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ON THE LINGUISTIC REPRESENTATION OF TONE

City University of New York PH.D. 1984

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ON THE LINGUISTIC REPRESENTATION OF TONE

by

Paul J. Camhi

A dissertation submitted to the Graduate Faculty in Linguistics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1984

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Abstract

ON THE LINGUISTIC REPRESENTATION OF TONE

by

Paul J. Camhi

Adviser: Robert Vago

The puropose of this thesis is to investigate the linguistic representation of tone within the standard theory of generative phonology (Chomsky & Hall, 1968) and also within the autosegmental theory of tone (Goldsmith, 1976); and to propose a set of non-trivial revisions to the theory which it is argued, will result in a more descriptively adequate analysis of tonological data.

Specifically, it is argued that the universal claims of autosegmental theory's Well-formedness Condition (WFC) and Convention on Tone Melodies (CTM), both of which explicate the formal principles by which tones are associated with vowels, are not universally supported by the data; and that the language-particular claims of the Major Association Procedures (MAP), which explicate the formal principles by which tones are associated with vowels, do not operate consistently in the languages inspected. By formally imposing the constraint on the WFC that all tones are associated with one and only one syllable rather than maintain the earlier claim that all tones are associated with at least one syllable, the Revised theory, proposed in this thesis, succeeds in formally prohibiting the CTM from operating and also replaces the excessively "complicated" MAP with a lexical specification process. The lexical specification process is preferred since it is intrinsically predicted by the operation of the proposed Condition on the Well-formedness of

Lexical Representations, which states that a lexical representation is well-formed if and only if its structural description satisfies the structural requirements necessary for the operation of the Revised WFC. Therefore, the lexical specification process, unlike the lexical association process, constitutes a redundancy procedure, which is not ad hoc, and which does not constitute a formal complication to the theory.

A preliminary formal investigation into a syllable-based model for tonological organization is also explicated in this thesis. It is proposed that such a model which logically employs both hierarchical- and co-constituent analyses of phono/tonological organization results in a more unified analysis of tonological data.

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PREFACE

The purpose of this thesis is to investigate the linguistic nature of tone within the transformational generative framework and to propose a set of formalisms which, we argue, will increase the descriptive powers of the theory to explicate tonological phenomena in natural languages.

The major focus will be on a number of crucial theoretical issues regarding the analysis of tonological phenomena which the standard theory (Chomsky & Halle, 1968) fails to formally resolve. Since these mechanical failings stem largely from the theory's formal treatment of distinctive features, it is necessary, first, to carefully inspect the logical status of distinctive features within the standard theory.

It is tacitly assumed in the standard thoery (Chomsky & Halle, 1968:335-336) that the segment is the only unit on which phonological rules operate and thus the only unit on which distinctive features are mapped. The segment is assumed to represent an event that is frozen in time. Thus, the set of features mapped onto the segment is displayed simultaneously (i.e. frozen in time) rather than concatenously (i.e. as a time-varying series across a single segment). This constraint reflects adherence to the Saussaurian principle of logical opposition (Jakobson & Halle, 1970:15). When applied to distinctive features, it means that only <u>one</u> of two lo-

gically possible specifications of a single bi-polar feature can be specified onto the segment at any given moment in time.

An inspection of the following feature-mapping paradigms should make this point clear:

(a) * $[+F_1, -F_2, -F_3, +F_4 \cdots]$

(b) * $\begin{bmatrix} +F_1 \\ -F_1 \\ +F_2 \\ -F_2 \\ \cdot \\ \cdot \\ \cdot \end{bmatrix}$

(c) * $[+F_1, -F_1, +F_2, -F_2 \cdots]$

(where items enclosed within the brace brakets, $[\ ]$, represent feature specifications for a single segment.)

Specification (a) is not permitted in standard distinctive feature theory since features cannot be sequentially mapped onto a single segment. Specification (b) is not permitted since it violates the principle of logical opposition: it is logically impossible for a feature to be specified for both of its polar values at a moment frozen in time. Specification (c) is also not permitted since (1) features are constrained from being mapped across a segment; and because (2) both values of a bipolar feature cannot be specified for the same segment.

However, if the constraint against mapping features on a segment across time were relaxed, then Specification (c) can be logically permitted since the constraint against specifying both values of a single bi-polar feature refers only to features that are mapped at a moment frozen time, not to features that are mapped across time. This last point is an essential one and will be returned to later.

The only logically possible feature specification for the segment within the standard theory is:

(d) $\left[\begin{matrix}\{\pm\}F_1\\ \{\pm\}F_2\\ \{\pm\}F_3\\ \vdots\end{matrix}\right]$

(where the curly braces, $\{\ \}$, signal the instruction that either + or −, but not both, can be specified for the feature in question.)

In summary, the constraint against mapping distinctive features across the segment precludes the possibility of specifying both the plus and minus values of any distinct feature onto the segment, at any given moment in time. This is so since such a specification violates the principle of logical opposition.

It is precisely on this point that it can be shown

that the constraints placed on the standard mapping procedures will only permit analyses of a range of phonological data regarding feature specifications for contour tones that are less than descriptively adequate; and that these constraints must be relaxed and/or revised so that the grammar can reveal phonological operations that, in its standard form, it fails to reveal.

Chomsky & Halle (page 329) do not present a formal treatment of tonal phenomena, except for a somewhat tenuous endorsement of Wang's (1967) work. (For a critical evaluation of Wang's proposal, see Section 1.5.1. below.)

However, inspection of a small corpus of data from Mende (Spears, 1967), a contour-tone language, will help to crystallize the kinds of problems a phonology must address regarding the formal structure and operating procedures of distinctive feature theory:

(1) (a) pele + ngaa = pelengaa 'houses'
(b) bele + ngaa = belengaa 'pants'
(c) ngi + kenya = ngikenya 'his uncle'
(d) mbu + ngaa = mbungaa 'owls'

(where ˊ signifies high tone, ˋ signifies low tone, ˆ signifies falling tone and ˇ signifies rising tone.)

The standard feature-mapping procedures permit only the following analysis of the data:

(2) [+syllabic, -consonantal, +falling tone] → [+high tone] / ___ [+low tone]

[+syllabic, -consonantal, +rising tone] → [+low tone] / ___ [+high tone]

Such an analysis is observationally adequate in that it accounts for the data. However, it is ad hoc; it is not descriptively adequate in at least two ways.

First it fails to capture the linguistically significant generalization that, for the Mende data, it is the last member of a series of level tones that is being deleted; and it is deleted only if the last tone member of the series agrees with the specification of the tone on the following tone-carrying unit. This can be expressed in the following way:

(4) Tone-deletion Rule

$$[\alpha H][-\alpha H][-\alpha H] \rightarrow [\alpha H]\,[-\alpha H]$$

(where H stands for high tone and the curved line, ⁀ , indicates that the sequence of features below it occur on a single tone-carrying unit.)

Rule (4) explicates that individual tone members of a contour tone must operate independently, thus supporting the hypothesis that they must be treated as phonologically distinct.

The formal machinery available to the standard theory, however, prevents the explication of such a descriptively adequate analysis (see Rules (2) and (3)) since, under the standard theory analysis, distinctive features cannot be mapped concateneously across a single segment;[1] i.e. H H cannot be mapped across a single segment.

The standard theory analysis also fails to capture another linguistically significant generalization, namely that for the data in question, segmental information is irrelevant to the operation of the rule.

This observation suggests the possibility that tone may occupy a phonological domain which is independent of the segmental domain. From the Mende data, we see that information regarding the number of segments, as well as the feature analysis of these segments, is irrelevant to the operation of the rule.

Other data from Nupe (see Section 1.5. below) however will be presented which will show that, in some cases, segmental information must indeed play a role in the operation of tonological processes.

The important points to emphasize from this evaluation of the Mende data are as follows: (1) the standard theory does not formally permit an analysis of contour tones as a series of level tones; and (2) it also does not formally permit the operating domain

of phonological rules to be on any unit other than the segment.

Since, as we have shown, the formal machinery available in the standard theory does not permit a descriptively adequate analysis of tonological operations, the theory is therefore in need of revisions.

Chapter One of this thesis presents an historical perspective and a critical evaluation of post-standard theory (pre-autosegmental theory) analyses of tonological data. The theoretical considerations that these analyses address have added important insights into the way tonological analyses must be formally organized.

In Chapter Two, three versions of the autosegmental theory of tone - Goldmsith's (1976), Leben's (1978) and Clements & Ford's (1979) - are critically evaluated in terms of the formal and empirical efficacy of their theoretical apparatus. It will be argued that while the above-mentioned versions of the autosegmental approach have significantly increased the descriptive adequacy of the theory, especially with regard to the dynamic interplay of segmental and suprasegmental domains, the theory's essential formalisms are still in need of revisions.

In Chapter Three, a set of nontrivial revisions to the autosegmental theory of tone is set forth. It will be argued that the incorporation of these revisions into the theory will result in a more unified analysis of the

tonological data.

Finally, in Chapter Four, a preliminary formal investigation into a syllable-based model for tonological organization is explicated. It will be argued that an analysis in which the syllable is formally treated as an independent phonological unit provides for a more descriptively adequate analysis of the data.

TABLE OF CONTENTS

CHAPTER ONE: THE PRE-AUTOSEGMENTAL TREATMENT OF TONE

1.1. General Introduction

This chapter constitutes a critical review of the literature dealing with the pre-autosegmental treatment of tone, especially contour tone, in transformationsl generative phonology. We have shown, in the Preface, that while the question of how to represent a descriptively adequate analysis of tonal phenomena within a formal framework is far from being resolved, the question of how not to represent tone has been resolved - at least in the sense that the standard theory's approach has been shown to be a logically impossible one.

In this chapter, some of the major post-standard theory proposals regarding the formal operating procedures of tone will be evaluated - those of Woo (1970), Wang (1967), Leben (1971 & 1978) and Fromkin (1972). Based on the critical evaluation of these proposals, it will be concluded that an overall simplification results from an analysis in which (1) contour tones are logically described as a series of phonologically distinct level tones; and in which (2) tonological phenomena are formally described on units other than the segment.

1.2. Classificatory Scheme for the critical review of the literature

The results of the findings in the Preface , regarding the mechanical failings inherent in the standard

theory analysis of tone, suggest that there are two pivotal questions which a phonological theory must address concerning the formal description of tone in contour-tone languages.

(1) Is tone a feature on the segment or on some unit other than the segment (such as the syllable, morpheme, etc.)?

(2) Are contour tones formally described as a single contour feature or as a series of distinct level-tone features?

The critical consideration of these questions will form the anchor from which we will scrutinize the major post-standard theory proposals. Let us now consider four logically-possible resolutions to questions (1) and (2):

(1) Contour tones are described on the segment as single distinct contour features.

(2) Contour tones are described on the segment as a series of distinct level-tone features.

(3) Contour tones are treated on the syllable (morheme,etc.) as single distinct contour features.

(4) Contour tones are treated on the syllable (morpheme, etc.) as a series of distinct level-tone features.

We will inspect, in this chapter, these four proposals, as well as two other logically-possible reflexes of the two pivotal questions:

(5) Contour tones are treated on both the morpheme (and/or syllable) and on the segment as a series of distinct level-tone features.

(6) Contour tones are treated on the segment both as a series of level-tone features and as single distinct contour features.

The remainder of this chapter will therefore be organized into six sections, each section representing one of the six proposals described above. This organizational scheme will serve as a means of anchoring our critical review of the literature to the issues of major theoretical import.

1.3. Proposal (1): Contour tones are treated on the segment as single distinct contour features.

1.3.1. Chomsky & Halle (1968)

We have already inspected the Chomsky & Halle proposal at some length in the Preface. The Chomsky & Halle proposal is, in the formal sense, the most highly constrained of the six that we will scrutinize in this chapter.

We have shown that such a tightly-constrained system does not capture a number of "linguistically significant generalizations" that might otherwise be captured if some of the constraints on the system were relaxed. However, we do not want to relax these constraints to such an extent that an excessive number of logically possible, yet empirically impossible outputs will be

derived.

1.3.2. Jakobson, Fant & Halle (1963) and Jakobson & Halle (1971)

The Jakobson, Fant & Halle (henceforth JF&H)/Jakobson & Halle (henceforth J&H) proposal represents and earlier and, in a number of ways, more insightlfu attempt to exploit the notion of distinctive features in phonological analyses. We will concentrate on their formal treatment of tone in distinctive feature theory.

Their monographs on distinctive feature theory are more statements of general principle than they are carefully worked-out phonological justifications for the efficacy of these principles. Their proposals have provided fertile ground for the testing of later hypotheses that aim at tackling the two pivotal questions that have important consequences on how tone is to be formally treated on contour-tone languages.

In one sense, the JF&H/J&H system may be regarded as fitting into Proposal (1). However, in another sense, their proposal, by implication, has generated insights that have led to the development of a number of revised Proposals that will be discussed and evaluated in this chapter.

They propose that distinctive features are divided into two classes: (1) Inherent and (2) Prosodic. J&H (1963:37-38) neatly describe the distinction between these two classes in the following way:

> "The recognition and definition of an Inherent feature is based on the choice between two alternatives admissible in the same position (emphasis mine-PC) within a swquence. No comparison of the two polar terms is invòlved...(Prosodic features involve two coordinates)...(1) Polar terms such as high and low register, rising and falling pitch...all may appear in the same position within the sequence. (2) Both polar terms are fully recognizable only when both are present in the given sequence."

Such a distinction implies that the tone domain is differently organized for prosodic and inherent features. Prosodic features are identified only by a comparison of a sequence of features across time. Inherent features, on the other hand, are identified without such sequential reference, but rather by comparison with other features at a moment frozen in time.

JF&H/J&H regard the syllable as the most elemental unit on which prosodic information is carried; and they regard the contrast of vowel vs. consonant within the syllable as the pivotal principle of syllable structure where for the most part the vowel forms the crest of the syllable, and the consonant(s) form the slope(s) of the syllable. (They also allow for cases where some consonants may be regarded as syllabic, and thus form the crest of the syllable.) JF&H assume that prosodic features "are superimposed upon (inherent features and) are lumped together with them into phonemes (1963:13)"

Even though they regard the syllable as the most elemental unit on which prosodic information is carried, JF&H nevertheless regard prosodic features as formally carried only by syllabic segments, i.e. they are formally specified only on inherent segments. Under their proposal, then, the syllable does not operate as a formal unit in the phonological model. For this reason, th e JF&H/J&H system falls into the Proposal (1) category.

Their distinction between Inherent and Prosodic features represents a statement of principle that must be empirically tested against data from natural languages. It will be shown in this chapter that the exploitation of such a distinction in phonological theory will result in a more "natural" analysis of tonological operations in contour-tone languages. It will also be suggested that such a distinction, when formalized, will provide the system with more predictive phonological power.

JF&H/J&H do not formalize this distinction. We will show that the treatment of prosodic features carried only the segment (and thus never by the syllable) is not as well-founded on the independent grounds that they claim. We will show slso that it is not well-founded on phonological grounds.

Their independent justification for the treatment of prosodic features on the segment relies heavily on

the distinction between the crest (where tones may be carried) and the slope (where tones may not be carried) of the syllable, and on Stetson's Motor Theory of Syllable Production (1951), which they claim supports this distinction.

Stetson hypothesized that the motor correlate of the syllable is "a puff of air forced upward through the vocal channel by a compression of the intercostal muscles," and that three successive factors hallmark each syllable: release, culmination, and arrest of the pulse. JF&H suggest that the culmination factor corresponds to the crest of the syllable and that release and arrest factors correspond to the slope(s) of the syllable.

Stetson's hypothesis has been empirically falsified by electromyographic studies (Hodhiko,1960); and Draper et al., 1959) which have shown that there is not always a one-to-one correlation between the activity of the intercostal muscles and the production of a single syllable. Thus, independent evidence for the syllable crest is weakened. Such evidence also ostensibly weakens the argument for the syllable. However, it will be shown later (Section 1.5.1. below) that both perceptual and phonological evidence strongly support the treatment of the syllable as an independent unit.

Counterevidence to the JF&H claim that tonal information is carried only by the crest (or syllabic segment) of the syllable is provided by Wang (1967), who shows

that tone is capable of being distinctively carried by any of the voiced segments of the syllable (see Section 1.5.1. below).

Wang (1967:95) also shows that, in a number of contour-tone languages, tone sandhi rules operate independently of segmental environments, where segmental information is not required in the structural description of the rules in order for the structural change to take place. If tone were treated by the segment, the rule would then require irrelevant segmental information for the statement of its generalization. Such was shown to be the case in our earlier analysis of the Mende data (see the Preface above).

Finally, a point that well be discussed and exemplified throughout the remainder of this chapter: For contour-tone languages, it is phonologically more efficacious to map tone features onto the syllable as a whole rather than onto an arbitrary "syllable crest" or syllabic segment. To map tones onto units which are formally associated with a single segment obviates the formal importance of the syllable as a phonological unit and also complicates what will be shown to be highly regular and independent procedures for mapping inherent and prosodic features onto their phonologically distinct levels.

1.4. Proposal (2) Contour tones are treated on the segment as a series of distinct level-tone features.

1.4.1. Woo (1970)

Woo postulated that (1) contour tones are formally treated as a series of distinct level-tone features, and that (2) these tone features are carried by the segment.

We have argued in support of the first part of Woo's proposal in the Preface. We reasoned that the formal treatment of contour tones as strings of distinct level tones is phonologically desireable since such a treatment explicates the linguistically significant generalization that individual tone members of contour tones operate as phonologically distinct.

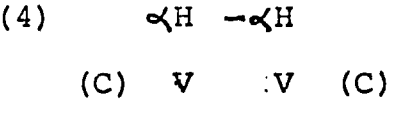
Recall from the Mende data in the Preface that there is never a case where the entire contour is deleted, and this deletion occurs only when the last member of the contour agrees with the tone on the next tone-carrying unit.

We argued, therefore, that if contour tones were treated as single contour features, as Proposal (1) suggests, rather than as a series of distinct level tones, as Proposal (2) suggests, then the linguistically significant tone deletion of Mende could not be explicated by the theory.

The formal efficacy of Woo's proposal comes into question, however, with regard to its second part, namely that the domain of tone is the segment. Consider that if the segment were to carry a series of tones, then a complicated set of "exception" procedures would be re-

quired by the theory in order to explicate contour-tone data. This would be required since the standard mapping procedures permit only simultaneous mappings onto the segment.

Woo recognized that her proposal might be regarded as a formal muddle to the theory. However, she still maintained that the phonological domain of tone was the segment. She based her claim on the following argument: Contour tones can be phonologically displayed only when they are associated with at least as many tone-carrying segments as there are distinct tones in the contour. For example, a contour tones consisting of a sequence of two level tones can be carried only by a long or geminate vowel. Thus, a falling or rising tone is carried only by syllables of the following types: (C)V(V) or (C)$\overline{V}$(C). These syllables are treated phonologically as (C)VV(C), where the vowels are treated as two distinct segments and where each of the two level tones comprising the contour tone is carried by a distinct segment:

(4)


In this way, standard mapping procedures are not violated.

If such an analysis were borne out by the data, the

result would be an almost ideal resolution to the question of how tone is to be formally treated in the theory. Under Woo's system, the additional formal baggage that would be required to permit concateneous mapping of tone onto the segment would be avoided, as might also be the requirement for invoking more than one level of phonological organization as Proposals (3) and (4) (see Sections 1.5. and 1.6.) suggest.

However, such an "ideal" analysis is empirically falsified by the data since it has been shown in many languages that contour tones must often be displayed on fewer distinct tone-carrying segments than there are distinct tones in the contour. For example, in Gwari (Hyman & Schuh, 1974) in the word asesa, 'sitting,' the final syllable is contour-toned, yet the vowel in that syllable must be treated as phonologically short. This results in a clear violation of standard mapping procedures. Another example comes from Mende (Fromkin, 1972), where the words, mbu, 'owl,' and mba, 'companion,' carry two and three level tones, respectively, on single short vowels.

It has therefore been shown that in natural languages, contour tones are carried on short vowels as well as on long vowels. Evidence such as the above provides support against treating the segment as the phonological domain of tone in contour-tone languages.

