrú (àkwhá 'eggs')

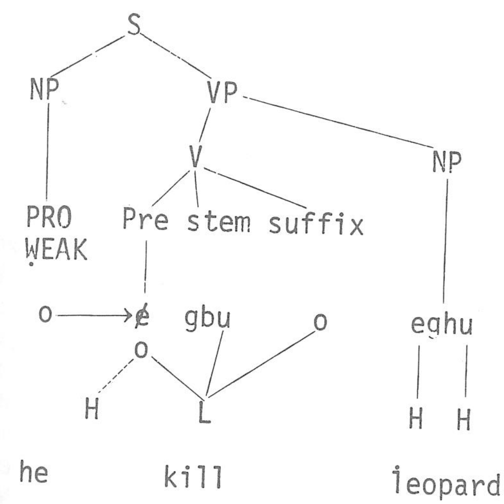
In all these cases, the *na* could have been present, attracted the High tone, and then these nouns would have displayed their isolation tones as cited. In the following sentences, the *na* may not appear, since these are not relative clauses, and the same subject tone raising occurs as noted above.

(70) Khwàchíé úzò
Shut the door lest...

ághú	ègbùò	éghú	ághú	
leopard	kill	goat	'leopard'	HH
òké	àtàà	ákhú	òké	
rat	eat	palm kernels	'rat'	LH
úžè	àtàà	yá	úžè	
squirrel	eat	them	'squirrel'	HL
ènwó	àtàà	yá	ènwò	
monkey	eat	them	'monkey'	LL

If in one of these "lest . . ." clauses, as in (70), the subject were a weak cliticizing pronoun, it would undergo the cliticization expressed in (65) and (66) above. Looking at the tree in (67), we see it would then be to the right of the H tone, in a certain sense; inasmuch as the cliticized pronoun partakes of the verb stem's L-tone just as the *a* prefix in (67), the H-tone docking rightward now will give rise to a *Falling* tone! All this is clear geometrically: see (71).

(71)

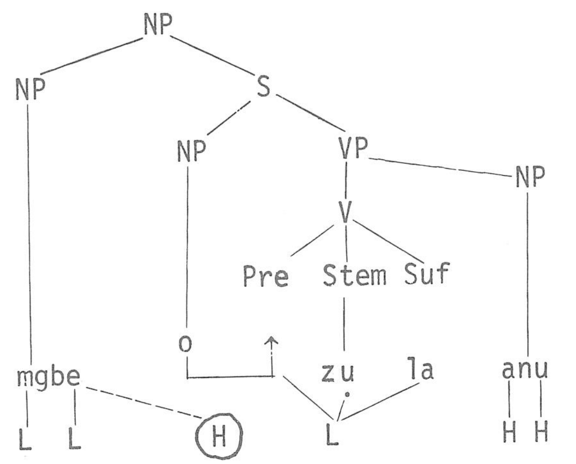


'lest he kill the leopard'

ô gbùò éghú

Lastly, when the relative clause or subordinate clause is constructed appropriately, the H-tone can dock right out of its clause. Thus, if the subject is a clitic, and moves by rule (65) over the floating H (much as in (71)), the floating H may then dock leftwards onto what is to its left. If we have a relative clause where the head is coreferential with an NP in some position other than subject in the relative clause, we get a situation as in (72), and one can say either (73a), maintaining the *na*, or (73b), where the floating tone docks leftward onto the head *m̀gbè*.

(72)



m̀gbé ɔ́zụ̀là ánú
time he buy meat

"Whenever he buys meat, ...'

(73) a. m̀gbè ɔ́náàzùlà ánụ́ ...

(73) b. m̀gbè ɔ́zùl̩à ánụ́ ...

In summary, the floating H tone appearing before the verb in certain tenses in Igbo docks onto various vowels depending on the derived syntactic structure: the end of the subject of the clause it is in, or the beginning of the subject clitic pronoun of that clause, or the grammatical particle *na*, or the head of the relative clause.

5. AUTOMATIC SPREADING

The fifth and last argument for autosegmental phonology here comes from the phenomenon of bidirectional spreading and, we would suggest, its *un*governed nature in these cases; that is, the spreading is not due to a specific phonological rule, but rather to the geometry of autosegmental representations, and its Well-formedness Condition (or WFC as expressed in Section 1.3).

It should be clear from the examples in each section how the Well-formedness Condition creates the spreading of tonemes over various syllables automatically; we have seen examples from English, Mende,

and Igbo. In this section, I will look at a particularly interesting example, one in which the autosegmentalized level is not tone, but rather nasalization. The language is Guarani; the data and much of the initial arrangement of it comes from Lunt [12] and especially Rivas [15].

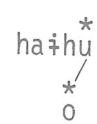
Let us begin by considering the forms that morphemes may take. We observe in (74) that there are basically two forms for the affixes *no*, *ro*, and *i*: each have a basically nasal form and a basically oral form.

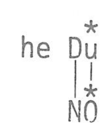
(74) a. ⁿdo + ro + haɨhu + i (oral stem)

b. no + ro + heⁿdu + i (oral stem with nasal in it)

c. no + ro + nupa + i (nasal stem)

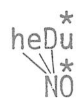
The prefix *nõ* thus alternates with *ⁿdo*, as does *r̃õ* with *ro*, and *ĩ* with *i*. Which alternate appears is determined by the stem, the morpheme which contains the acute accent in the examples above. In general, a vowel with an accent in Guarani is also one endowed with a nasality melody or specification. That is, if we say nasality is autosegmentalized in Guarani, we specify that the nasality melodies (essentially just Oral or Nasal) are initially associated with accented vowels, just as we saw in Section 1.2 that the tone melody in English was initially associated with the accented vowel. In addition, true nasal consonants are endowed with an inherent Nasal specification on the autosegmental level (these true nasal consonants are *m*, *n*, *n*, *ŋ*, *ŋʷ*). We shall represent a stem as in (74a) by (75a); a stem as in (74b) by (75b).

(75) a. 

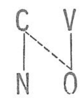
b. 

(For explanation of new symbols, see text.) The symbol D represents all the normal feature specifications of an *n* except for nasality—raised tongue, and so forth. When associated with a [+nasal] autosegment, the two of them *are* an *n*. The O symbolizes [−nasal]; N symbolizes [+nasal] (read "oral" and "nasal," respectively). As above, the star * indicates an accent; corresponding autosegments are accented (starred) also.

The Well-formedness Condition must apply to the forms in (75). The form in (75a) becomes all oral, as in (74a). The form in (75b) becomes the form in (76), which would be transcribed as *h̃ẽnu* in the standard theory.

(76) 

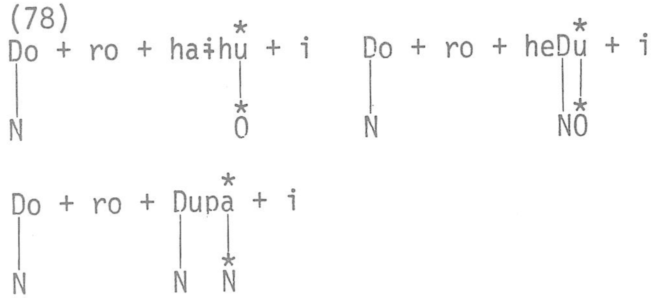
The empirical difference between the form created by the Well-formedness Condition and the actual form is that the Condition does not create forms like ⁿ*d*, the prenasalized stops. This is not, however, a bad result; the prenasalized stop is a complex configuration, and the universal theory should not produce them automatically. Rather, the language-particular rule (77) creates the form as in (74b) from the form in (76). When we apply (77), Postoralization, to (76), we get the correct form.

(77) Guarani Postoralization Rule: 

(The reader will recall that the dotted line in an autosegmental rule indicates the addition of an autosegmental line by that rule.)

With this autosegmental interpretation of the data, let us derive the forms in (74) precisely. We note that when the Well-formedness Condition applies here, if there is an ambiguity as to whether a starred or an unstarred autosegment spreads, it is the starred element that does.

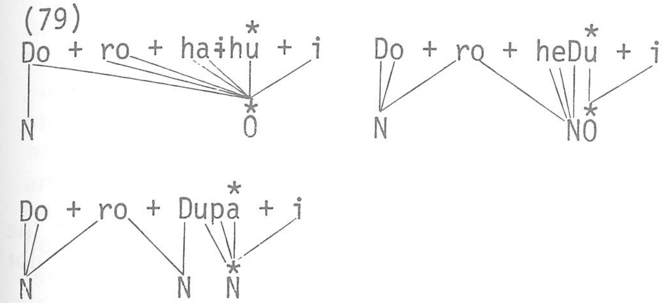
(78)



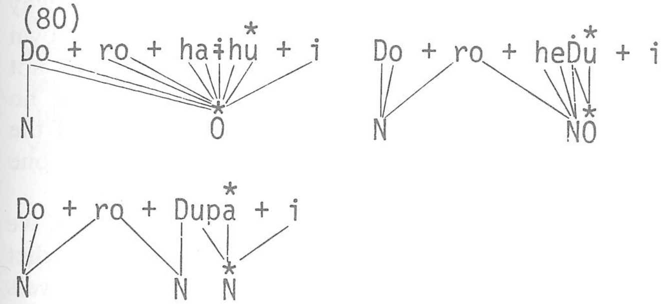
(78) represents the underlying forms. The Well-formedness Condition

changes these to (79)[14]; rule (77) Postoralization creates (80), the correct output (compare (74)).