As additional support, consider the following data

from Gwari (Hyman & Schuh, 1974:88). The data represent an example of a language which has developed contour tones by means of the basic principle that "if two contiguous syllables differ in tone, a natural process would be for the tone of the first syllable to 'spread' into the second syllable (pages 88-89):"

(5) (a) /ôkpá/ [ôkpǎ] 'length'

(b) /súkNù/ [súkNú] 'bone'

Additional languages which have developed contour tones in this fashion according to Hyman & Schuh (page 89) are Yoruba, Nupe and Ngizim.

Hyman & Schuh analyze the data in the following way:

(6) [αH][−αH] ⟶ [αH] [αH][−αH]

where tone on the first syllable is copied (or spread) onto the second syllable.

The Hyman & Schuh analysis captures the following linguistically significant generalizations:

(1) Contour tones must be treated as a series of phonologiclly distinct level tones.

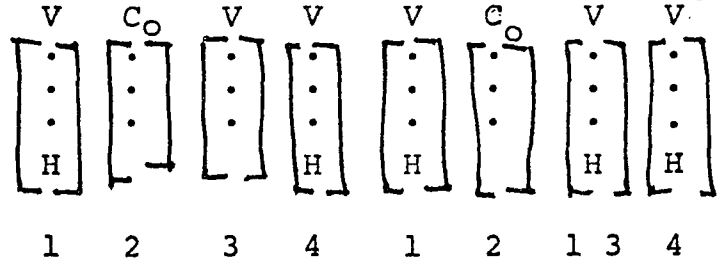
(2) The tonological operation in question does not require, in the structural description of its rule, information regarding segmental environments, i.e this tonological rule operates on a

domain independent of segmental information.

Under a Woo analysis of the data, generalization (2) cannot be captured and, consequently, neither can generalization (1) be captured in a formally "satisfying" way. Under the Woo analysis, tone must be carried on the segment, and therefore irrelevant segmental information is specified in the structural description of the rule.

Rule (7), below, represents a possible Woo analysis for the Gwari data:

(7)



Condition: 1 & 4 = only tonal information.

(where $\begin{matrix}\cdot\\\cdot\\\cdot\end{matrix}$ represents feature specifications of the segment).

Since under a Woo analysis, tone must be carried on the segment, and since formal considerations require that a series of level tones be carried on a series of distinctive segments, Woo might (as one alternative) invoke a "dummy" vowel (represented as variable 3 in Rule (7)) on the second syllable, so that the series of

level tones, H H , can be explessed in the output of the rule on the second syllable.

Consider, however, that the positing of this "dummy" vowel does not resolve the formal impasse; it merely shifts it to another part of the grammar. Since vowels in the second syllable are phonetically short in the Gwari data, either vowel 3 or vowel 4 must be deleted. Therefore, a Woo analysis of the data is still faced with the formal muddle in that <u>eventually a series of distinct tone features must be mapped onto a single segment.</u> This can be represented as follows:

(8) $\begin{bmatrix} \alpha H \\ V \end{bmatrix} \begin{bmatrix} -\alpha H \\ V \end{bmatrix} \rightarrow \begin{bmatrix} \alpha H & -\alpha H \\ & V \end{bmatrix}$

We might possibly avoid such a formal impasse, under a Woo analysis, by invoking a set of conditions into the theory whereby the constraint against concateneous feature mappings onto the segment can be violated under explicitly-defined eoperations.

However, such a set of conditions would, besides "complicating" the theory, also formally treat highly regular tonological operations, such as Rule (6), as "exceptions to the rule." The shortcomings of such a procedure will be discussed in more detail under Proposal (5)(see Section 1.7. below).

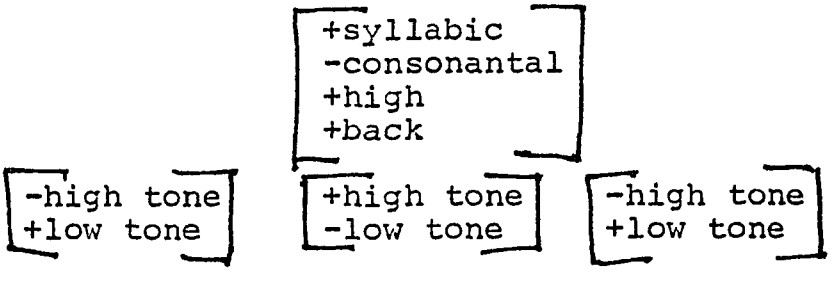
<u>1.4.2. Campbell (1974)</u>

Campbell developed the notion of the Complex Symbol. He did not argue for it on tonological grounds, yet we can tacitly assume that it can be exploited to deal with tonological operations.

Under the Complex Symbol treatment, a segment is viewed as a single unit which can nevertheless be represented by more than one column of simultaneous bundles of distinctive features, and where feature members of each column can operate independently of feature members of other columns of the same segment.

Such ananalysis clearly fits into the Proposal (2) category since individual tones may be treated as independent sub-units which are "dominated" by common segmental features. For example, consider a Complex Symbol treatment of the vowel in the Mende work, mbû, 'companion:'

(9)



A critical evaluation of the Campbell proposal would follow along lines similar to the Woo proposal. There is, however, one important difference between the two. Woo was concerned with the formal problems that would result from setting up separate mapping procedures

for different features onto the same unit (the segment). Remember that she developed her hypothesis regarding distinct level-tone features on the grounds that such concateneous mappings onto a single segment would not be required. Campbell, on the other hand, specifically proposes that these separate mapping procedures onto the segment be set up.

Despite the differences in the formal reasoning behind the development of the two proposals, it turns out that, faced with the data from natural languages, both the Woo and Campbell systems make nearly identical formal claims. Therefore, a separate critical review of the Campbell system is redundant.

1.5. Proposal (3) Contour tones are treated on the syllable as single distinct contour fea- features.

Note that the Wang hypotheses are in polar opposition to those of Woo (see Proposal (2)). Wang proposes the following:

(1) Tone is underlyingly a suprasegmental feature which is carried either on the syllable or on the morpheme.

(2) Contour tones are treated as phonologically distinct rather than as a series of distinct level tone components.

In support of his first hypothesis, Wang points out that it is often an arbitrary decision as to which segment carries tone. For example, in Chinese, he shows

that tone features may sometimes be associated with the initial voiced consonant of the syllable, sometimes with the nuclear vowel and sometimes with the final voiced consonant of the syllable. He reasons that if tone were carried by the syllable as a whole, then the problem would be resolved.

Wang also points out, in support of the phonological treatment of tone as a suprasegmental, that very often segmental features are not relevant to various types of tone sandhi rules, where phonological conditions required for the operation of tone rules are independent of segmental information.

There are, however, cases which may serve as counter-examples to Wang's first hypothesis, where it can be shown that segmental information does affect the output of tonological operations in contour-tone languages. Consider, for example, the following data from Nupe (George, 1970):

(10) (a) ètu → ètu 'parasites'

(b) èdu → èdu 'taxes'

(c) èkpa → èkpa 'length'

(d) ègba → ègba 'a garment border'

In these Nupe data, it is the low-tone specification on the first syllable that is copied onto the second

syllable, only if the intervening consonantal segment is voiced. This provides evidence from a natural language in which suprasegmental information is dependent on segmental information in order to derive correct outputs in tonological operations.

However, in support of the Wang hypothesis, we have also shown, in analyses of data from Mende (see Preface) and Gwari (see Section 1.4.1.), that there are cases in which the domain of tonological operations is regarded as exclusively suprasegmental.

Given that data from natural languages support the hypothesis that conditions for the operation of tonological rules are sometimes dependent on segmental information and sometimes independent of it, it is evident that the Wang hypothesis regarding the domain of tone is not sufficiently powerful to reconcile the apparently conflicting claims that the data from natural languages make.

Consider now that if tone were to be treated as a suprasegmental, then on what phonological unit would it be carried: on the syllable; on the morpheme; on both the syllable and the morpheme; or on some other unit? Wang, as we have seen, presents one argument in support of the treatment of the syllable as an efficacious phonological unit.

Consider now additional arguments which support the treatment of the syllable as an independent phono-

logical unit.

Fromkin's (1973) study of Performance errors that English speakers make provides supporting evidence for the psychological reality of the syllable. In errors involving the interchange of consonants she has shown that syllable-initial consonants almost always interchange with syllable initial consonants (e.g. Yew Nork for New York). Such errors provide support for the hypothesis that the syllable is a perceptually salient unit of speech, and thus might be utilized as an operating unit in a phonological theory.

Also, cursory observation supports the hypothesis that syllables are comparatively easy units to identify. Ladefoged (1975) observes that people not educated in alphabetical writing systems find it much more difficult to break up syllables into their component segments (consonants and vowels) than it is to break up utterances into their component syllable units. It might also be added that even people trained in an alphabetical writing system will find it easier to identify distinct syllables than to identify the segments that make them up.

Consider also that the ease with which people can "tap out" syllables lends support to the physiological saliency of the syllable as a unit in production.

Anderson (1974) convincingly argues that since languages show significantly different principles of syl-

labification in terms of the placement of syllabic boundaries for the same sequence of segmental elements, such systematic differences must be included in phonological representations.[2]

He cites examples from Sommer's (1970) work on a number of Australian languages (Oykangard, Olgol, Okunjan and Kawarrang), where the canoncial syllable shape is not C_oV but VC_o. Thus in VCV strings, the syllable boundary falls after the C, and in VCCV strings, the syllable boundary falls after the two consonants: elw.an.udn.an.am, 'from sleeping.'

Anderson also shws based on Gibson's (1956) observations that more than one vowel can co-occur without a syllable boundary between the vowels. In Pame, for example, three vowel elements can appear in the same syllable so that ŋgwâoi, 'her (two) daughters'-in-law,' is treated monosyllabically. Therefore, syllabification varies not only in terms of placement of consonants within the syllable, but also in terms of placement of vowels.

The independent and phonological arguments presented above give support to the hypothesis that the syllable may be treated as an independent unit in phonological analysis.

Wang's second hypothesis requires further explanation. He posits the feature Contour in order to distinguish "stationary" from "non-stationary" tones. He hypothesizes that for tones specified as +contour, three

additional features are available: Rising, Falling and Convex, where Convex refers to bi-directional tones, such as Falling-Rising or Rising-Falling. Using this set of features, Wang distinguishes eight contour tones:

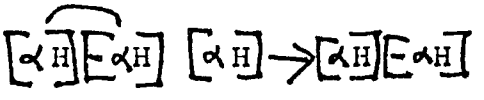
(11)

Contour	+	+	+	+	+	+	+	+
High	+	-	+	-	+	-	+	-
Rising	+	+	-	-	+	+	-	-
Falling	-	-	+	+	-	-	+	+
Convex	-	-	-	-	-	-	+	+

Such an analysis succeeds in classifying contour-tone distinctions. However, it fails to explicate regular tonological operations in a "natural" way. This has been shown to be the case for all the tonological analyses presented in this chapter.

As an illustration of this, consider the Tone-deletion Rule that Leben posits for Hausa, Yala and Mende. Such a rule was described under (4) in the Preface. It will be repeated here, under (12)

(12) Tone-deletion Rule



Data from Hausa (Leben, 1971) support this rule:

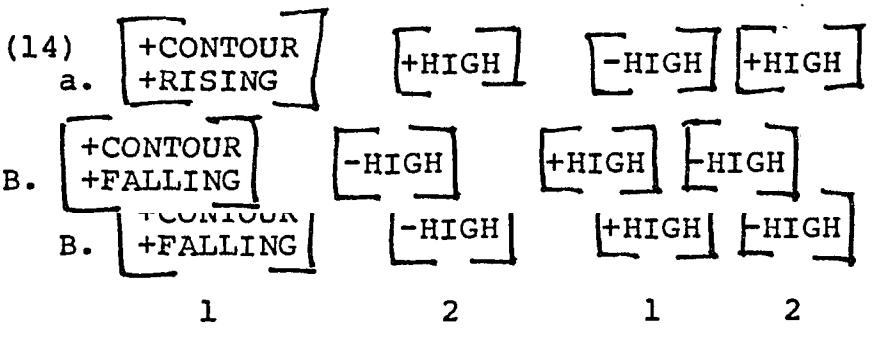
(13) alhaamis + ii alhaamis + ii 'Thursday'

nàa + wa	nàa +wa	'mine'
bèebee + aa	bèebèe + aa	'deaf mute'

Rule (12) supports the generalization that the second tone of the first syllable is deleted if it agrees in tone specification with the tone of the second syllable.

Under the Wang hypothesis, the following rule would have to be formulated in order to account for the Hausa data in (13):

(14)



(where the features within the brace brackets are features of the syllable.)

The predictable alternation process that is explicated by Rule (12) seems ad hoc under the Wang treatment under (14). The linguistically significant generalization that the series of tones that make up contour tones operate as phonologically distinct is being missed. Such a generalization should be explicated by the theory, and the Wang treatment of contour tones as single distinct features does not capture this generalization.

Thus far, all of the data that has been inspected strongly support the claim that the treatment of contour tones as distinct level tones "buys" us a more descriptively adequate analysis than one which treats contour tones as single features.

Fromkin (1971:61-66), however, puts forth the following argument in favor of the feature, Contour: Contour tones cannot be dispensed with since "the univeral set of features must include a feature of feature combinations which will distinguish between level tones and contour tones (page 66)," since contrasts between level tones and contour tones do occur in natural languages. She presents an example of this from Yala, drawing her data from Leben (1971:185):

(15) (a) ó ka̋ 'he said'
(b) kó ka̋ 'let him speak'

as well as an example from Nupe (George, 1970):

(16) (a) ɔ̀bɛ́ka̋ 'he will remain'
(b) ɔ̀bɛ́ka̋ 'he will bite it'

It seems that this problem regarding the need for Contour features can be resolved by invoking a convention which states that, at the phonetic level, a series of level tones specified within a single syllable

constitutes a contour tone. In this way, the feature, Contour, as well as the features Falling, Rising, High and Convex would be treated as phonetic, rather than classificatory or phonological features. This can be justified on the grounds that no phonological evidence to my knowledge has shown that the feature, Contour, is required at the underlying level.

Therefore, it would seen that the proliferation of additional contour features to the set of underlying distinctive features in order to handle a requirement that a language-universal statement will satisfy is not justified on phonological grounds.

I propose, then, that the following language-universal Convention for generating Rising and Falling Contour Tones, <u>at the phonetic level</u>, be formalized:

(17) $$\left[\left[\alpha H\right]\left[-\alpha H\right]\right]_{\Sigma} \longrightarrow \left[\begin{array}{l}+\text{CONTOUR}\\ -\alpha\text{RISING}\end{array}\right]_{\Sigma}$$

where features within the brace brackets, $\left[\ \right]_{\Sigma}$, are features of the syllable.

1.6. <u>Proposal (4)</u> <u>Contour tones are treated on the morpheme (and/or syllable)as a series of distinct level-tone features.</u>

<u>1.6.1. Leben (1971)</u>

The Leben proposal represents an attempt to reconcile the opposing positions of Woo (Proposal (2)) and Wang (Proposal (3)). He supports the first part of the

Woo hypothesis - that underlying tones are always level - but rejects the second part - that underlying tones are segmental rather than suprasegmental. Conversely, he supports the second part of Wang's hypothesis - that underlying tones are phonologically regarded as suprasegmental features - but rejects the first part - that single "contour" featues are phonologically regarded as the distinctive features of tone.

For the most part, the argument he developed (1971) supporting the hypothesis that underlying tones are always level follows a line of argumentation similar to that presented in the first three proposals.

Leben finds his strongest support for this hypothesis in an analysis of the way tone-copy rules operate in contour-tone languages. He presents the following data from Mende (Leben, 1971:194):

[3] (18) (a) nika + hani = nika + hani

(b) ≠ nika + hani

(19) (a) bebee + aa = bebee + a

≠ bebee + a

For tone-copying rules, it is the last member of the sequence of tones which comprises the contour tone that is copied; it is not the entire contour tone that is copied. Leben claims that this provides strong evi-

dence for the treatment of contour tones as sequences of level-tone features that are phonologically distinct.

His arguments for the treatment of tone as supra-segmental are more innovative. He claims that, besides giving the theory too much power, it would not be clear, with the treatment of tone as underlyingly segmental, how to prevent the tone-copying rule from incorrectly copying [[H] [H]] instead of copying only [H].

Such a problem, he reasons, does not arise if tones are treated as suprasegmentals. He proposes that tone might be lexically specified on the morpheme in the same way that segments are specified on the morphemes, i.e. as linear sequences; and that phonological rules should be able to pick up individual tones in the same way that they are able to pick up individual segments. (Leben does not explicate how such a procedure should take place.) He also proposes that such linear specifications may take place on the syllable as well. (He also does not pursue this question.)

I support Leben's hypothesis for treating tone as underlyingly suprasegmental, yet not his line of argumentation for treating tone on the morpheme - since it results in an unnecessarily "complicating" analysis which is not warranted on the phonological grounds that he claims. I shall argue that for the data which Leben presents the underlying treatment of tone on the syllable is preferrable.

Consider, first, Leben's argument supporting the underlying treatment of tone on the morpheme. He argues that for Mende a constraint must be stated to rule out HLH sequences on morphemes, so that the following are not permissable: *CV, *CVCV and *CVCVCV. Such a general statement, he claims, cannot be made if tone were carried on the syllable.

I will now present an argument to show not only that the treatment of tone on the morpheme is not essential for the data in question, but also that such a treatment will constitute a complication to the theory which can be avoided by treating the syllable as the unit on which tone is carried.

Consider how Leben might treat tone specifications on polysyllabic morphemes, such as the following one in Hausa:

(20) /alhaamis/ 'Thursday"

Under Leben's system, tone was treated underlyingly on the morpheme, and therefore the specification might look like this:

(21) $\underset{M}{[}$ L L H L $\underset{M}{]}$

where the features enclosed within the brace brackets are features of the morpheme.

It will now be argued that the procedures for specifying tone on the morpheme, as represented in (21), are not sufficiently powerful to account for the fact that uderlyingly the morpheme in question must be represented as in (20). Given specification (21) alone, the following two underlying tone specifications for the morpheme are logically possible:

(22a) */alhaamis/

(22b) /alhaamis/

However, it is essential for an observationally adequate analysis that the empirically-incorrect expression of (22a) be constrained by the theory; and that the empirically-correct expression of (22b) be permitted by the theory.

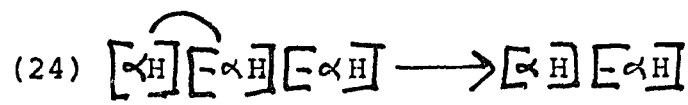
That this must be the case will be shown by considering the phonetic consequences of treating both (22a) and (22b) as underlying when the suffix -ii is affixed to both of them.[4]

(23a) /alhaamis + ii/ → *[alhaamisii]

(23b) /alhaamis + ii/ → [alhaamisii]

The underlying representation of (23b) provides

the environment necessary for the independently motivated Tone-deletion Rule (24) to perate (see Preface for further discussion of this rule):

(24) 

which when applied, correctly derives the phonetic output of (23b): [àlhàamísíi]. The underlying representation of (23a), on the other hand, does not provide the environment necessary for the Tone-deletion Rule to operate, nor does it provide the environment necessary for any other tonological rule to operate, where the empirically-correct output is derived. Therefore, our theory must prevent the underlying representation of of (22a) from being expressed.

We have seen then that it is essential, on phonologically, to capture the fact that the final tone-carrying unit (the syllable is the most logical choice on phonological and independent grounds) of (20) must be treated underlyingly as contour toned, i.e. represented as (22b) and not as (22a).

We have also seen that a Leben analysis of tone, represented undelyingly only on the morpheme, cannot capture this fact without resorting to the positing of separate and highly costly procedures for each polysyllabic morphemes that may derive, without such procedures, empirically impossible tonal displays. In

other words, without such costly procedures we cannot prevent the empirically-nonexistent *[àlhàamísíi] from being derived.

By invoking the syllable as the domain on which tone is displayed, we can capture this fact in a highly regular and predictable way. Consider the following tonal display for (25):

(25) / L / L / H L /

where features enclosed by the slashes, / /, are features of the syllable. Note that the tone specifications, as represented by (25), capture the phonologically essential fact that the last syllable of (20) is contour-toned.

In summary: If the morpheme (as Leben suggested) were treated as the domain on which tone is carried, then it would be necessary to posit ad hoc morpheme-specific procedures for mapping empirically-correct underlying tonal displays for a large class of polysyllabic morphemes. In order to avoid such complications, we invoke the syllable as the most logical alternative to represent the unit on which tone is carried. In so doing, we accomplish the task of correctly and efficiently specifying tone distribution on underlying levels.

Since Leben alludes to the possible treatment of tone on both the morpheme and the syllable, let us now

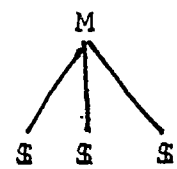
briefly consider this treatment. Such a specification for àlhaamis might look something like this:

$$(26)_M \left[\overline{/\ L\ /\ L\ /\ H\ L\ /} \right]_M$$

where features enclosed by brace brackets, $_M[\ ]_M$, are features of the morpheme and where features enclosed by slashes are features of the syllable.

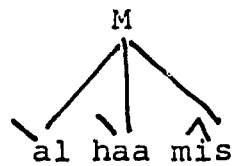
Note that a tone specification procedure such as represented by (26) reflects hierarchical patterning. Such patterning can be schematized as follows:

(27) (a)



or

(b)



where M represents the morpheme and $ represents the syllable.

By incorporating such a treatment, information on two distinct domains is required in order to capture the necessary facts of tone distribution on the suprasegmental level. This is precisely the kind of formal treatment that Leben argues most strongly against in

his treatment of tone as a suprasegmental.

He attributes this, his strongest argument for tone as a suprasegmental to Wang (1967). Leben (1971: 198) states this argument as follows:

> "If tone is a feature on some entity more abstract than the segment - such as the syllable or the morpheme - then it is impossible to state a rule which changes the tone in an enviroment determined by segments below it."

We can appreciate, in the abstract, that such an assumption is formally efficacious since it presupposes that the grammar contains distinct phonological domains with distinct constraints on how phonological rules may operate on those domains. With such a system, we may limit the power of the theory by constraining phonological operations that would otherwise predict very large numbers of impossible outputs.

The important question to ask, however, is whether such a system, formally constrained in the way Leben and Wang propose it, represents a valid model for phonological explanation in all natural languages.

A number of counterexamples can be presented to show that such a system, as constrained by Leben and Wang, is empirically falsified by data from natural languages.

Consider first the argument we developed earlier in this Section regarding tone specification procedures for the underlying tonal representation for the Hausa morpheme, <u>alhàamis.</u> Given the Leben proposal that tone

tone is carried by the morpheme, and given, as we hve shown, that tone must also be carried by the syllable, which is "dominated" by the morpheme, we can obseve that such a display would constitute a violation of the highly constrained Leven-Wang assumption. This is so, since as we have seen for alhaamis, information on both the more abstract (in this case, morpheme) level and the less abstract (syllable) level is required.

Leben would have predicted that a tone-specification procedure, as represented in (26) and (27) above, is impossible. We have however shown that usch a procedure is required by Leben in order to permit at least observationally adequate account of the Hausa data.

Other more obvious counterexamples to the Leben-Wang assumption can be cited. Leben however considered these to be only "apparent" counterexamples. In attempting to show this, he modified his proposal. His modified proposal states that contour tones are treated on both the morpheme (and/or syllable) and on the segment as a series of distinct level-tone features.

His modified proposal will be called Proposal (5), and it will be considered in the section immediately below.

1.7. Proposal (5) Contour tones are treated on both the morpheme (and syllable) and on the segment as a series of distinct level-tone features.

1.7.1. Leben (1971, 1978)

Leben (1971:198) cites the following, he claims, "apparent" counterexample to the Leben-Wang Assumption:

> "One apparent counterexample is the rule of Low-Tone Raising in Hausa stated in ((28)) which changes a low tone into a high tone on a long vowel word-finally after a low tone."

(28) Low-Tone Raising in Hausa

$$L \quad L \quad \# \longrightarrow L \quad H \quad \#$$

$$\begin{bmatrix} -\text{syll} \\ +\text{Long} \end{bmatrix} \qquad \begin{bmatrix} -\text{syll} \\ +\text{Long} \end{bmatrix}$$

The following Hausa data taken from Leben (1978) explicates this point:

(29)

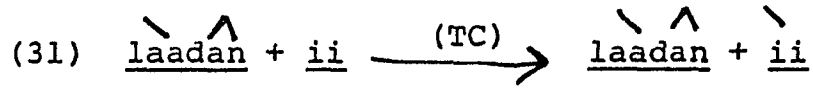
Form without -ii		Form with -ii	
(a)	biyar	biyarii	'five'
	baabur	baaburii	'motorbike'
(b)	fam	famii	'pound'
	laadan	laadanii	'muezzin'
(c)	maalam	maalamii	'teacher
	fensir	fensirii	'pencil'

For (29a) the -ii suffix inherits the H tone of the previous vowel by means of a Tone-Copying (TC) Rule:

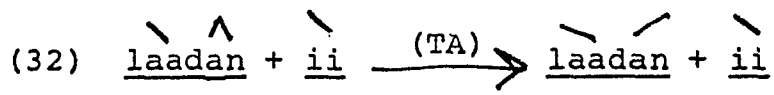
(30) biyar + ii $\xrightarrow{(TC)}$ biyar + ii

For (29b) the -ii suffix inherits the final member

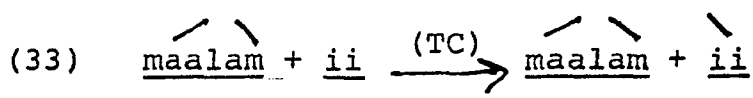
of the contour tone on the previous vowel, also by means of the TC Rule:



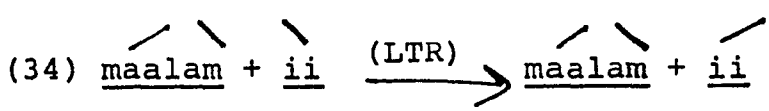
Then a Tone-Absorption (TA) Rule applies, deleting the last tone member of the contour tone when its tone specification is identical to that of the following suffix:



For (29c) the -ii suffix inherits the L tone of the previous vowel by the TC Rule:



This assigned L tone on the suffix is raised to H by means of the Low-Tone Raising Rule (LTR) (see (28) above):



We observe that the Tone-Copying Rule and the Tone-Absorption Rule both operate solely on a tonological domain and thus do not violate the Leben-Wang Assumption. However, the Low-Tone Raising Rule requires both tonolo-

logical and segmental information for its statement. Therefore, we may reason that such a rule is in violation of the Leben-Wang Assumption since "it is impossible to state a rule which changes...tone in an environment (segmental) determined below it (leben, 1971: 198)."

Leben, however, reasons that this is not a "real" counterexample since at the point in the derivation in which this rule operates, tone is not realized as a feature on suprasegmental units, but rather as a feature on segmental units.

Thus, he is stating that tone is treated as both a suprasegmental feature and as a segmental feature. He claims, based on data from Hausa, that at the level of underlying representation, tone features are always treated as suprasegmental; and that, at some point in the derivation, when segmental information is required for the operation of a tonological rule (as in (28)), tone features are then formally treated as segmental.

Leben's revised proposal has clearly been evoked in order to maintain the strong claim of the Leben-Wang Assumption. By invoking this Assumption he aims at constraining a phonological theory so as to limit the class of possible phonological grammars defined by the theory which might, if not so limited, predict large numbers of empirically impossible outputs.

It has been shown in our discussion of Propo-

sal (4) that such a constraint would, in principle, be highly efficacious if and only if it fit the empirical data of natural languaged. However, if it becomes essential to proliferate ad hoc "exception" procedures to the theory in order to maintain the formal status of the Leben-Wang constraint, then we can show that the arguments supporting the Leben-Wang constraint are largely specious.

It can be argued that the Leben-Wang Assumption is not empirically supported by the data and that the Low-Tone Raising Rule represents, contrary to Leben's argumentation, a real counterexample to the Leben-Wang Assumption.

Let us review more carefully the derivation of the Hausa word, máalàmíi. At the underlying level, there are two distinct domains of representation; the suprasegmental where tone is carried and the segmental where segmental features are carried. Since the Tone-Copying Rule applies only on the suprasegmental domain, there is no violation of the Leben-Wang Assumption (see (33)). Low-Tone Raising is the next rule to apply (see (34)), However, according to Leben, it cannot apply since the structural description of the rule requires both suprasegmental and segmental information. Therefore, a Low-Tone Raising Rule of the form:

(35) L L # L [-syll +Long] #

[-syll +Long] → [-syll +Long]

is considered logically impossible according to the Leben-Wang Assumption.

In order to avoid such a violation, Leben posits a phonological rule which applies after all purely tonological rules have applied and before any rules which require that both tonological and segmetnal rules have applied. This phonological rule maps the units of suprasegmental tone patterns into segmental tone features.

Therefore, after the application of Leben's "phonological" rule, the new form of the Low-Tone Raising Rule would look something like this:

(36) [+syll +Long +L,+L] → [+syll +Long +L,+H]

A rule such as (36) does not violate the Leben-Wang Assumption. However, tone features are now concatenously-mapped across the segment - a serious violation of the highly regular feature-mapping procedures (see arguments developed under Section 1.4.), and for every derivation in which both suprasegmental and segmental information is required for the operation of a phonological rule, Leben must posit additional ad hoc

"phonological" rules whose operations are not intrinsically motivated by the empirical data but are rather motivated by the formal demands that the Leben-Wang Assumption not be violated. In other words, such rules are posited in order to maintain the formal status of the Leben-Wang Constraint; to formally "legitimize" the Leben account of the empirical data.

Thus, on metatheoretical as well as empirical grounds, rules such as Low-Tone Raising constitute a real counterexample to the Leben-Wang Assumption. Such rules require that a highly costly "exception procedure" be invoked whose operation results in a significant weakening of the highly regular mapping procedures. Consequently, Leben's argumentation in support of this Assumption is rendered specious.

1.8. Proposal (6) Contour tones are treated on the segment as a series of level-tone features and as single distinct 'contour' features.

1.8.1. Fromkin (1972)

The Fromkin proposal, like the Leben proposal, represents an attempt to reconcile the antithetical claims made by Wang and Woo.

Regarding the question of whether contour tones are to be treated as single distinct 'contour' features or as a series of distinct level-tone features, Fromkin agrees with Woo and Leben that rules such as Tone-

Copying, Tone-Deletion and Low-Tone Raising strongly support the phonological treatment of level tones as formally distinct; and that, at some point in the derivation, contour tones must be treated as such. However, she also agrees with Wang with to the inclusion of 'contour' features into the set of distinctive features.

Fromkin's argument supporting the inclusion of 'contour' features into the set of distinctive features has been presented in detail under Proposal (3) (see Section 1.5.1.). Briefly reviewed, it was shown that she supports invoking 'contour' features since languages show contrasts between contour tones and level tones; and therefore the theory must formally distinguish them.

We argued that such a treatment of this distinction can be handled by low-level conventions at the phonetic level, which treat series of level tones on a single syllable as contour features; that since no phonological evidence has been put forth to show that 'contour' features are needed underlyingly, contour features should not be included in the inventory of classificatory features, but rather as low-level phonetic features.

The hypothesis Fromkin presents regarding the question of whether tone is a feature on the segment or on the suprasegment is more interesting, and it will be

discussed here in more detail.

Fromkin argues that the Leben resolution to this question - in which he claims that tone is a feature on both the segment and the suprasegment - is largely vacuous.

As I have shown in the critical evaluations of Leben's Proposals (4) and (5) (see Sections 1.6. and 1.7.)), I concur with Fromkin on that point. However, I do not concur with her specific formal resolution of the question as to what constitutes the proper formal domain of tone in contour-tone languages.

She argues that since, in the Leben analysis, sequences such as [<H][-<H] are eventually mapped onto the segment inthe course of its derivation, it would cause fewer "formal problems" if tone were mapped onto the segment at the very beginning of the derivation, i.e. at the underlying level.

The "formal problems" that Fromkin alludes to are the following: that (1) all other things being equal, it is preferable on formal grounds to posit a single segmental matrix rather than two distinct matrices, namely segmental and suprasegmental; and (2) since, under the Leben proposal, sequences of level-tone features are ultimately mapped onto single segments, this constitutes a violation of the "regular" feature-mapping procedures that Woo tried to prevent.

Fromkin proposes that these two formal problems can

be resolved by treating contour tones underlyingly as sequences of distinct level tones on the segment. In order to avoid problem (2) , i.e. in order that there will be as many tone-carrying units as there are distinct level tones in the contour, Fromkin invokes a [-segmental] unit, which carries only tone features.

The segmental matrices that Fromkin proposes for the following three Mende words can be schematically represented as follows:

(37)

	phonetic level		underlying level
(a)	mbu̍	'owl'	HL mbuØ
(b)	mbǎ	'rice'	LH mbaØ
(c)	mb̍a	'companion'	LHL mbaØØ

where Ø represents a [-segmental] unit which may bear only tone specifications.

Note that under the Fromkin proposal (as represented in (37)), the Woo constraint against concatenous feature mappings onto a single segment is not violated, whereas under the Leben proposal (see Section 1.7.), the Woo constraint <u>is</u> violated since at some point in the derivation, the following representations must be expressed:

(38)

(a)	mbu̍	HL m b u
(b)	mbǎ	LH m b a

(c) mba ∧ LHL
m b a

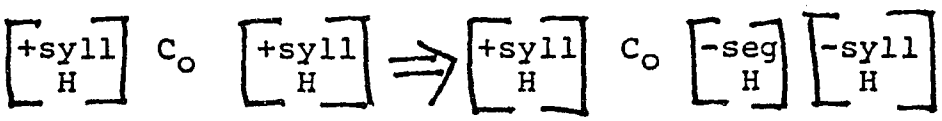
where series of leveltone features are specified on a single segment.

In summary, Fromkin argues that since the Leben analysis proposes a segmental treatment of tone at some point in the derivation, as represented in (38), it may as well permit a segmental treatment from the start, thus avoiding the need to invoke two distinct feature matrices. She also argues that since the treatment of tone on the segment, as represented in (37), will prevent the violation of the Woo constraint, then a formal treatment, as represented in (37), should be incorporated into the theory.

The Fromkin argument is forceful in its critical evaluation of the formal inadequacies of the Leben proposal regarding the treatment of sequences of tone on single segments.

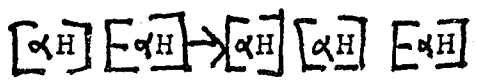
However, let us consider what the Fromkin proposal does not "buy" us. It does not formally explicate the fact that many tonological processes operate on a domain independent of segmental information, so that a Tone-Copying Rule such as the one in Gwari (see Section 1.4.) would need to be posited as follows, under the Fromkin proposal:

(39) Fromkin Tone-Copying Rule



The Leben analysis would posit the rule as operating as follows:

(40) Leben Tone-Copying Rule



Since segmental information is irrelevant to the operation of the Gwari Tone-Copying Rule, the Leben analysis (40), on the other hand, must include in the structural description of its rule irrelevant segmental information. Thus, it fails to formally capture the independent status of the domain on which the tonological rule operates. It also, as we have shown, requires that we invoke [-segment] units which seem suspect on independently-motivated grounds.

1.9. Conclusion to Chapter One.

We have inspected some of the major pre-autosegmental post-standard theory proposals regarding the organization of tonological phenomena in natural languages. The theoretical considerations that these proposals invoke have added insight into the problems that a phonological theory must address regarding the treatment of tone, especially contour tone, in natural languages.

By scrutinizing the proposals in light of the data, we were able to conclude (1) that an overall simplification of tonological analyses seems to result from the formal treatment of contour tones as strings of phonologically distinct level tones; and (2) that the domain on which to formally describe tone is not always the segment.

We found that despite the efficacy of these insights to increase the descriptive adequacy of the theory, none of the proposals inspected had succeeded in formally resolving standard theory's inherent mechanical failings to explicate the dynamic interrelationship between the segmental and suprasegmental domains.

In Chapter Two, a number of more radical revisions in tonological theory are presented and critically evaluated, in shich the dynamic interplay of segmental and suprasegmental domains is explicated.

FOOTNOTES FOR CHAPTER ONE

1. (5) represents Hyman and Schuh's (1979) diachronic hypothesis regarding the way in which contour tones have developed in Gwari, as well as Yoruba, Nupe and Ngizim.

2. Anderson's line of reasoning comes from his observation that a number of languages systematically differ in the parameter Released/Unreleased, even though no language seems to use this feature distinctively. This feature, nevertheless, must be included in the universal inventory of phonetic features.

3. These data represent the operation of Leben's Tone-Copy operation on Compound Words in Mende. In his analysis, the first syllable of hanì is underlyingly toneless - as is the syllable aa. Tone specification on these syllables is derived by the Tone-Copy Rule.

4. In Hausa, "nouns ending lexically with a consonant often have a variant form with the ending -ii attached...The tone of -ii is not uniform from word to word, but it is predictable." (Leben, 1978:208)

CHAPTER TWO: CRITICAL OVERVIEW OF AUTOSEGMENTAL THEORY

2.1. General Introduction

In this chapter, autosegmental phonology is explicated, as it applies to tone, as developed by Goldsmith (1976) (in Section 2.2.) and further revised by Leben (1978) (in Section 2.4.) and Clements & Ford (1979) (in Section 2.5.).

In the light of the data from Lomongo, Igbo, Mende, Etsako, Kinyarwanda, Anyi and Kikuyu, the empirical and formal status of three central apparatus of autosegmental theory will be inspected and critically evaluated: the Melodic Association Procedures, the Convention on Tone Melodies and the Well-formedness Condition. It will be argued that the language-particular claims of the Melodic Association Procedures are not supported by the data; and also that the universal claims of neither the Convention on Tone Melodies nor the Well-formedness Condition is universally supported by the data. Therefore, it is argued that further modifications in the theory's formalisms are required.

2.2. Goldsmith (1976)

Goldsmith's innovative hypothesis represents an attempt at formally resolving the mechanical problems inherent in the standard theory regarding tonological phenomena. In his analysis, tone features are factored out from the segmental level and are then placed on what Goldsmith names the autosegmental level.

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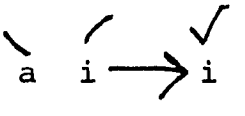
2.2.1. Phonological Motivation for Autosegmental Phonology.

Goldsmith inspects a number of tonological phenomena (contour tones, melody levels, floating tones and automatic spereading) which are problematical within standard theory (1976:21-53). I will present one of these phenomena, tone stability, as a means of inspecting some of Goldsmith's crucial argumentation in support of autosegmental phonology.

Tone stability, which occurs regularly in many African languages, refers to the observation that when a vowel is deleted by a phonological rule the tone which is canonically associated with that vowel often does not disappear. Rather, it surfaces on some other vowel; i.e. the tone has stability independent of the vowel.

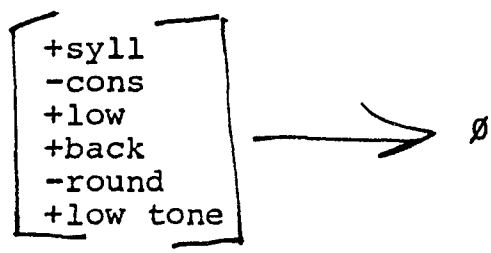
Goldsmith presents the following paradigm to demonstrate this point:

(41) 

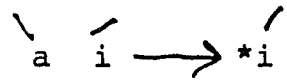
where the vowel, a, carrying the low tone is deleted, yet the tone itself, which is associated with that vowel, is not deleted. Rather, it is carried by another vowel in the utterance.

The standard theory explication of (41) is obviously problematical in that it cannot formally distinguish the set of tone features on a vowel from the set of segmental features (roundness, tenseness, height, etc.) on that same vowel. Therefore, a Vowel-deletion Rule within the standard theory framework must logically result in the deletion of the tone, along with the other feature specifications that make up the vowel segment:

(42) Standard Theory's Vowel-deletion Rule



As a result of the application of standard theory's Vowel-deletion Rule, an incorrect output is derived:

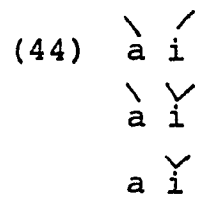
(43) 

Since the Vowel-deletion Rule of standard theory cannot formally save the tone of the vowel(within a single operation), and since the theory must empirical-

ly save it - the pivotal question is: how can we formally delete the vowel, yet save its tonal features?