(79)



(80)



As expected, we have seen that prefixes and suffixes adopt their nasality from the stem they are attached to. These prefixes are found with the usual + morpheme. Note that this bidirectionality of spreading is expressed only with additional specification if handled by a phonological rule; within autosegmental theory, the bidirectionality of the spreading is the result, in a sense, of the fact that there are prenasalized stops! That is, the existence of the prenasalized stops required the autosegmental analysis, which in turn brought with it bidirectional spreading. In summary, borrowing from Rivas [15], suffixal nasality spreading is as in (81).

(81) $\widetilde{\text{Stem}} + \text{suf} \longrightarrow \widetilde{\text{stem}} + \widetilde{\text{suf}}$ (nasal)

$\overline{\text{Stem}} + \text{suf} \longrightarrow \overline{\text{stem}} + \overline{\text{suf}}$ (oral)

$\tilde{\text{S}}\overline{\text{tem}} + \text{suf} \longrightarrow \tilde{\text{s}}\overline{\text{tem}} + \overline{\text{suf}}$ (nasal-oral)

[14] The reason why the starred autosegment has precedence in spreading in these cases, as opposed to cases like (21), is detailed in Chapter 3 of [7].

There are also suffixes separated by word-boundary (#) endowed with their own nasality-specification, according to Rivas [15], as in (82).

```
(82)  ## Stem # Suffix ##
      ||      |        ||
      ## αNas # βNas   ##
```

We see in (82) what has been only implicit up to this point: the universal convention that corresponding word boundaries, but not morpheme boundaries, are connected by association lines.

Another logical possibility is predicted by the notation so far: why could there not be an accented suffix—that is, one with its own nasality melody—but one which has only a morpheme boundary, not a word boundary. With a morpheme boundary, there will be no association line, and the nasality autosegments of the stem and the suffix will interact. We predict, then, the following type of suffix, one which meets the description given by Rivas for the *–ré* suffix.

From *–ré*, endowed with an oral melody on its stressed vowel, we derive *ĩr̃ṹré*, as in (83). Autosegmental theory does not predict whether the second *r* is nasal or oral; when surrounded by vowels with conflicting specification as in (83), such a determination is not possible.

```
         *    *
(83)  iru + re    from ĩr̃ũ
       \\|    |
         *    *
         N +  O
```

When *–re* is placed on a nasal stem with a nasal consonant to the right of the accent (such as *mẽ́nã*) we get the correct result, as illustrated in (84), a remarkable form.

```
        *           *          *           *
(84)  B e D a + r e    →    B e D a + r e
      | | |         |       | | |  \    \ |
        *           *         *          *
      N N N         O       N N N         O

                              mé^n daré
```


6. CONCLUSION

In the five general cases reviewed in the foregoing sections, we have seen that phenomena that are puzzling on the standard view of phonological representations are quite tractable and reasonable when viewed from an autosegmental perspective. We have seen, furthermore, connections between these phenomena that are not otherwise revealed. If we may draw some morals from this result, perhaps they are that advances in phonological theory may start from an interest in low-level articulatory facts; that if they are interesting, they go beyond these superficial facts to unexpected phenomena; and most importantly, that we do not begin our research with an understanding of the nature of the most elementary linguistic observables. The most astounding revelations may be those that change our conception of what we thought were the observables, either in phonology or semantics. We should not restrict our attention to constraints on rules—phonological, syntactic, or semantic—at the risk of missing the very nature of the items involved.

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The Tones in English Intonation*

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This article aims to consider some characteristics of English intonation and to formulate an account of those that draw on what we know about tonal systems in general. I will focus on two problems in particular: first, the vocabulary in which intonation contours are expressed, and second, the principles which match a given intonation contour with a given string of words. The general outlines of this study are drawn from Armstrong and Ward [1] and Goldsmith [8]. I will attempt to deal with a few of the phonological complexities in English intonation discussed by Bolinger [3–5], but from a different vantage point.

Armstrong and Ward describe two "tunes" for English: a falling contour, which characterizes normal declarative sentences along with some *wh-* questions and exclamations, and a falling-rising contour, which is used for yes–no questions and for certain polite statements. The latter tune also appears in a modified form, with the rise preceded by a more level low pitch rather than by a falling contour. In the following sentences from Armstrong and Ward, dashes represent the pitch of what they refer to as "stressed" syllables, and dots represent the pitch of their "unstressed" syllables.

TUNE 1

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I followed him to a tiny apartment//at the back of the house.
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