In an effort to resolve this dilemma, Goldsmith (1976:30-33), in the guise of the deveil's advocate, presents the obvious solution of first positing a Tone-Copying Rule, which copies the tone specification(s) of the first vowel onto the neighboring vowel. Then he posits a Vowel-deletion Rule, which results in the following derivation:

(44)



underlying

Tone-Copying Rule

Vowel-deletion Rule

Such a solution is formally untenable within the standard theory since the Tone-Copying Rule will generate a concatenous string of features (+low tone +high tone) onto a single segment. Standard theory, of course, permits only simultaneous mappings onto the segment.

Notwithstanding this formal muddle (a quintessentially significant one, we might add) which stems from such a violation of mapping procedures, the above analysis requires that for every Vowel-deletion Rule that is posited, which results in a stranded tone, an additional Tone-Copying Rule must also be posited - thus missing the generalization that when a segment which is carrying tone is deleted, the tone is transferred to

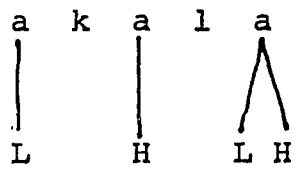
the nearest tone-carrying segment. The requirement that standard theory posit two separate rules does not capture the generalization of the single operation.[1]

2.2.2. Formal Resolutions within Autosegmental Theory.

Goldsmith's formal solution to impasses such as the above is to claim that "tonal features are (not) features of the vowel. Rather, the tonal features are factored out to another level. Feature specifications on the other level constitute segments, but their relation to the vowel with which they are associated is merely one of simultaneity in time (Goldsmith, 1976:22)."

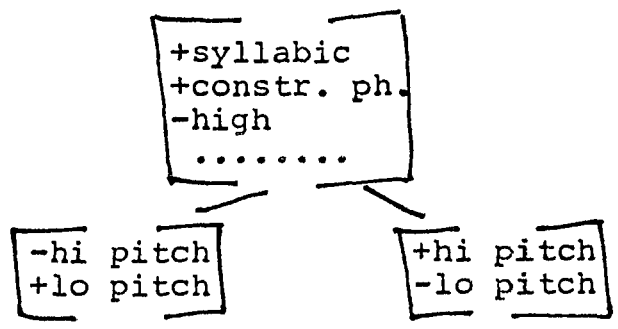
Goldsmith implements this solution by proposing autosegmental displays like the following for the Igbo word ákálá (1976:23)

(45)



where the lines connecting vowels to tone speicifications are called association lines, and where the final vowel, á, can be formally represented as follows:

(46)



Goldsmith takes the position not to abandon the standard feature-mapping procedures onto the segment, but rather to abandon the axiom that tone features are features of the vowel. For him, the latter are features of the autosegment, instead.

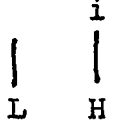
Therefore, under Folsmith's formalism, when a rule such as Vowel-deletion (see (41) above) deletes a vowel, it does not delete any of its tone specifications. This is because tone is not specified on the on the vowel segment, but instead is specified on the autosegment, which represents a formally distinct domain from that of the vowel segment.

The derivation for (41), the Vowel-deletion operation, will look like this under the autosegmental framework:

(47) (a)

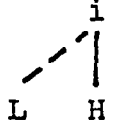
(underlying)

(b)



(by Vowel-deletion Rule)

(c)



(by Well-formedness Condition which requires that every tone be associated with some vowel (see (48) below))

(a) represents the underlying representation (after the application of the Major Association Rules (described in Section 2.2.3. below)). (b) represents the point in the derivation after the Vowel-deletion Rule has applied. Note that since tone is formally mapped onto a distinct autosegment, the tone specification "associated" with the deleted vowel is not also deleted. Finally, (c) represents the final output after the operation of the Well-formedness Condition (hereafter the WFC). The WFC requires that every tone be associated with a vowel; that every vowel be associated with a tone; and that association lines do not cross (see Section 2..23. for a formal account of the WFC). Note that the dotted line represents the association of the L tone onto the remaining i.

We can observe from (47) the following two impasses to a "linguistically significant" analysis within the autosegmental framework: First, the concatenous string of level tones across i is no longer a formal violation since this string now refers to a string of tone autosegments, not to a logically-impossible sequential string of features on the vowel. Second, the vowel-deletion operation of the Vowel-deletion Rule (with the WFC transferring the segmentless tone to the next vowel) rather than by applying a Tone-Copying Rule as well (see (44) above).

2.2.3. The Well-formedness Condition and the Major Association Rules.

These are essential apparatus in the Goldsmith theory. Their incorporation into the theory makes a formal statement about the way tonological phenomena are organized in natural languages. To a large extent, the formal status of autosegmental theory, as a whole, rests on the theoretical and empirical efficacy of these apparatus to explicate tonological phenomena in a descriptively adequate way. Therefore, a substantial part of the remainder of this thesis will concern itself with detailed analyses of their operations and with their theoretical and empirical efficay.

The WFC explicates the formal principles by which tones are "associated" with vowels:

(48) Well-formedness Condition

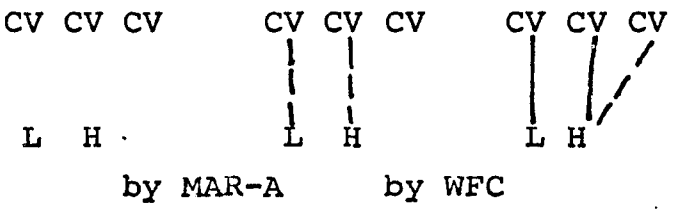
(1) All vowels are associated with at least one tone.
All tones are associated with at least one vowel.

(2) Association lines do not cross.

(Goldsmith, 1976a:141)

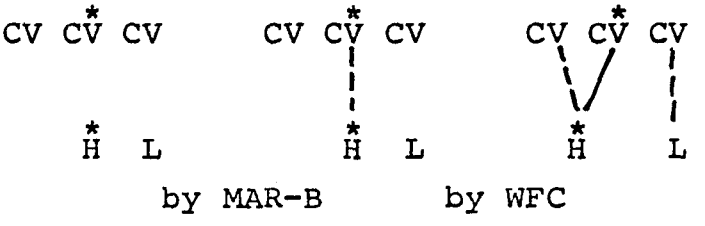
The Major Association Rules (henceforth MAR's) explicate how most tones are originally associated with a vowel. These rules use wither one of two procedures (Goldsmith, 1975:141):[2] (A) MAR-A: tones spread out one-to-one from a boundary (see (49-A)):

(49-A)



or (B) MAR-B; a specifically-marked (asterisked) tone is associated with a specifically-marked vowel (see (49-B)):

(49-B)



Examples of the actual workings of these apparatus in the theory will be shown throughout the remainder of this thesis.

2.2.4. The Theory in Operation.

We will now inspect how Goldsmith's theory handles actual data.

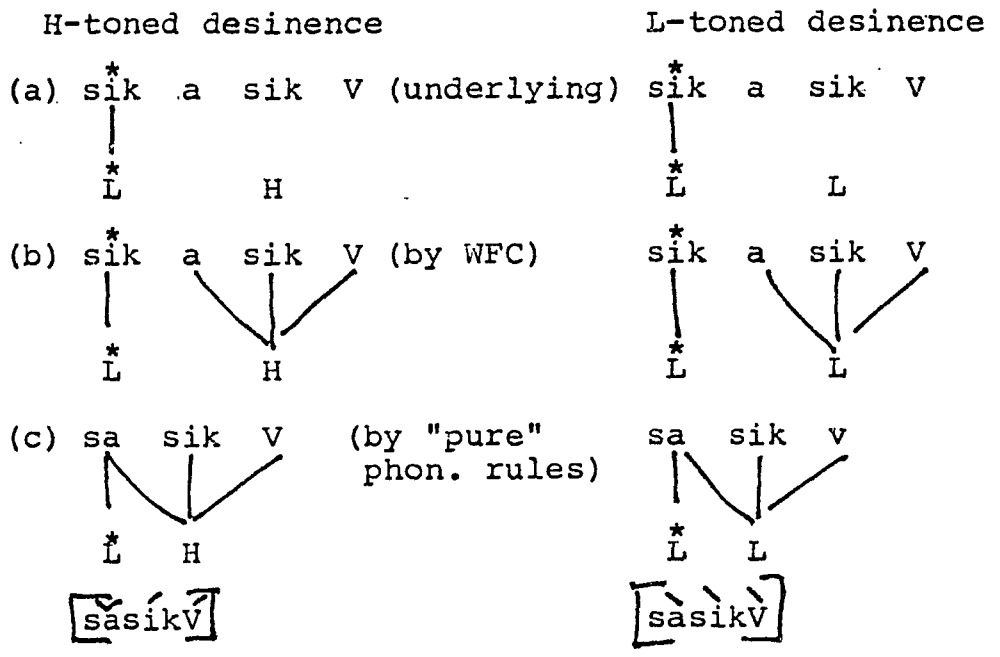
2.2.4.1. Lomongo

In the following example, he inspects data from Lomongo, taken from Lovins (1971a, 1971b). He aims to show that (1) contour tones must indeed be treated as a concatenation of tones on a single segment; and that (2) vowel deletion takes place, while the tone of the

deleted vowel is salvaged onto the surface representation.

In Lomongo, verbs are lexically marked for tone; they can be either H or L. The stem is reduplicated and an -a- infix is inserted between two copies of the stem. Then either a high-toned or a low-toned desinence follows. The following examples are taken from Goldsmith (1975b:44-45):

(50) L-tone stem sik 'stop'



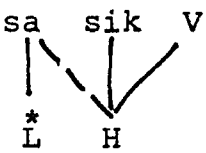
The last stage is reached by pure phonological rules: k → Ø and ia → a.

In (50), (a) represents the underlying representation after MAR-B has applied: "a specifically-marked tone is associated with a specifically-marked vowel (Goldsmith, 1975a:141)." (b) represents the point in

the derivation after the WFC has applied. And finally, (c) represents the final output after the application of the "pure" phonological rules - the most important one for our purpose being the Vowel-deletion Rule, ia ⟶ a.

Lovins describes the phenomenon which takes place in Lomongo, as follows: "If two vowels are juxtaposed, within a word or across a word boundary, it is usual for the first vowel to be elided. Its tone remains and combines with that of the following vowel." The operation of this process within the Goldsmith framework looks like this:

(51)



where the dotted line represents the structural change.

Note that Goldsmith's analysis of two separate levels explicates the phonological operations in what appears to be an elegant way. It succeeds in automatically separating the segmental from the tonological levels so that the vowel-deletion operation may delete the vowel while salvaging the underlying associated tones.

This is exactly what we wanted to accomplish, and Goldsmith has succeeded in achieving "conspiratorial results" without having to posit global-type rules. He

has also avoided the formal muddle associated with standard theory which prohibits concatenous mappings of features across a single segment.

2.2.4.2. *Igbo*

Further insight into autosegmental theory, as Goldsmith had formulated it in 1976, may be gained from inspecting the way in which he handles the following data from Ohuhu Igbo. We will consider the "1 Root" verb forms where the verb stem is low toned and where this low tone causes a tonal change in the subject noun which precedes it. (This change does not occur if the subject is a pronoun.) Goldsmith (1976:24) provides the following examples with ci, 'carry:'

(52) (a) O ci akhwa

He carry eggs

(b) Eze ci akhwa

Chief carry eggs Eze =(HL)

(c) Ekwe ci akhwa

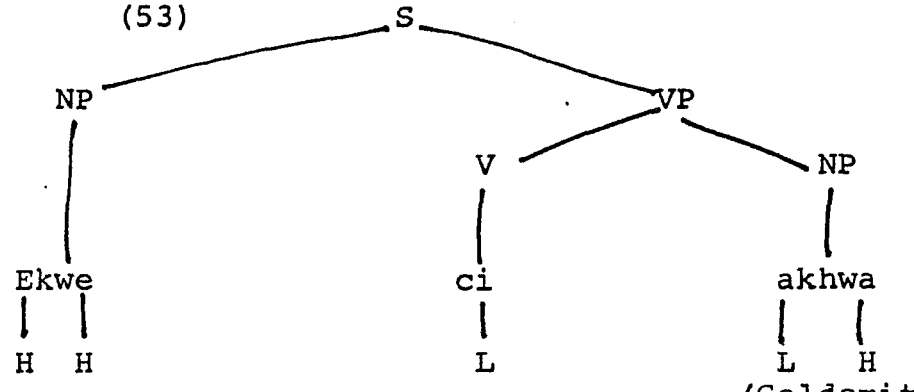
Ekwe carry eggs Ekwe =(HH)

In (a) the low tone of the verb stem is not transferred to the subject NP since the subject is a pronoun. In (b) the low tone of the verb does not assimilate to the noun since the noun ends in a low tone. In (c), however, the low tone of the verb assimilates to the

subject NP since it ends in a high tone and is not a pronoun.

Autosegmental notation explicates teh phenomenon as represented in (52c) in the following way:

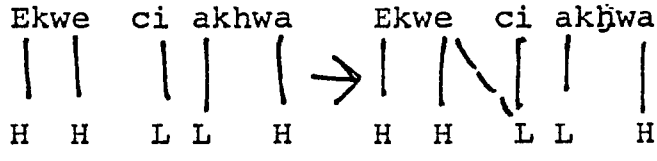
(53)



(Goldsmith, 1976: 25)

or in a less transparent, yet more familiar way:

(54)



(Goldsmith, 1975:25)

where the dotted lines in (53) and (54) represent structural changes that take place in the operation of the rule.

Observe that the final vowel in Ekwe is associated with a contour tone - represented as a series of level tones H and L - in the derived structure. This does not constitute a violation under the Goldsmith framework since tone is formally described not as a a feature of the vowel segment but as a series of

"autosegments" - that is, tones constitute segments which are formally independent from the canonical segments of standard theory.

2.3. Modifications of the Goldsmith Analysis

Leben's (1978) and Clements & Ford's (1979) versions of autosegmental theory represent revisions to some of Goldsmith's basic formalisms. The Leben analysis differs from Goldsmith's in that (1) Leben modifies Goldsmith's Major Association Rules, and also in that (2) Leben incorporates the Convention on Tone Melodies as a universal principle operating on tone languages.

The Clements & Ford analysis differs from the Goldsmith analysis in that (1) MAR's are further modified, (2) the WFC is modified, and (3) the syllable becomes the unit on which tone is formally defined.

Leben's and Clements & Ford's versions will be critically evaluated, below, in Sections 2.4. and 2.5.

2.4. Leben's Version of Autosegmental Theory.

In this section, Leben's version of autosegmental theory will be presented with regard to the formal and empirical status of MAR's and the Convention on Tone Melodies, both of which differ from the Goldsmith versions. I will argue that neither Goldsmith's nor Leben's version of the MAR's works consistently in accounting for regular tonological data in Mende. I will also argue that neither Goldsmith's nor Leben's version of the MAR's works consistently in accounting for regular

tonological data in Mende. I will also argue that the incorporation of Leben's Convention on Tone Melodies, as a universal principle, is not universally supported by the data. The efficacy of this Convention will be tested against data from Etsako, Kinyarwanda, Kikuyu and Mende.

2.4.1. On the formal status of Leben's Melodic Association Rules.

One of the major questions underlying autosegmental theory concerns the formal nature of MAR's and their empirical efficacy. According to Goldsmith (1976) and Leben (1978) versions of the theory, tones and tone-bearing units are underlyingly unassociated, and MAR's are language-particular rules which predict, in unexceptional cases, the mapping of tones to tone-bearing units. Those mappings which require lexical specifications, i.e. which require the association of tones to tone-bearing units at the lexical level, are formally regarded as exceptional, and thus add to the complexity of the representation. According to these versions of the theory, such lexical specifications constitute a violation of regular Melodic Procedures.

In the argument immediately below, I will inspect, in the light of data from Mende, the formal and empirical efficacy of Melodic Association Rules in the Leben and Goldsmith versions of the theory.

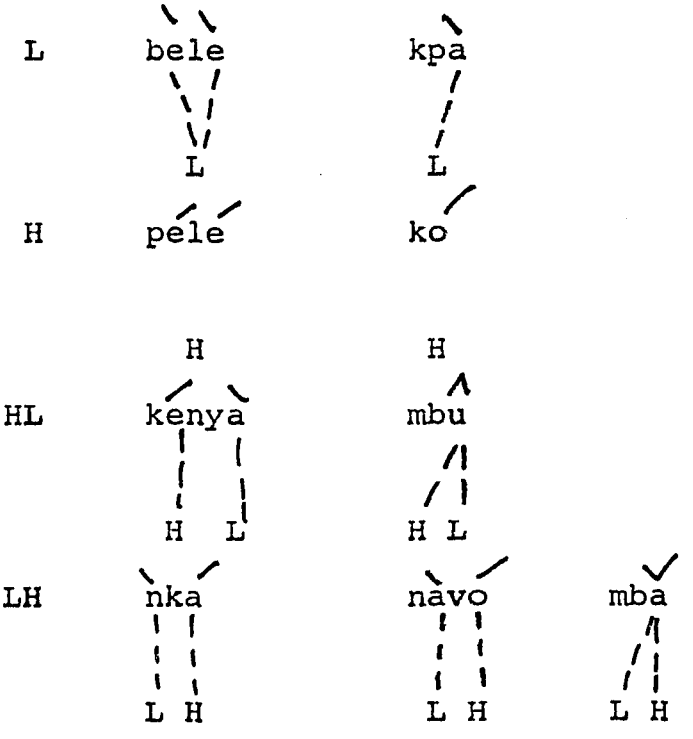
2.4.1.1. Mende

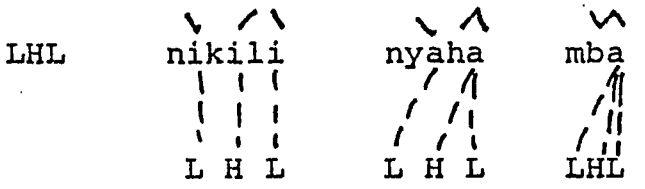
Goldsmith (1976) presents data on Mede, taken from Leben (1973), as support for the autosegmental treatment of melody levels on Mende words. Leben observed that morphemes in Mende are one to three syllables long, and that only five underlying tone patterns (or melodies) are observed on them.

Leben's (1976) initial Tone-Mapping Principles essentially followed Goldsmith's MAR (49-A) (see Section 2..2.3.). Both Goldsmith and Leben state that tones map out one-to-one left-to-right from a boundary, adhering to the conditions of Goldsmith's WFC.

The Mende data given below illustrate all of Mende's possible tone patterns and show how Mende words are analyzed in terms of Goldsmith's and Leben's tone-mapping rules:

(55)



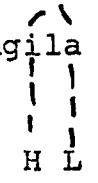


Observe in (55) that the autosegmentally-based mapping principles of Goldsmith and Leben are empirically supported by the data thus far presented.

In 1978, Leben incorporated a modification to his Tone-Mapping Principles. This was done in order to "accomodate (certain) contrasts" in the data. For example, in Mende, there is a contrast in the way the HL pattern is displayed on ngíla and ngɔ́nyɔ̂.

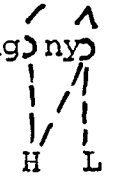
The mapping procedures, explicated in (55), can only accomodate ngíla:

(56)



It cannot logically accomodate ngɔ́nyɔ̂:

(57)



Leben's modification is invoked so that "the H tone can be lexically associated with some syllable in exceptional (emphasis mine - PC) words that appear

to violate (regular tone-mapping procedures)(1978:191)." His modification, we will show, correctly derived ngɔ́nyɔ́ by specifying, lexically, that H is associated with the final vowel [ɔ] , of this word (see (58a) below; and then by applying the WFC (see (58b) below):

(58) a. ngɔnyɔ (underlying rep.)

H L

b. ngɔnyɔ (WFC application)

H L

It is important to note that his "modification" is not equivalent to Goldsmith's Major Association Rule (49-B) (see Section 2.2.3.). It is not equivalent since the MAR (49-B) applies to Accentual languages; and Mende is not regarded as an Accentual language (Goldsmith, 1976; Leben, 1978).

After scrutinizing additional Mende data, Leben (1978) abandoned his original Tone-Mapping Principles (including the "modification" described above) and proposed a Revised set of Mapping Principles:

(59) Leben's Revised Mapping Principles

(a) Associate a final H with the rightmost syllable.

(b) For any tones that are not associated with any syllables, associate

the first tone with the first syllable, and the second with the second, and so on.

(c) Any syllable that has no tone is associated with the tone of the preceding syllable, if there is one. Otherwise, tone assignment takes place according to the WFC. (1978:200)

Observe that the "exception" word, ngɔ́nyɔ̌, which required lexical association under the Original Mapping Principles, is now, under the Revised Mapping Principles not an exception:

(60) ngɔ́nyɔ̌ → (59a) → ngɔ́nyɔ̌ → (59c) → ngɔ́nyɔ̌

H L H L H L

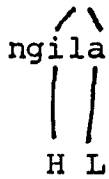
Observe also, however, that the heretofore "regular" ngila has now become "exceptional:"

(61) ngila → (59a) → ngila → (59c) → *ngila

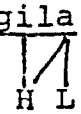
H L H L H L

In order to accomodate the empirically-correct output, ngíla - instead of the incorrect output, *ngíla, derived in (61) by the Revised Mapping Prin-

ciples - words such as ngíla must now be treated as exceptions in which H will be lexically associated with i and L with a:

(62) 

so as to prevent (59a) and subsequently (59c) from operating and thus incorrectly producing *ngila.



The number of "exceptions" to the "regular" Revised Mapping Principles proliferates as we inspect the Mende data. For instance, kénya and nìkíli, taken from the Mende data in (55) above, will by the Revised Mapping Principles become:

(63) HL 

and

LHL 

An "exception" procedure must therefore be invoked in order to handle "irregularities" which were not irregularities until the theory was "improved upon."

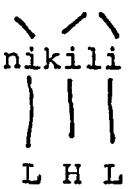
In order to predict the empirically-correct kenya, the H tone must be lexically (i.e."exceptionally") associated with e and the L tone with a:

(64)

so as to prevent (59a) and subsequently (59c) from operating and thus incorrectly predicting *kenya.

Likewise, in order to predict the empirically-correct nikili, the H tone must be lexically ("exceptionally") associated with the second i and the final L tone with the final i:

(65)



2.4.1.2. Conclusions

To summarize: Leben, finding Goldsmith's MAR (49-A) empirically inadequate to handle initial tone associations in Mende without having to invoke ad hoc "exception" procedures to salvage the formalism, developed a Revised set of Mapping Principles. I have shown that Leben's Revised set is also inadequate in handling associations without having to invoke ad hoc "exception"

procedures.

Leben (1978:179) states that although his Tone-Mapping Principles "are not totally universal, at least they can be shown to apply consistently in the language under examination."

I have argued against this statement, showing that the tone-mapping formalism tht he has developed does not work consistently for regular tonological data in the language that he examined rather thoroughly, i.e. Mende. I have suggested that perhaps a "consistent" formal statement that will correctly predict tone-vowel/syllable associations is non-existent. In other words, perhaps lexical associations with vowels (or with syllables) may not be so much an exception procedure, as Goldsmith and Leben claim, but rather may be a logical reflection of the way tone languages actually operate.

Put in another way, Leben's "exceptions" to the tone-mapping formalism might actually represent exceptions to the autosegmental formalism rather than represent exceptions to the real data. We have observed, for example in Leben's analysis, that data considered to be "exceptions" have been altered to "regular" status as the formalism was altered.

2.4.2. On the Universality of Leben's Convention on Tone Melodies.

In the subsections that follow (2.4.2.1. - 2.4.2.5.),

I will argue against the universal status of Leben's Convention on Tone Melodies. I will show that its incorporation as a universal principle is not universally supported by the data, and that therefore its strong claims must be weakened. The data inspected will come from Etsako, Kinyarwnada, Anyi, Kikuyu and Mende.

(Aa a consequence of arguing against Leben's Convention, I will also be arguing that the WFC, in its strong version, does not always operate universally. This last point of argumentation has far-reaching consequences on the formal status of autosegmental theory. In Chapter Three, I will propose formal procedures for weakening the WFC so that its operations will be empirically supported by the data and logically supported by the theory.)

Leben's (1973) Convention on Tone Melodies can be formalized as follows:

(65) Convention on Tone Melodies

$$[\alpha H]\ [\alpha H] \longrightarrow [\alpha H] \qquad \emptyset$$

He is essentially saying that any two adjacent tonemes must be distinct so that, for example, LHH is not a possible pattern; it must be simplified, at any point in its derivation, to LH.

Goldsmith (1976:57) suffests that the inclusion of Convention (65) as a universal principle be abandoned,

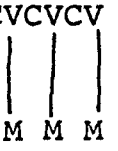
stating that a representation such as (66):

(66)

(where M = mid tone)

is underlyingly and empirically distinct from (67):

(67)



We should note that Goldsmith's argumentation supporting Convention (65)'s exclusion is not as rigorous as much of the other argumentation in his dissertation.

2.4.2.1. Etsako

In support of his Convetnion on Tone Melodies, Leben (1978:181) presents the following data based on Elimelech's (1976) analysis of Etsak/ uno odzi

(68) a. úno A ódzi $\xrightarrow{\text{(LTR)}}$ úno ódzi $\xrightarrow{\text{(CR)}}$ únodzí
'mouth' 'crab' 'a crab's mouth'

b. àmè A èθà $\xrightarrow{\text{(LTR}}$ áme èθà $\xrightarrow{\text{(CR)}}$ amêθà
'water' 'father' 'father's water'

Elimelech argued that a Low-Tone Raising Rule (LTR)

(see (69) below) changes the final L of a noun to H when it precedes the associative marker, A (which occurs between words in possessive constructions and in a few other constructions); and that a Contraction Rule (CR) also applies, its formulation made obvious by inspecting its operation in (68) above.

The Low-Tone Raising Rule can be specified as follows:

(69) Low-Tone Raising Rule

$$L \longrightarrow H \;/\; \_\_\_\; A$$

Leben forcefully argues that his Convention (65) must have applied to the underlying representation of (68b) (specifically on the forst noun) in order to have derived the correct output. (Note that for (68a), Convention (65) does not apply to the first noun since the adjacent tonemes are distinct and thus do not meet the structural description of Convention (65).)

Leben's autosegmental analysis of (68) is as follows:

(70)

a. /uno A odzi/ —(LTR)→ uno A odzi —(VC)→ [únodzi]

H L H H H H

b. /ame A eθa/ (LTR)→ ame A eθa (VC)→ [ámêθà]
L L H L
(Leben,1978:182)

Leben's arguments for the inclusion of Convention (65) rests on the empirical consequences of derivations such as (70b). He argues that his Convention on Tone Melodies must have applied at the underlying level of (70) in order to have derived the correct output, [ámêθà] (after the application, of course, of the Low-Tone Raising Rule and the Vowel Contraction Rule). He reasons that if Convention (65) had not applied at the underlying level, then the incorrect output, [*àmêθà], would have been derived:

(71)

b. /ame A eθa/ (LTR)→ ame A eθa (VC)→ *[àmêθà]
L L L L L H L L

Observe that the distinct outputs of (70b) and (71b) derived from their having (on pre-A nouns) the distinct underlying representations of ame (L) and ame (L L), respectively. Since Convention (65) has applied to (70b) and has not applied to (71b), and since (70b) results in a correct output, and (71b) results in an incorrect output, Leben argues, the choice between ame (L) and ame (L L) has

empirical consequences, where adherence to Convention (65) will generate the correct output and non-adherence will generate the incorrect, or more "complicatedly," derived output.

Based on this kind of argumentation, as well as the obvious one that by invoking Convention (65), we reduce the inventory of tonal patterns that must be displayed for any any given language, Leben makes the following statement (1978:186):

> "Unless we find examples that are parallel to (the Etsako example), except that they differentiate between L and LL, this stands as striking confirmation of...(Convention ((65))."

It turns out that there exists a plethora of examples from a number of languages which parallel the Etsako data, "except that they differentiate between L and LL." I will show that for these languages there are highly productive phono/tonological operations which, when Convention (65) is applied to them, result in incorrect outputs.

2.4.2.2. Kinyarwanda

An example of data which supports the exclusion of The Convention on Tone Melodies (Convention (65) as a universal principle come from Kinyarwanda (Kimenyi, 1976), a Bantu language, in which Kimenyi observes that for Kinyarwanda, as well as for a number of other Bantu languages, "H's at the systematic phonemic level belong to the next syllable on the left (page 72):"

(72) Tone-Anticipation Rule

L - H ⟶ H - L

Kimenyi's scholarly observations concerning the Tone-Anticipation process is not put into any particular theoretical framework. He, in fact, closed his study with the hope that "much more work (will) be done to determine the correct formulation (of) the tone anticipation process (page 179).: For the purpose of testing the empirical efficacy of Convention (65), we shall therefore organize the data into an autosegmental framework.

Observe the following six disyllabic noun stems in Kinyarwanda, where those noun stems in column (a) carry only low tone on both syllables, and where those in column (b) carry high tone on the first syllable and low tone on the second syllable.

(73)

(a)		(b)	
L - L		H - L	
ìfù	'house'	ífí	'fish'
ìndà	'stomach'	índà	'louse'
ìnzà	'house'	ívù	'ash'

We will now observe what happens to these noun stems when they are prefixed - in our example, with the diminutive markers, ga-/ka-, and the pejorative marker,

ru-. These prefixes are regarded as underlyingly L-toned. They are also preceded by their respective pre-prefixed: in the case of ga-/ka-, the pre-prefix a-; and in the case of ru-, the pre-prefix u-:

(74)

	(a)	(b)
(i.)	ìfù	ífì
	àgàfù	àgáfì
	ùrùfù	ùrúfì
(ii.)	ìndà	índà
	àkàdà	àkádà
	ùrùdà	ùrúdà
(iii.)	ìnzù	ívù
	àkàzù	àkávù
	ùrùzù	ùrúvù

We can immediately observe that the prefixes associated with L - L noun stems maintain their low-tone status, whereas the prefixes associated with H - L noun stems acquire a H tone.

We have now set the stage for a non-trivial testing of Leben's Convention on Tone Melodies. We will go through a derivation of àgáfì (see (74 i.b.), utilizing the autosegmental framework, where we find that, empirically, it is essential to make a distinction be-

tween the two possible underlying representations below:

(75) a - ga - ifi
L H L

(76) a - ga - ifi
L L H L

The choice between (75) and (76) represents a choice between the inclusion and the exclusion of Convention (65) respectively.

First, let us observe the empirical consequences of applying Rule (72) to the underlying representation (75):

(77) a - ga - ifi —(TA)→ a - ga - ifi
L H L H L L

—(i-deletion)→ * agafi
H L

Now let us observe the consequences of applying Rule (72) to underlying representation (76):

(78) a - ga - ifi (TA) → a - ga- ifi

L L H L L H L L

(i-deletion)

agafi

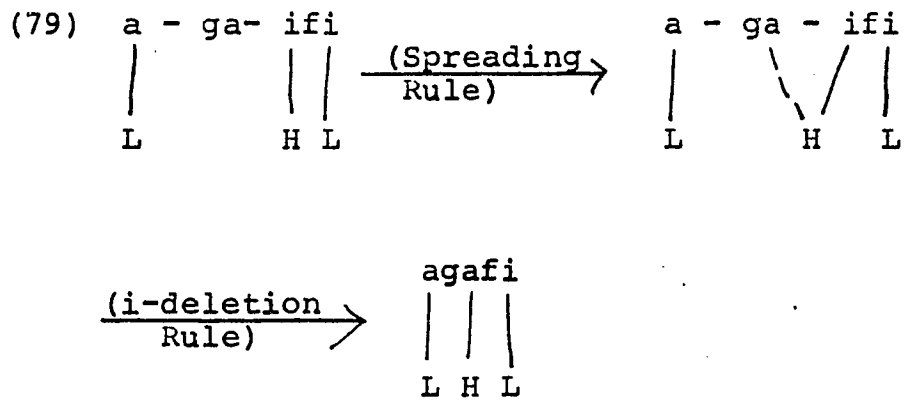
L H L

Notice in (78) that the output, àgáfi, is empirically correct.

Similar derivations can be performed on the other five examples in (74b). The outcome of each of the derivations will support the hypothesis that the distinction between LL and L, at the underlying level, is essential in order to generate the empirically-correct output, and that, all other things equal, the incorporation of the Convention on Tone Melodies will always result in incorrect outputs.

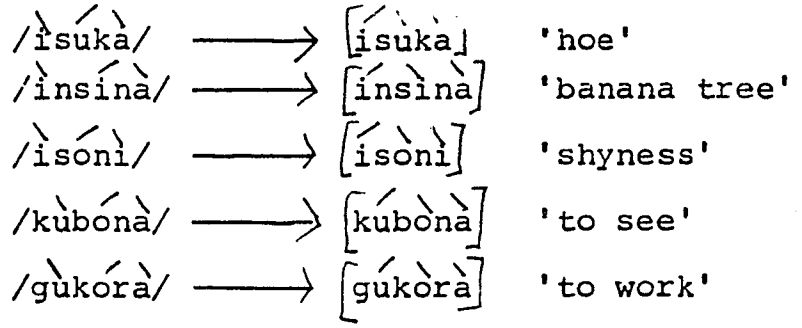
Given the data in (73) and (74), one might, as the devil's advocate, argue for an alternative analysis, in which the prefixes, ga-/ka- and ru-, are underlyingly toneless, and where the H tone is spread leftward onto the toneless pre-prefix, a-. A second rule - an i-deletion Rule - would then delete the i-segment which originally carried the H tone, resulting in the derivation given in (79) below:

(79)



We can show, however, on the basis of additional data from Kinyarwanda (Kimenyi, 1976:174) that such an alternative analysis is not plausible. Consider the nouns in (80) where the underlying forms are given on the left and the phonetic outputs are on the right, after the Tone-Anticipation Rule (Rule (72)) has applied:

(80)



Underlyingly, the first syllable in each of the words in (80) does carry a L tone, and the operation applied to each of these underlying forms is identical to the operation applied to the nouns in (74b) - namely Rule (72) (Tone Anticipation).

Therefore, if we were to assume the alternative analysis given in (79), such an analysis must also erroneously assume toneless underlying first syllables for (80). Since these syllables in (80) are not underlyingly toneless, we can conclude that analysis (79) is faulty.

We are left then with clear examples in Kinyarwanda of where the incorporation of the Convention on Tone Melodies into the theory results in incorrect outputs, which can be "corrected" only by the proliferation of additional rules to "undo" outputs predicted by the Convention.

2.4.2.3. Anyi

An additional example of data which supports the exclusion of the Convention on Tone Melodies (Convention (65)) as a universal principle comes from Leben's (1980) analysis of tone in the verbal system of Anyi, a Niger-Congo language spoken in Ghana. Leben proposed the derivation given in (81) below for ɔ_+kɔ, 'it was going.' This derivation is a representation of regular monosyllabic verb stems in the habitual aspect (Asp). The details of the system are not as important, for our purposes, as the kind of operation permitted in the derivation.

I will show that in the case of generating the correct output for regular monosyllabic verb stems in the habitual aspect, it is essential, on logical as well

as empirical grounds, to violate Convention (65). Leben's sample derivation is as follows:

(81) a. ɔ + kɔ — UNDERLYING

[L] Asp

b. ɔ + kɔ — TONE MAPPING

[L] Asp

c. ɔ + kɔ — FINAL LOW RAISING

L H

= ɔ́kɔ́

The Final Low Raising Rule raises a low tone on a verb when it is preceded by another low tone which is on a pronoun:

(82) Final Low Raising

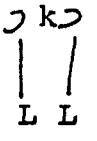
L ⟶ H / L + _____ Verb

It is crucial to this argument that we focus on point (b) in the Anyi derivation above. (81b) represents adherence to Convention (65). I will show that for these data, such an adherence will logically result in an incorrect output. Leben does not adhere to this convention, and thus erroneously predicts the correct output. His prediction is erroneous because the formal representation at point (81b) will not logically permit

the application of Final Low Raising (FLR), and thus will not permit the correct output: ɔkɔ́.

Let us consider the two possible interpretations for (81b) where one interpretation represents the consequences of not adhering to the Convention on Tone Melodies (see(83) below), and the other represents adherence to the Convention (see (84) below):

(83) Non-adherence to Convention (65)



(84) Adherence to Convention (65)

By making a formal distinction between (83) and (84) we are saying something about the empirical consequences that such a distinction makes in natural language. Analysis (83) logically distinguishes two L segments, whereas Analysis (84) does not.

Observe that the structural description of the Final Low Raising Rule is satisfied by Analysis (83), whereas it is not satisfied by Analysis (84). Observe also that Analysis (83) represents adherence to the Convention on Tone Melodies, whereas Analysis (84) does

not.

Based on such observations, we must therefore conclude that this Anyi data (which is completely regular) does not empirically nor logically support adherence to the Convention on Tone Melodies.

2.4.2.4. Kikuyu

Still another argument which supports the exclusion of Leben's Convention on Tone Melodies as a universal principle operating in tone languages comes from the inspection of Kikuyu data. The Kikuyu data and the tonological derivations based on these data is taken from Clements & Ford (1979).

A somewhat detailed description of the Clements and Ford analysis of Kikuyu follows immediately below in order to set the stage for a critical evaluation of Leben's Convention on Tone Melodies. It is to be kept in mind that the primary aim of this subsection is not to critically evaluate the Clements & Ford version of autosegmental theory (such an evaluation is the subject of Section 2.5 below), but rather to argue that Leben's Convention on Tone Melodies does not operate universally. However, since Clements & Ford tacitly support the Convention on Tone Melodies in their analysis of Kikuyu, the argument that I will develop in this subsection constitutes not only a criticism of the Leben version of the theory, but also a criticism of the Clements & Ford version.

Clements & Ford's derivation for the Kikuyu noun òní:ní, 'smallness,' is as follows (page 197):

(85)

a) o ni i ni (Initial Tone Association Rule 2)
L H L H

b) o ni i ni (Well-formedness Condition 1)
L H L H

c) o ni i ni (Well-formedness Condition 3)
L H L H

d) o ni i ni (High Tone Assimilation Rule)
L H L H

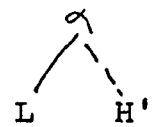
e) o ni: ni (Fusion Rule)
L H L H

f) o ni: ni (Rising Tone Simplification Rule)
L H L H

(a) represents the underlying representation after the Initial Tone Association Rule 2 has applied. This rule, taken essentially from Haraguchi (1977:323-324) is a language-particular rule which states that the

first tone is associated with the first tone-bearing unit. (c) represents the point in the derivation after the Clements & Ford versions of the Well-formedness Condition have applied. Note that for Clements & Ford's Well-formedness Condition, the final H tone is not associated to the final vowel. (A detailed analysis of Clements & Ford's version of the Well-formedness Condition is given in Section 2.5 below.) (d) represents the derived structure after the High Tone Association Rule has applied:

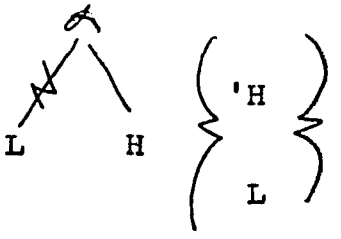
(86) High Tone Association Rule



α = tone-carrying unit

(where the superscript, ', signifies that H is a free tone, i.e. it is not already associated.) (e) represents the output after the Fusion Rule has applied. This rule derives the single syllable (ni:) from the underlying sequences of syllables (ni i). And lastly, (f) represents the final output after the application of the Rising Tone Simplification (RTS) Rule which has operated to delete the association line between the initial low tone and -ni:-.

(87) Rising Tone Simplification Rule



(where 'H represents a Downstepped Tone, and where the symbol, "z," indicates the deletion of an association line.)

We observe in this derivation that the Convention on Tone Melodies (65) has been tacitly accepted. I will, however, show, below, that the logical consequences of such an acceptance have not been formally addressed; and that if they were addressed, Clements and Ford would be forced to abandon adherence to the Convention.

For example, at point (c) in Derivation (85) above, after Clements and Ford's version of Initial Tone Association and the WFC have applied, the form oni is

derived. I will show below that a formal distinction between (88a) (adherence to Convention (65)) and (88b) (non-adherence to Convention(65)) has crucial empirical and logical consequences for the theory.

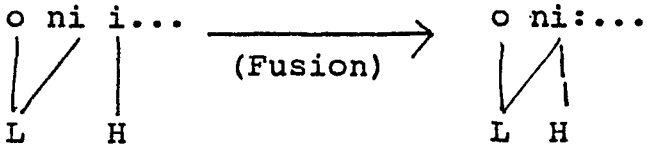
(88) a. 

b. 

(= point (c) in Derivation (85))

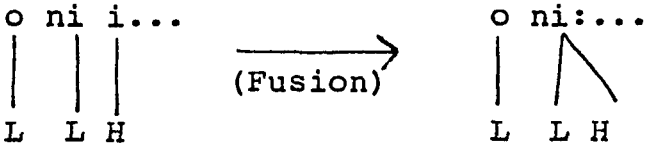
Let us first inspect the consequences of applying the Fusion Rule to form (88a) in which Convention (65) is assumed to be operating:

(89)



Now let us inspect the consequences of applying the Fusion Rule to form (88b) in which Convention (65) is assumed not to be operating:

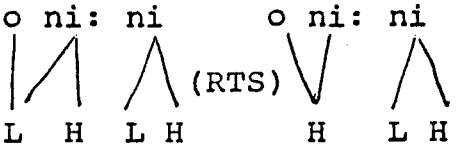
(90)



We shall now take the derived outputs of (89) and (90) and apply the Rising Tone Simplification (RTS) Rule to each of them.

(91) represents the application of the RTS Rule to the derived output of (89) - where Convention (65) is assumed to have operated.

(91)

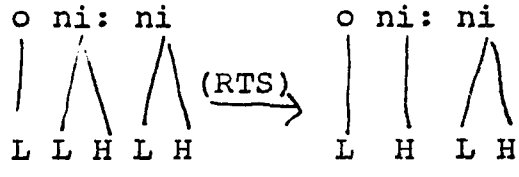


Observe that the formalism, as represented in the

structural description of the input in (91), requires the deletion of L on both the second and first syllables. Since the tone segment, L, is associated with both syllables, o and ni:, then a rule which deletes the L segment will also logically result in the deletion of its association with both of the syllables. This, of course, is an output we want to avoid, since it now becomes essential to propose a ludicrous ad hoc Low-Tone Insertion Rule, in order to replace the low tone that was incorrectly deleted by the formalism.[3]

Consider now (92) below, where we apply the RTS Rule to the derived output of (90) - in which the Convention on Tone Melodies has not been adhered to:

(92)



In this instance, the formalism dictates that the L tone be deleted only on the second syllable, since the L tone on the first syllable is formally distinct from the second syllable. The explication of this formal distinction is a direct result of non-adherence to the Convention on Tone Melodies. This results in the correct output oni:ni.

It is interesting to note that the Clements and Ford analysis of the data has skirted this formal issue

entirely. We have thus shown that the power of their argumentation is reduced, due to the lack of rigour with which the formalism had been addressed, and that their derivation will not logically predict the correct output.

We have therefore presented another argument in which the empirical and logical consequences of adherence to the Convention on Tone Melodies has been crucially tested. It has been shown that adherence to it often results in incorrect outputs to regular phonological processes, where a proliferation of ad hoc rules is then required to undo the errors generated by adherence to the Convention.

2.4.2.5 Mende Revisited

Additional examples supporting the non-universality of Convention (1) abound. Let us return, for another example, to the Mende data presented in Section 2.4.1.1. In that section we argued against the formal status of the Goldsmith and Leben Melodic Association Rules.

We observed that Goldsmith's Major Association Rules formally treated the underlying tonal inventory for both kénya and ngɔ́nyɔ̂ as HL. We also showed that Goldsmith's and Leben's original Principles required that kénya be formally treated as unmarked (Regular), and ngɔ́nyɔ̂ as marked (Irregular).

We then showed that Leben's Revised Tone-Mapping Principles subsequently treated kénya as marked and ngɔ́nyɔ̂ as unmarked - a complete reversal in the marked-

ness status of these two words.

We concluded that a formalism which alters the markedness-status of a linguistic phenomenon, based on the choice of the formalism employed (in this case, a choice among the various versions of the Melodic Association Rules), rather than on the linguistic distribution of the data is highly suspect.

I will argue, in this Section, that a tonological analysis in which a distinction between HL and HHL is formally permissible, will result in less "complex" analyses of the data. In other words, I will argue against the universality of the Convention on Tone Melodies, which requires that HHL be simplified to HL.

Observe how a formal underlying distinction between HL and HHL will result in a linguistically-significant simplification of the data.

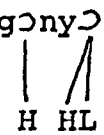
If the tonal specification of kénya were to be formally treated as underlyingly HL, then the following empirically-correct output would be derived (given a simple left-to-right mapping procedure):

(93)

If the tonal inventory of ngɔ̀nyɔ́ were to be formally treated as underlyingly HHL, then the following empiri-

cally-correct output would be derived (given, again, a simple left-to-right mapping procedure.):

(94)



Observe that (93) and (94) represent an analysis in which Convention (65) is not universally adhered to, and that as a result, both kénya and ngɔ́nyɔ̌ can be formally specified as unmarked. In other words, both can follow equally "regular" mapping procedures, and neither requires additional formal machinery (as kénya and ngɔ́nyɔ̌, and other equivalent forms, do in the Goldsmith and Leben analyses (in Sec. 2.4.1.1.) to derive empirically-correct outputs.

In summary, we have argued that under any of the Goldsmith and Leben tone-mapping analyses, it is formally necessary, for Mende, that one of the two regular forms be specified as irregular, and that under the analyses represented in (93) and (94), however, both of these forms require no such irregular specifications; also the two forms which require separate tone-mapping procedures in both the Goldsmith and Leben analyses, do not require separate tone-mapping procedures in the analyses represented in (93) and (94).

The overall simplification of analyses (93) and (94) over previous analyses is therefore clear. The essential

point to stress is that this overall simplification is a direct result of non-adherence to the Convention on Tone Melodies as a universal principle.

2.4.2.6 Conclusions

Based on the argumentation developed in Sections 2.4.2.2. through 2.4.2.5., we must conclude that the Convention on Tone Melodies as a universal principle governing tonological organization makes an obviously over-strong statement. The empirically-inadequate results stemming from adherence to this Convention strongly suggest that a formal means of preventing its universal occurence be implemented. I propose, among other things, such a formal implementation in Chapter Three.

2.5 Clements & Ford's (1979) Version of Autosegmental Theory

Clements & Ford's version of the autosegmental theory of tone constitutes the following revisions to the Goldsmith version:

(1) a modification in the Melodic Association Procedures;

(2) the formal acceptance of the Convention on Tone Melodies as an operating principle in tone languages;

(3) a replacement of Goldsmith's formalization of the vowel as the unit onto which tone is associated with Clements & Ford's formalization of

the syllable as the unit onto which tone is associated; and

(4) the replacement of Goldsmith's Well-formedness Condition with Clements & Ford's Conventions 1, 2 & 3 of the Well-formedness Condition.

With regard to the Melodic Association Procedures, Goldsmith, Leben and Clements & Ford posit various versions of these tone assignment rules. They are called Major Association Rules by Goldsmith (See Section 2.2.3.), Revised Mapping Principles by Leben (See Section 2.4.1.1.) and Initial Tone Association Rules by Clements & Ford (See Section 2.4.2.4.). These three investigators each posit language-particular rules which, along with the operation of the Well-formedness Condition, are meant to account for original tone assignments. Since equivalent claims are made by each of them about the formal role of Melodic Association Procedures, within autosegmental theory, the three versions of these Procedures must therefore be regarded as logically equivalent. Thus, the arguments developed against Melodic Association Procedures throughout section 2.4., for Leben and Goldsmith, apply also to Clements & Ford.

With regard to the formal status of the Convention on Tone Melodies as a universal principle, Clements & Ford (as shown in Section 2.4.2.4.) tacitly concur with Leben. Therefore, as was the case with the Melodic Association Procedures, the arguments developed against

Leben in which it was shown that universal adherence to the Convention on Tone Melodies is not universally supported by the data - also apply to Clements & Ford.

With regard to revision (3), Clements & Ford (1979) maintain that tones are not directly associated with vowels as is the formal claim made by Goldsmith (1976). Rather, Clements & Ford maintain that tones are associated with the syllable-final or "rhyme." Such a proposal was developed in detail by Kahn (1976) for English and was later elaborated by Elements & Ford (1979) for Kikuyu. I have argued in this thesis (See Section 1.6. in particular) in favor of the syllable as a formal operating unit for tonological analyses.

In Chapter Four, I will present additional arguments from Tiv and Kinyarwanda which support the formal treatment of the syllable as an independent phonological unit. In that chapter, I will also present a tentative formalization of a syllable-structure model for autosegmental theory.

Revision (4) will be scrutinized in Section 2.5.1. immediately below.

2.5.1. Clements & Ford's Conventions 1, 2 & 3 of the Well-formedness Condition

These language-independent Conventions are proposed in place of Goldsmith's Well-formedness Condition. They are designed to eliminate the indeterminacy of tone-vowel/syllable associations that sometimes occur when the

Well-formedness Condition is used alone.

C & F's Conventions represent a slightly modified version of Haraguchi's Conventions (1977, chapter 15).

Convention 1 applies to representations containing an associated tone and tone-bearing unit (i.e. a bound tone) with free tones and tone-bearing units to the right. In other words, Convention 1 applies to the right of bound tones only. An example is given below:

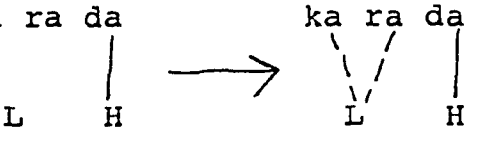
(95)

(Clements & Ford, 1979:183)

If the number or syllables are unequal, then the excess of tones or syllables remain unassociated and and are subject to later conventions.

Convention 2 applies to free (unassociated) tones and syllables that remain unassociated after Convention 1 has applied:

(96)



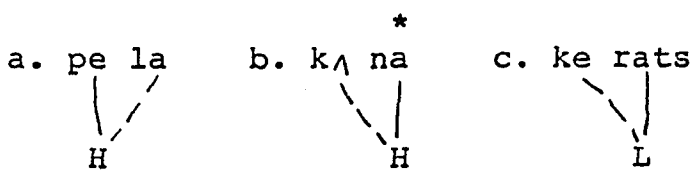
Condition: T' has no free tone as a left or right member. (C&F, 1979: 184)

T' represents a free (or unassociated) tone. For (2) above L represents T'.

Convention 3 applies to the syllables still unassociated after the application of Conventions 1 & 2. This Convention requires that accented ("*") vs. unaccented ("-*") be formally distinguishable. C & F state Convention 3 as follows: "...free tone-bearing units are assigned their tone from unaccented tone-bearing units if possible, and from the tone-bearing unit on the left if possible, with the first condition overriding the second in case of conflict (C & F, 1979: 185)."

The effect of this Convention is given in the following examples:

(97)



(C & F, 1979:186)

These Conventions guarantee that all syllables are associated with at least one tone. However, it does not guarantee that all tones will be associated with at least one syllable. Only those tones that meet the requirements of Conventions 1, 2 & 3 will be associated with at least one syllable.

This means that those tones not meeting the requirements of the Conventions are "floating" (or free)

tones. Two examples in which none of the Conventions applies to free tones, which thus become "floating" tones, are given below:

(98) a. ba b. a ma

L H H L H

(C & F, 1979:186)

We have seen this effect in operation in C & F's analysis of Kikuyu (See Section 2.4.2.4.) We observed in derivation (85) that the initial tone mappings onto the Kikuyu word oni:ni are the result of the operations of Initial Tone Association Rule 2 and of Conventions 1 and 3 of the WFC. The final H tone remains unassociated or "floating" since none of the three Conventions of the WFC will permit the tone to associate onto the final syllable (-ni).

The final H tone ultimately becomes associated with the final syllable, deriving the contour-toned syllable, -ni, as a result of the application of the tonological rule, High-Tone Assimilation (HTA).

Under the C & F version of the WFC, as we have shown, a contour-toned mapping onto a single syllable requires the positing of independent phonological rules instead of being the output of the predictable operations of the WFC. Under the C & F version, therefore, contour-toned specifications add to the formal

complexity of the theory since such specifications are more costly to formulate.

2.6 Conclusion

Based on our critical analyses of the Goldsmith, Leben and Clements & Ford versions of autosegmental theory, we concluded that it is formally and empirically essential, within the autosegmental framework, to weaken the language-particular claims of the Melodic Association Procedures; and to weaken the language-universal claims of the Convention on Tone Melodies.

Regarding the Melodic Association Procedures, neither the Goldsmith, nor Leben, nor Clements & Ford versions of these Procedures works consistently in accounting for regular tonological data in the languages inspected; each of these versions required a proliferation of formal "exception" procedures (lexical tone-mappings) to account for tone mappings on regular tonological data. We have suggested, based on the inspection of the data, that these lexical association procedures may not be so much "exception" procedures (as Goldsmith, Leben and Clements & Ford claim), but may rather be a logical consequence of the way tonological phenomena are actually organized in natural languages.

Regarding the Convention on Tone Melodies, which was developed by Leben and tacitly accepted by Clements & Ford, we argued that the incorporation of the Convention on Tone Melodies as a universal principle is not

universally supported by the data. We tested the efficacy of the Convention against data from Kinyarwanda, Anyi, Kikuyu and Mende, and we found that, for these languages, formal adherence to this Convention requires that empirically-incorrect outputs be derived.

In light of these conclusions, I will formally propose, in Chapter Three, a number of nontrivial modifications to autosegmental theory, modifications which I will argue result in a more descriptively-adequate analysis of tonological phenomena.

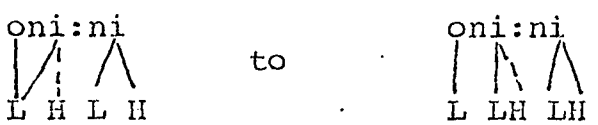
FOOTNOTES TO CHAPTER TWO

1. Goldsmith (1976b) suggests that a second possible approach to the tone stability "problem" might be to posit a general "derivational constraint" in the form of a "global" tone-copy rule, after vowel-deletion has occurred. In this way, the tone-copy rule looks back in the derivation to the stage just before vowel-deletion has occurred, and retrieves the tone associated with the deleted vowel, and then transfers it to the nearest neighboring vowel. His position on this type of rule is that it is unnecessarly complicated. He views these types of rules as "suspect" within received generative theory: "theory countenancing global rules approaches vacuity."

   Spa (1973) in order to handle this kind of problem, has proposed a General Derivation Constraint, applying to all tone rules, which states that when a segment, carrying tone, is deleted, the tone is transferred to the nearest syllabic segment. Goldsmith considers such a constraint also global and therefore "suspect."

2. Goldsmith (1976a:136) makes a distinction between Accentual and Non-accentual languages and in the way the Major Association Rules apply. MAR (49-A) applices to Non-accentual languages and MAR (49-B) applies to Accentual languges.

3. RMR Hall suggests that there might be some other kind of Convention which could have applied after the application of the Fusion Rule (see (e) in Derivation (65)) to convert:



   According to RMR Hall, this Convention would have the effect of saving the Convention on Tone Melodies though probably at some ad hoc expense. He thinks that this Convention would be "ugly, but not as ugly as Low-Tone Insertion."

CHAPTER THREE: SOME REVISED FORMALIZATIONS IN THE AUTOSEGMENTAL THEORY OF TONE.

3.1. Introduction

We have now set the stage for proposing a number of non-trivial revisions to the autosegmental theory of tone, as developed by Goldsmith (1976) and later modified by Leben and Clements & Ford (1979).

In Section 3.2., the revised formalism will be motivated, by arguing that the formal and empirical problems inherent in the earlier versions of autosegmental theory stem largely from the overly-powerful operating options available to the Well-formedness Condition; and that in order to increase the descriptive adequacy of the theory, it is necessary to formally constrain the "spreading" options of the Well-formedness Condition from universally operating.

In Section 3.3., the revised formalism will be presented, most importantly the Revised Well-formedness Condition and its adjunct Condition on the Well-formedness of Lexical Representations. Also, the formal status of the Convention on Tone Melodies and of Contour Tones Configurations will be explicated according to the machinery of the revised formalism.

In Section 3.4., the non-trivial formal distinctions between the earlier versions of the theory and the revised versions of the theory will be spelled out.

In Section 3.5., the revised formalism is tested against the data from Mende, Kinyarwanda, Anyi and Kikuyu, where it is shown that the revised formalism intrinsically predicts a lexical specification process of relating tone onto tone-bearing units as opposed to a lexical association process. The theoretically important distinction between these two processes is explicated.

Finally, Section 3.6. concentrates on data from Mende and Kikuyu and argues against the Clements & Ford version of the Well-formedness Condition and its effect on the formal representation of Contour Tones.

3.2. The Well-formedness Condition as an overpowerful formalism.

Two arguments are presented in this section, the first demonstrating that the operation of the Convention on Tone Melodies represents the logical consequence of the formal operating options available to the Well-formedness Condition, and the second showing that the Melodic Association Procedures often require the operations of the Well-formedness Condition as a proper subset of its statement.

The conclusions derived from these arguments will provide us with important clues as to the revisions necessary in autosegmental theory to increase its descriptive adequacy.

3.2.1 The Convention on Tone Melodies and its Formal Relationship to the Well-formedness Condition.

When considering the relationship between the Convention on Tone Melodies and the Well-formedness Condition, the following points should be borne in mind:

(1) The operation of the Convention on Tone Melodies is a logical consequence of the formal operating options available to the Well-formedness Condition.

(2) The Convention on Tone Melodies is not empirically supported by the data as a universal formalism.

(3) Since the Convention on Tone Melodies is not empirically-supported by the data as a universal formalism, then the operating options available to the Well-formedness Condition must be limited so as to prevent the universal application of the Convention on Tone Melodies.

(4) By constraining (or limiting) the operating options available to the Well-formedness Condition, we are modifying the universal statement it makes about the tonological behavior of natural languages in general.

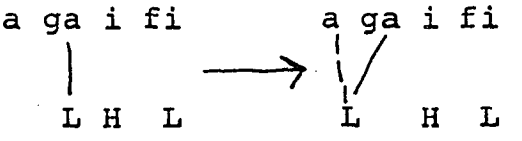
We will now elucidate each of these points in turn:

Regarding Point (1), let us reconsider in (100) below, representative data which is taken from Kinyarwanda, Anyi and Kikuyu. (For more detailed analyses of these languages, see Sections 2.4.2.2., 2.4.2.3. and 2.4.2.4. respectively.) The data under column (i.)

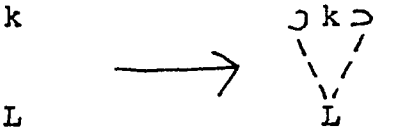
correspond to underlying representations, and the data under (ii.) correspond to the next step in the derivation:

(100) (i.) (ii.)

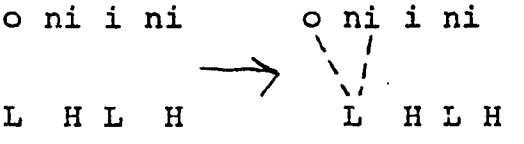
a. Kinyarwanda



b. Anyi



c. Kikuyu



Observe in (100) that the circled configurations represent adherence to the Convention on Tone Melodies and that the only way the circled configuration of association lines can be derived, within the autosegmental framework, is through the formal spreading options available to the Well-formedness Condition.

We have thus illustrated Point (1) of our argument, namely that the operation of the Convention on Tone Melodies is the logical consequence of a formal operating

option available to the Well-formedness Condition.

Regarding Point (2), we have argued extensively that for each of the cases in (100) (which represent regular tonological data), adherence to the Convention on Tone Melodies, and thus adherence to the spreading options available to the Well-formedness Condition, will always result in incorrect outputs.

Therefore, in order to prevent these incorrect outputs from being derived, we must formally prevent the spreading option of the Well-formedness Condition from automatically associating a distinct tonal segment onto more than one tone-carrying unit - at least at this point in the derivation. In order to accomplish this, we must "complicate" our language-particular grammars, by positing additional tonal segments (circled in (101) below) to the lexical inventories:

(101) a. a ga i fi

(L) L H L

b. ɔkɔ

(L) L

c. o ni i ni

(L) L H L H

Such a procedure results in limiting the options available to the Well-formedness Condition - since the option of spreading low-tone specifications to adjacent tone-carrying units has been replaced, in our analyses, by distinct tonal specifications for each of the tone-carrying units. We have argued that such a procedure is essential since the universal spreading of tone is neither empirically supported by the data nor logically supported by the theory.

It is at this point (Point (4)) in our argument that we may appreciate the far-reaching implications of formally abandoning the Convention on Tone Melodies as a universal principle. By formally abandoning adherence to it, we are weakening the language-universal Well-formedness Condition in favor of more powerful language-particular procedures. These "more costly" language-particular analyses are to be preferred since these, as we have shown, will logically generate the correct outputs for regular data, whereas the "less costly" language-universal analyses simply will not.

3.2.2. The Melodic Association Procedures and their formal relationship to the Well-formedness Condition

Parallel arguments are presented below which show that on formal and empirical grounds it is necessary to formally modify Melodic Association Procedures - and thus formally modify the claims of the Well-formed -

ness Condition.

Consider first the argument, immediately below:

(1) Both Goldsmith's and Leben's versions of the Melodic Association Procedures require in their formal statement the operation of the Well-formedness Condition. (See Goldsmith's version in Section 2.2.3. under (49A); and see Leben's version in Section 2.4.1. under (5) (specifically option (5c) for details). Therefore, the operation of the Well-formedness Condition is often a proper subset of the operation of the Major Association Procedures.

(2) We argued (in Section 2.4.1.1.) that both Goldsmith's and Leben's versions of the Procedures are empirically inadequate in handling initial tone mappings without having to invoke ad hoc "exception" procedures to salvage the formalism. Specifically, we argued that the empirically-incorrect Mende outputs for regular words, (60) *ngíla and (62) *kényâ and *nìkìlî stem from the operation of option (5c) of Leben's Revised Mapping Principles (where option (5c) represents the operation of Goldsmith's Well-formedness Condition).

(3) Therefore, the unrestrained operation of the Well-formedness Condition results in the proliferation of empirically-incorrect outputs.

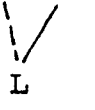
(4) This analysis therefore supports, on empirical and formal grounds, a modification in the operation of

the Major Association Procedures of Goldsmith and Leben - and as a consequence, a modification in the operating options available to the Well-formedness Condition (hereafter WFC).

Similar argumentation shows that Clements & Ford's (C&F's) version of MAP's, i.e. the Initial Tone Association Rules (ITAR's), also requires the operation of their version of the WFC in order to map tones onto syllables.

We have shown (in Section 2.4.2.4.), in the derivation for the Kikuyu word òní:nǐ, that tones are initially mapped onto a word as a result of the operations of C&F's ITAR2 and of Options 1 and 3 of WFC. We found, specifically, that Option 3 of the WFC formally spreads the L tone (which was originally mapped onto the second syllable of òní:nǐ by ITAR2) onto the first syllable as well. We argued that the resulting configuration:

(102)



which represents adherence to the WFC, logically required the derivation of an empirically-incorrect output.

We can therefore conclude that any attempt to formally revise Clements & Ford's Initial Tone Associa-

tion Rules will also have to take into account the operation of Clements & Ford's Well-formedness Condition. For the Kikuyu data, our analysis strongly supports a modification in the spreading options (Conventions 2 and 3) of Clements & Ford's Well-formedness Condition.

3.3. The Revised Formalism

Since we have shown that universal adherence to the Convention on Tone Melodies and language-particular adherence to the Melodic Association Procedures are not supported by the data, and since we have also shown that their operations are logical consequences of the formal operating options available to the Well-formedness Condition, then if we were to constrain these options from universally applying, we could thereby eliminate their empirically-incorrect outputs from being derived.

This is exactly what we propose to do: to formally impose the constraint on the Well-formedness Condition that all tones are associated with one and only one syllable, rather than maintain the Goldsmith, Leben and Clements & Ford claim that all tones are associated with at least one syllable.

Based on the conclusions drawn from analyzing the inadequacies of the previous versions, we propose the following Revised version of the Well-formedness Condition:

(103) Revised Well-formedness Condition

(1a) All syllables are associated with at least one tone.

(1b) All tones are associated with one and only one syllable.

(2) Association lines do not cross.

The important difference between the Goldsmith version and our version lies in the statement of Condition (1b). We will show that the empirical and formal consequences of positing Revised Condition (1b) are far-reaching in terms of the revisions required in the model's structural organization and also in terms of its efficacy in explicating tonological phenomena in a descriptively adequate way.

(We will show in Section 3.4. that our Revised Well-formedness Condition does not represent a simple notational variation of the Goldsmith/Leben or Clements & Ford version.)

We also propose the following adjunct to the Revised Well-formedness Condition, which we will show has important formal and empirical implications in the statement of the theory:

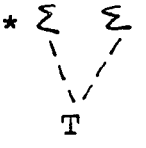
(104) Condition on the Well-formedness of Lexical Representations

A lexical representation is well-formed if

and only if its structural description satisfies the structural requirements necessary for the operation of the Revised Well-formedness Condition.

3.3.1. The status of the Convention on Tone Melodies in the Revised Formalism

Revised Condition (1b) of the Well-formedness Condition has been invoked in order to formally prohibit the operation of the Convention on Tone Melodies, at this point in the derivation. Therefore, derived Configuration (105) below, which represents adherence to the Convention on Tone Melodies, is regarded as ill-formed by the revised formalism since it violates Revised Condition (1b):

(105) 

(where represents the syllable and T represents the tonal segment).

Specifically, (105) is regarded as ill-formed since T is associated with more than one syllable rather than with one and only one syllable, as required by Revised Condition (1b).

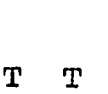
It is at this point that we come across an "apparent" impasse in motivating our revised formalism. We

have shown that it is formally impossible, under our revised formalism, to derive configurations such as (105). However we also know, based on inspection from many tone languages (see Sections 2.4. through 2.5.) that it is often empirically essential to derive representations in which contiguous syllables carry identical tone specifications: for example the derived representation ɔ́kɔ́, in Anyi, just prior to the application of the Final Low Raising Rule (see Section 2.4.2.3. under (81b)).

How are we to resolve this impasse? The answer does not seem to lie in abandoning Revised Condition (1b) since this Condition succeeds in formally prohibiting the Convention on Tone Melodies from universally operating; and we have argued extensively (see Section 2.4.) that the Convention on Tone Melodies must be prohibited from universally operating.

The answer, instead, appears to lie in specifying, at the lexical level, the structural requirements necessary for the Revised WFC to derive well-formed outputs. What we mean is that in order for derived Configuration (105) to become well-formed (as defined by our Revised WFC), at least the following syllable-tone structural requirements must be met, lexically, prior to their being associated with each other:

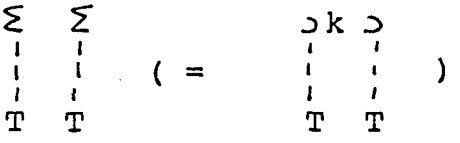
(106)



Configuration (106) is regarded as lexically well-formed since its structural description formally permits each syllable to be associated with at least one tone (Condition (1a)), and it also formally permits each tone to be associated with one and only one syllable (Revised Condition (1b)).

Therefore the following well-formed output is derived from the well-formed lexical Configuration (106):

(107)



Thus, we have observed that the Revised WFC makes a statement on the well-formedness of lexical representations as well as making a statement on the well-formedness of derived representations. We have called this adjunct statement: Condition on the Well-formedness of Lexical Representations; it is repeated below:

(104) Condition on the Well-formedness of Lexical Representations

> A lexical representation is well-formed if and only if its structural description satisfies the structural requirements necessary for the operation of the Revised WFC.

In the case of lexical Configuration (108):

(108) *Σ Σ

T

it is regarded as lexically ill-formed because its structural description does not satisfy the necessary structural requirements for the operation of the Revised WFC.

In order for (108) to meet the structural requirements of the Revised WFC and therefore become well-formed, it is necessary for the theory to specify an additional (circled in (109) below) T segment at the lexical level: 1

(109) Σ Σ

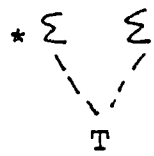
T (T)

Since lexical Configuration (109) now satisfies the structural requirements necessary for the operation

of the Revised WFC, specifically that each tone may be associated with one and only one syllable (Revised Condition (1b)), it is regarded as well-formed.

3.3.2. The Status of Contour Tones in our Revised Formalism

Whereas Configuration (105), as we have shown, constitutes a logically-impossible (i.e. ill-formed) output, given our revised formalism:

(105) 

Configuration (110);

(110) 

on the other hand, constitutes a logically-possible (i.e. well-formed) output.

Configuration (110) represents, as we have shown throughout Chapter Two, the formal representation of contour tone within the autosegmental framework. It is regarded as well-formed since it does not violate any of the Conditions in the Revised WFC. Specifically, one syllable is associated with at lease one tone (in this case two tones) as Condition (1a) dictates;

each tone is associated with one and only one syllable as Revised Condition (1b) dictates; and also association lines do not cross, as dictated by Condition (2).

3.4. Non-trivial formal distinctions between earlier versions and the revised version.

Before testing the Revised WFC against the data from tone languages, we will set forth in terms of their formal consequences, two non-trivial ways in which Goldsmith's/Leben's,[2] Clements & Ford's and Camhi's versions of the Well-formedness Condition differ from each other.

This is shown in TABLE I below. It reveals which operating options of the Well-formedness Condition (diagrammed in TABLE I) are permissible within the Goldsmith/Leben, Clements & Ford and Camhi versions.

Option A represents formal adherence to the Convention on Tone Melodies, and Option B represents the formal Contour-tone Configuration within the autosegmental framework.

Before inspecting TABLE I, it is extremely important to note that both Options A and B can be derived, also, as the result of the operation of phono/tonological rules. We want to emphasize the distinction between those options derived as a result of the operation of the Well-formedness Condition and those derived from the operations of phono/tonological rules. This TABLE refers only to those options resulting from the

operation of the Well-formedness Condition.

TABLE I: OPERATIONS FORMALLY PERMISSIBLE IN THREE DIFFERENT VERSIONS OF THE WELL-FORMEDNESS CONDITION

Option A

Option B

GOLDSMITH/ LEBEN	YES	YES
CLEMENTS & FORD	YES	NO
CAMHI	NO	YES

We find that Goldsmith's formalism permits both The Convention on Tone Melodies and Contour Tone Configurations to be derived by the operating options available to his version of the WFC. We observe that Clements & Ford's version of the WFC permits, as does Goldsmith's version, the universal operation of the Convention on Tone Melodies. The Camhi version, however, formally differs from both the Goldsmith and Clements & Ford versions in that the Camhi version does not formally permit the Convention on Tone Melodies to be derived from its Revised WFC.

We observe further that whereas both the Goldsmith and Camhi versions formally permit Contour Tone Configurations to be derived as the result of the operating options available to the WFC, the Clements & Ford version of the WFC does not formally permit Contour Tone Configurations to be derived from it.

It is clear then that these three versions of the WFC are not just notational variants of each other. Each is formally distinct from the other two, and thus each makes its distinct empirical predictions.

We have thus presented the Goldsmith, Leben and Clements & Ford versions of autosegmental apparatus in operation on data from various tone languages. I will now show, in the next Section, how these same data can be treated by my version.

3.5. The Revised Formalism and the data.

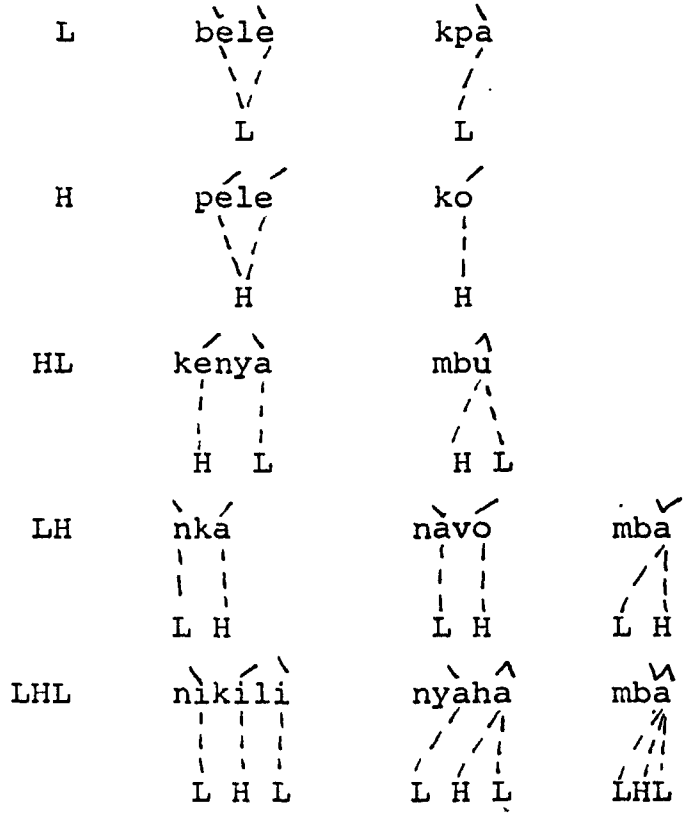
We have now set the stage for the testing of the Revised formalism against the data; and for critically comparing its phonological efficacy with that of the Leben/Goldsmith and Clements & Ford formalisms.

We will show that an analysis of the data which employs both the Revised Condition (1b) of the WFC and the Condition on the Well-formedness of Lexical Representations will result in a more descriptively adequate analysis of the data.

3.5.1. Mende

We will first re-inspect the Mende data taken from (55) in Section 2.4.1.1. The data are presented again in this Section, under (111):

(111)



According to our revised formalism, as defined in Section 3.3., all of the configurations in (111) are well-formed, except for bèlè and péle. These are not well-formed since they violate Revised Condition (1b) of the WFC. Specifically, the low tone specified on bèlè and the high tone specified on péle are associated with more than one syllable rather than with one and only one syllable.

In order for bèlè and péle to become well-formed, within our revised system, an additional L tone for bèlè and an additional H tone for péle must be lexically specified so that the lexical representations of these words meet the structural requirements necessary for the operation of the Revised WFC.

In our revised analysis, therefore, the derived configurations for bèlè and péle must look as follows in order for them to be well-formed:

(112)

(where the circled tone specifications refer to those added to the lexical level by the operation of the Conditions on the Well-formedness of Lexical Representations).

We observed for other Mende data - under the operation of Goldsmith's and Leben's Original Tone Mapping Principles (in which tones associate with vowels/syllables left-to-right) and with the subsequent operation of Goldsmith's WFC - that ngílà is correctly derived by the theory; and that ngɔ́nyɔ̌ is not correctly derived by the theory:

(103) a. ngila
H L

b. *ngɔnyɔ
H L

Therefore, under the Goldsmith/Leben analysis, ngɔ́nyɔ̌ must be formally treated as an "exception" word, where the "exception" procedure consists of lexically associating the H tone in ngɔ́nyɔ́ with its word-final syllable (See (104a).): and then of the operation of Goldsmith's WFC (See (104b).):

(104) a. ngɔnyɔ
H L (lexical association)

b. ngɔnyɔ
H L (WFC)

(Observe that the derived output (104b) constitutes an ill-formed configuration, according to our

Revised WFC, since this configuration violates Revised Condition (1b): i.e. the H tone is associated with two syllables, instead of with one and only one syllable.)

Leben then revised his Original Mapping Principles (see (5) in Section 2.4.1.1.), which also incorporated the operation of Goldsmith's WFC (see (5c)), with the result that: *ngíla̋, which in Leben's previous analysis (see (103a)) was correctly derived by the theory is now incorrectly derived by the theory; and ngɔ́nyɔ̋, which in Leben's previous anslysis was incorrectly derived by the theory (see (13b)) is now correctly derived by the theory:

(105) a. *ngila (H L) b. ngɔnyɔ (H L)

The solid association lines represent adherence to the Leben's Revised Initial Tone Mapping Principles (associate the final H tone with the right-most syllable) and the broken association lines represent adherence to the operation of Goldsmith's Well-formedness Condition.

We concluded that, in the Leben analysis, a single formalism could not accomodate both of these forms and that as Leben changed the formalism, so did the "regular"/"irregular" status of these words change.

We will show that whereas a unifying explanation of the data is not logically possible under the Leben/

Goldsmith analysis of the data, such a unifying explanation is logically possible under our analysis of the data. Our analysis incorporates the Revised Well-formedness Condition and its adjunct Condition on the Well-formedness of Lexical Representations.

Let us consider ngɔ́nyɔ̂ first. In deriving ngɔ́nyɔ̂, an additional (circled) H tone must be specified in the lexical inventory of the word:

(106) ngɔnyɔ

Ⓗ H L

so that when empirically-correct output (107) is derived, neither of the lexically specified H tones will become associated with more than one syllable; i.e. Revised Condition (1b) will not be violated:

(107) ngɔnyɔ

H H L

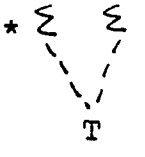
3.5.1.1. The formal distinction between lexical specification and lexical association.

At this point, we will go into a somewhat formal excursus in order to explicate the important distinction between lexical specification, the formal procedure which our analysis supports, and lexical associa-

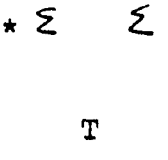
tion, the formal procedure which is supported by the Goldsmith/Leben analysis.

Since the Revised WFC requires the lexical specification of an additional H tone onto Configuration (106) in order to satisfy the structural requirements necessary for its operation, then the Revised WFC makes a formal statement (by means of the Condition on the Well-formedness of Lexical Representations) not only on the well-formedness of derived outputs, but also on the well-formedness of lexical representations.

Let us explore further the reasoning behind this statement. By positing the Revised WFC, the theory is universally constrained from deriving ill-formed configurations such as (108):

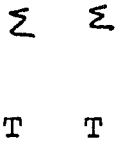
(108) 

Thus, the theory requires, by means of the Condition on the Well-formedness of Lexical Representations, that the Revised WFC change the ill-formed lexical representation (109):

(109) 

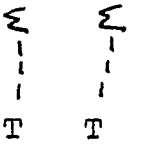
to the well-formed lexical representation (110):

(110)



in order that the well-formed derived output (111) will be derived:

(111)



Let us extend our logic one step further. Since our revised formalism requires that lexical representations be specified as well-formed (by means of the Revised WFC and the Condition on the Well-formedness of Lexical Representations), our theory therefore intrinsically predicts what constitutes a well-formed lexical representation. For the case of lexical representation (106), e.g., the theory intrinsically predicts the lexical specification of an additional H tone.

Therefore the process of specifying tones onto lexical representations constitutes a redundancy procedure and does not add formal "cost" to the theory. Rather, as we will see, it "simplifies" or unifies the explication of the data.

With regard to this point, let us return to the

Leben derivation of ngɔ́nyɔ̌ in (105). We observed that the Leben analysis required lexical association (as opposed to lexical specification) in order for the empirically-correct output to be derived.

By lexical association, we mean the association or linking of tones with syllables prior to the point in the derivation in which the predictable (language-specific) Initial Tone Mapping Principles operate and in which the predictable (language-universal) Well-formedness Condition operates to associate tones with syllables.

Clearly, then, the process of associating tones with syllables, lexically, constitutes a formal complication to the theory since the process does not constitute a predictable operation. It is an ad hoc "exception" procedure, which weakens the role of the predictable WFC and Melodic Association Procedures to explicate tonological phenomena.

We have shown, on the other hand, that the process of specifying tone lexically constitutes a formal operation which is intrinsically predicted by the theory's formalism. Therefore it is not ad hoc; it does not constitute a formal complication to the theory, and it does not weaken the descriptive role of the Well-formedness Condition.

Returning now to the Mende data, we see that our revised proposal accommodates both ngɔ́nyɔ̌ and ngíla

unexceptionally, without having to invoke (as the Leben/Goldsmith version requires) two separate Tone Mapping Procedures, and without having to lexically associate tones onto syllables (as the Leben/Goldsmith version also requires) prior to the operation of the otherwise predictable association procedures of Tone Mapping and the Well-formedness Condition.

The lexical representations for ngíla and ngɔ́nyɔ̌, within our revised analysis, are as follows:

(112)

ngila	ngɔnyɔ
H L	H L

where the lexical tone specifications are predicted by the formalism (Condition on the Well-formedness of Lexical Representations). The empirically-correct and well-formed outputs (see (113) below) for both words result from the predictable operation of the Original Tone Mapping Principle i.e., associate the first tone on the left to the first syllable on the left (represented by the solid association lines); and from the predictable operation of the Revised Well-formedness Condition) (represented by the broken association lines).

Observe that under our analysis, unlike the Leben/Goldsmith analysis, neither of the two forms is formally treated as "exceptional:"

(113) 

3.5.1.2. Summary

Under the Leben/Goldsmith analysis of Mende, two distinct sets of Melodic Association Procedures, as well as Goldsmith's version of the Well-formedness Condition, are posited in order to account for the "predictable" behavior of "regular" data. Moreover, the incorporation of additional "exception" operations (lexical associations) is still required in order to accommodate the data.

On the other hand, an analysis of these data, incorporating our Revised WFC and its adjunct Condition on the Well-formedness of Lexical Representations will permit a more unified analysis of the data since such an analysis does not require that additional Melodic Association Procedures be invoked and also does not require that ad hoc "exception" operations be invoked.

Therefore, an analysis based on our revised formalism provides a more descriptively-adequate analysis of the data than does the analysis based on the Leben/Goldsmith formalism. By constraining the WFC from permitting tones to be associated with more than one syllable, we have found that the descriptive powers of the theory have increased.

3.5.2. Kinyarwanda, Anyi, Kikuyu and the Revised formalism.

Our revised formalism also predicts empirically-correct outputs for the Kinyarwanda, Anyi and Kikuyu data, scrutinized earlier in Sections 2.5.3., 2.5.4. and 2.5.5. respectively. A very brief demonstration of this follows:

Recall that in Section 3.2.1. we argued that all of the data for Kinyarwanda, Anyi and Kikuyu, which were problematical for the earlier versions of autosegmental theory, could be logically and empirically accommodated by a theory which specifies additional tone segments in its lexical inventories. (116) below illustrates this lexical specification process, where the circled tonal segments represent the additionally-specified lexical tones:

(116) a. (Kinyarwanda)

a ga i fi

Ⓛ L H L

b. (Anyi)

ɔkɔ

Ⓛ L

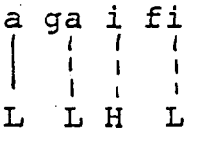
(Kikuyu)

o ni i ni

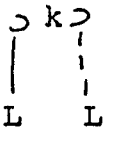
(L) L H L H

In (117) below, we will present the tone-mapping derivations for the sample data from Kinyarwanda, Anyi and Kikuyu, where the solid association lines represent the application of the Initial Tone Mapping Rule and where the broken association lines represent adherence to our Revised Well-formedness Condition:

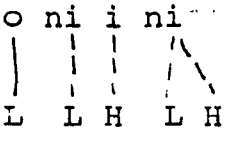
(117) a. Kinyarwanda



b. Anyi



c. Kikuyu



Observe that the tone-mapping derivations for these

representative forms follow the identical procedures employed in our analysis of the Mende data: the Condition on the Well-formedness of Lexical Representations intrinsically predicts the specifications of additional tonal segments so that the Revised Condition (1b) of the WFC will not be violated; also the Initial Tone Mapping Rule employed for these data is the same rule employed for the Mende data.

3.6. The Revised Formalism and its treatment of Contour-tone Configurations.

In this section, we will argue that Clements & Ford's modification to the Well-formedness Condition, namely that syllables are associated with one and only one tone, results in analyses of the data that are less descriptively adequate than a version of the Well-formedness Condition in which syllables are associated with at least one tone. In other words, we will argue that the formal and empirical claims made by the Goldsmith, Leben and Camhi versions of the Well-formedness Condition are formally preferable to those made by the Clements & Ford version, on this issue of deriving contour-tone configurations from the operation of the Well-formedness Condition.

We have shown in TABLE I (see Section 3.4.) that whereas the Goldsmith, Leben and Camhi versions of the Well-formedness Condition permit contour tone configurations to be derived from the operation of options

available to their versions of the Well-formedness Condition, the Clements & Ford version of the Well-formedness Condition, however, does not formally permit contour tone configurations to be derived from it.

None of the three Conventions of the Clements & Ford version of the Well-formedness Condition (see Section 2.5.I.) permits any syllable to be associated with more than one tone. The formal approach taken by their version is that those tones not meeting the requirements of Conventions 1, 2 & 3 are "floating" or free tones.

For the sake of organizational clarity, we will restate the Clements & Ford version of the Well-formedness Condition in terms that will easily relate it to the statements made by the Goldsmith/Leben and Camhi versions of the Well-formedness Condition.

(118) Well-formedness Condition (Clements &
- (1a) all syllables are associated with one and only one tone
- (1b) all tones are associated with at least one syllable
- (2) association lines do not cross

In summary, then, Contour-tone Configuration (119) (as shown in TABLE I, Section 3.4.)

(119) Σ

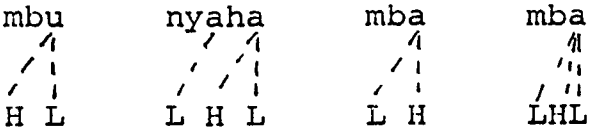
T T

is formally permitted as the direct output of the Goldsmith/ Leben and Camhi versions of the Well-formedness Condition since for these versions (1a) states that all syllables are associated with at least one tone. Contour-tone Configuration (119), however, is not formally permitted as the output of the Clements & Ford version of the Well-formedness Condition since (1a) of their version states that all syllables are associated with one and only one tone.

3.6.1. Mende

Let us re-inspect some of the Mende data (under (111) in this chapter), where there are four words that display contour-tone configurations:

(120)



These four configurations, all of which display contour tones, have satisfied the structural requirements for the operation of the Goldsmith/Leben and Camhi versions of the Well-formedness Condition. Therefore, they are regarded as well-formed and are formally permissible outputs of the Well-formedness Condition.

Note, however, that under the Clements & Ford version, these forms cannot be derived solely by the operation of their version of the Well-formedness Condition (see (118) above). Their version would derive the following outputs:

(121)

mbu	nyaha	mba	mba
H L	L H L	L H	LHL

The Clements & Ford formalism would then require the operation of additional independent phono/tonological rules in order to fully derive the contour-tone specifications.

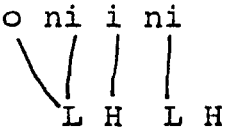
This, we will argue, constitutes a serious formal complication to their theory since the Clements & Ford formalism requires that all contour tone phenomena in all languages be treated as highly marked. Since the proscription against the derivation of Configuration (119) is built into the statement of their Well-formedness Condition, contour tones are universally prohibited from being derived by their Well-formedness Condition. We will argue that such a proscription is not warranted by the data, on universal grounds.

3.6.2. Kikuyu

To clarify Clements & Ford's position on this issue, let us re-inspect Derivation (25) from Section

2.4.2.4. on Kikuyu. Observe that (122) below represents the point in the derivation after Clements & Ford's Initial Tone Association Rule 2 and Conventions 1 & 3 of their Well-formedness Condition have applied.

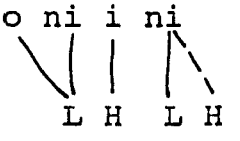
(122)



The final H tone remains unassociated or "floating" since none of the three Conventions of Clements & Ford's WFC will permit this tone to associate with the final syllable, -ni.

The final H tone becomes associated with the final syllable, deriving the contour-toned syllable, -nǐ, as the result of the application of the independent tonological rule, High Tone Assimilation (HTA). (123) below shows the point in the derivation just after the application of HTA.

(123)



Under the Clements & Ford version of the WFC, therefore, the mapping of more than one tone onto a syllable requires the positing of an independent phonological rule instead of being the output of the predict-

able operations of the Well-formedness Condition. The positing of the independent rule clearly adds to the formal complexity of the theory.

The important question to ask is why Clements & Ford have chosen such an analysis. The answer lies, in part, in that they provide a compelling diachronic argument in which they maintain that the systematic tonological differences between Kikuyu and other Bantu languages (of which family Kikuyu is a member) can be explained in terms of a tone-shift operation where tone specifications were shifted one syllable to the right in Kikuyu, but not in other languages of the same family. In other words, an important difference between Kikuyu and other languages of the same family lies in that the other languages have not undergone tone shift.

We will argue that to extend this particular diachronic explanation to a synchronic explanation of the present-day Kikuyu data is not as compelling; that the effects of the diachronic analysis is to add unnecessary complexity to the synchronic description of Kikuyu, not to mention the synchronic description of other languages which display contour tones.

Clements & Ford argue that Initial Tone Association Rule 1 (ITAR 1) applies to reconstructed Proto-Bantu and to all Bantu languages other than post tone-shift Kikuyu:

(124) Clements & Ford's Initial Tone Association Rule 1

"Associate the first tone with the first tone-bearing unit. (C & F, 1979:189)"

Initial Tone Association Rule 2 (ITAR 2) applies only to post-tone shift Kikuyu:

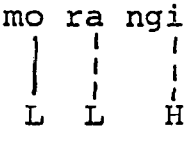
(125) Clements & Ford's Initial Tone Association Rule 2

"Associate the first tone with the second tone-bearing unit. (C & F, 1979:190)"

We will go through the C & F derivation of the word meaning 'bamboo' for Tharaka (a related Bantu language) and for Kikuyu.

(126) below represents the derivation for mòràngí in Tharaka

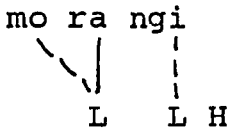
(126)



The solid association line represents adherence to ITAR 1 and the broken association lines represent adherence to Convention 1 of Clements & Ford's WFC.

(127) below represents the derivation for mòràngí in Kikuyu:

(127)

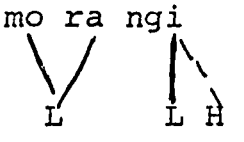


where the solid association line represents adherence to ITAR 2 and where the broken association lines represent adherence to Conventions 1 & 3 of C & F's version of the WFC.

Observe that at this point in the derivation for Tharaka, mòràngí is fully-associated, whereas for Kikuyu at the same point in the derivation, mòràngí is not fully-associated; for Kikuyu, the final H tone is left unassociated. It becomes associated by the application of the High Tone Association Rule (HTA) (see Section 2.4.2.4. for the structural description of this rule).

(128) below represents the point in the derivation after the application of the HTA Rule:

(128)

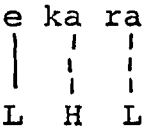


Let us now inspect additional data from Tharaka and Kikuyu, in which the Clements & Ford analysis for

the derivation of the word meaning 'charcoal' is shown.

(129) below represents the derivation for ékárà in Tharaka:

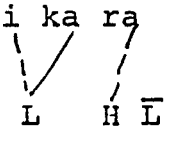
(129) Tharaka



where, again, the solid association line represents the application of ITAR 1 and the broken association lines represent adherence to Convention 1 of C & F's version of the WFC.

(130) below represents the derivation fir ìkárá! in Kikuyu. This Kikuyu word ends in a down-stepped tone (!):

(130) Kikuyu



where the solid association line represents the application of ITAR 2 and the broken association lines represent adherence to Conventions 1 & 3 of the C & F version of the WFC.

Observe for the data in (120) and (130) that the Tharaka word, ékárà, is fully-associated at this point

in the derivation as it was fully-specified at this point in the derivation from mòràngí. Observe that the Kikuyu word, ìkárá!, is not fully-associated, just as it was not fully-associated for mòràngí. However, unlike the Kikuyu mòràngí, the final $\bar{L}$ tone or downstepped tone is not subject to any later rule. It remains a free or floating tone.

We may now begin to appreciate why the Clements & Ford version of the Well-formedness Condition was invoked to prohibit the derivation of contour-tone configurations in its output. By prohibiting the final $\bar{L}$ tone from being associated by the WFC, they predict Downstepping, diachronically, in a regular way.

However, they also predict that contour-tone configurations are more marked than downstepped tone phenomena, and they formalize contour-tone configurations as more marked than non-contour-toned configurations.

It is possible that the data from Kinyarwanda might support such an analysis. (It would be necessary to study the language more scrupulously to determine the distribution of its contour-toned configurations, final-downstepped distribution, etc.) However, since the Well-formedness Condition represents a universal statement about the behavior of tonological phenomena, such an analysis as represented by the Clements & Ford constraint against the WFC deriving contour tone config-

urations is clearly too strong.

For example, the Clements & Ford analysis would clearly represent a complication of the highly regular tone-mapping behavior which we have demonstrated to exist in Mende, under our revised formalism (see Section 3.5.1.). To formally require that all contour tones be mapped by independent rules rather than by the Goldsmith/Leben/Camhi Condition (1a) of the Well-formedness Condition will result in an unwarranted complication of the theory.

This is shown to be the case with the Mende data, where the derived outputs in (121) above represent adherence to the Clements & Ford version of the Well-formedness Condition. The next logical step in the Clements & Ford analysis would be to require: a separate rule to associate the "free" L tone to mbû, a separate rule to associate the "free" H tone to mbǎ, and the operation of both these rules to associate the "free" H and L tones to mbâ.

In contrast, as we have shown in detail (see Section 3.5.), these Mende forms can be derived in a more unified way, by the operation of the Revised Well-formedness Condition, in which one of its conditions states that all syllables are associated with at least one tone. To universally constrain this condition from operating (as Clements & Ford have) in order to predistably account for the language-particular distribution

of Downstepping in Kikuyu is transparently unwarranted.

We maintain, therefore, that Condition (1a) of the Well-formedness Condition remain as stated: all syllables are associated with at least one tone.

3.7. Conclusion

In this chapter, a number of nontrivial revisions to the autosegmental theory of tone have been proposed. The incorporation of these revisions into the theory stems, in part, from the observation that by formally constraining the "tone-spreading" option of the Well-formedness Condition from universally applying, data which heretofore required formal "exception" status now are treated as formally "regular." In other words, by constraining the tone-spreading option from formally applying, the descriptive powers of the theory actually increase.

Based on these considerations, Revised Condition (1b) of the Well-formedness Condition has been proposed, which formally prohibits tones from being associated with more than one syllable; also the Condition on the Well-formedness of Lexical Representations has been proposed, which intrinsically predicts the specifications of additional tonal segments to lexical representations so that Revised Condition (1b) will not be violated.

It was also concluded that a lexical specification process is formally preferable to the earlier lexical

association process since lexical specification, unlike lexical association, constitutes a redundancy procedure which is not ad hoc, and which does not constitute a formal complication to the theory.

In the final section, an argument was made against the Clements & Ford modification in the Well-formedness Condition which universally prohibits contour-tone configurations from being derived by the Well-formedness Condition. It was argued on both formal and empirical grounds that a universal condition which permits a single syllable to be associated with one or more tones is preferable to a universal condition which does not.

FOOTNOTES TO CHAPTER THREE

1. It is important to note that an im portant formal distinction between the lexical specification of tones and the lexcial association of tones will be made in Section 3.5.1.1.

2. Since Leben's (1978) version of the Well-formedness Condition is essentially identical to Goldsmith's (1976) version, we will consider them as one (Goldsmith/Leben) in this Section. Leben's version of autosegmental theory differs in another way, however, as we have shown in Section 2.5. and 3.2.

CHAPTER FOUR: THE FORMALIZATION OF A SYLLABLE-STRUCTURE MODEL FOR TONE LANGUAGES

A preliminary formal investigation into a syllable-structure model for tone languages, within the autosegmental framework, is presented in this chapter. Kahn (1976) had developed in his dissertation a detailed syllable-based model for English. However, it did not specifically apply to tonological organization. Clements & Ford (1979) later incorporated a syllable-based model for tonological data in their analysis of Kikuyu (see Section 2.4.2.4.), which differed from Goldsmith's (1976) in that the latter had formally regarded tones as being directly associated with vowels rather than with syllables.

However, since Clements & Ford did not provide a detailed formalization of a syllable-based analysis of tone, such a formalization will be presented in this chapter. It will be maintained that the incorporation of the syllable into the theory as a salient phonological unit results in a more descriptively adequate analysis of tonological data.

4.2. On the formal treatment of the syllable as an independent phonological unit.

Data from Tiv is presented in this section. It will be argued that an analysis of the Tiv data regard-

ing the tonal display of verb "tenses" benefits significantly from an analysis which treats the syllable as an independent phonological unit.

4.2.1. The Tiv Verbal System

The Tiv verbal system has been the subject of extensive analysis over the past twenty years, most notably by Arnott (1964), McCawley (1970), Leben (1973) and Goldsmith (1976). Each of these investigators has made essentially the same observations concerning the tonological distribution of berb "tense" across verb stems. They differ, however, in the way they explicate this tonological distribution.

Tiv has twelve verb "tenses." These are:

General Past

Future

Imperative

Habitual 1, 2, 3 & 4

Recent Past A & B

Subjunctive

Continuous

Past Habitual

Each of these twelve tenses has six possible allomorphic tonal displays. (131) below gives an example of the six possible displays for the General Past tense (taken from Goldsmith, 1976:36):

(131) GENERAL PAST ve -'they'

!=Drop; see text

High	Low
ve!va	ve dza
ve!ungwa	ve vende
ve!yevese	ve ngohor

(131) illustrates that Tiv verb stems can be one, two or three syllables long and that each verb stem is marked lexically as either H or L. The symbol, !, represents a "Drop," which refers to a drop in pitch of one or two semitones between two successive High tones.

It has been consistently pointed out in the literature (Arnott, 1964; McCawley, 1970; Leben, 1973; Goldsmith, 1976) that the six tonal melodies for each verb tense are related to each other and that the language learner does not need to memorize all six melodies for each of the twelve tenses. It has been shown, in fact, that the specific allomorphic tonal displays for each verb tense are predictable from two factors: (1) the lexical marking of the verb stem as either H or L; and (2) the number of syllables in the verb stem.

Therefore, for each of the twelve verb tense morphemes, a basic tonal pattern or melody has been formalized. Based on the H or L lexical markings on the verb and the number of ayllables on the verb stem, the correct allomorphic tonal display can be predicted.

A schematic example from Goldsmith (1978:37) showing the possible tonal patterns for the General Past follows:

(132)	General Past	High	Low
	1 syll:	!H	L
	2 syll:	!HL	LL
	3 syll:	!HLL	LLL

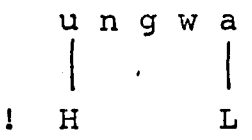
Goldsmith, "modifying Arnott's notation slightly," hypothesizes that the basic tonal pattern or melody for the General Past is, with some modification, as (133) below, where Arnott had originally pointed out that it is only the tone on the first syllable (B, which represents a variable ranging over H and L) that must be memorized, and that the remainder of the tonal pattern is predicted by (133):

(133) !BL

As an illustration, we will go through two derivations for the General Past, using the autosegmental approach (taken from Goldsmith, 1976).

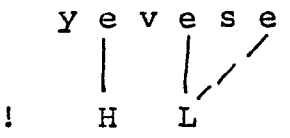
For a two-syllable H-marked verb, in which the !BL pattern is followed, we get the tonal display, !HL:

(134)



For a three-syllable H-marked verb, we get the tonal display, !HL:

(135)



In the case of (135) above, observe that the L tone spreads onto the third syllable.

We observe that Arnott's and Goldsmith's pattern (133) for the General Past is not without its problems. For example, in deriving L-marked verb stems for the General Past, an additional rule must delete !. Also, for monosyllabic H-toned verb stems, a rule must delete the final L.

Such details are, however, for our particular purposes, relatively unimportant. The important point to stress here is that even though some of these basic tonal patterns are somewhat complicated, it is far simpler for the language learner to memorize twelve patterns, i.e. one pattern for each of the twelve verb tenses, than it is to memorize twelve times six (seventy-two) patterns.

Goldsmith's autosegmental approach is capable of explicating this by associating the basic tonal melody for each verb tense onto the vowels of the verb stem (see (134) and (135)).

I will argue, however, against that aspect of the Goldsmith analysis, in which tone is formally associated with the vowel. Instead, it will be shown that an analysis of the Tiv data benefits from a model which describes tone as formally displayed on the syllable, rather than on the vowel.

In the Goldsmith analysis, in order to correctly link tones with segments, the segmental display must be scanned for [+ syllabic] segments, which are then associated with the tonal units. Since it is the number of syllables in the verb stem that will correctly predict the allomorphic distribution of tone on the verb-stem, and not the segmental composition which makes up those syllables, the consonant-vowel scanning procedure required by the Goldsmith analysis therefore constitutes an unnecessary complication to the theory.

It can be easily shown that, under a syllable-structure analysis, the procedure for correctly linking the tonological with the segmental domains is nontrivially simplified.

4.2.2. A syllable-structure analysis of some Tiv data

At the outset of this section, it is essential to face the question of what constitutes the phonological

representation of the syllable - more specifically, how phonological representations divide their segments into syllables.

We cited, in Section 1.5.1., examples of languages in which syllable representations were not the canonical CV, but rather were VC_o and C_oV_o. Somer (1970), for instance, showed that the syllable boundary in strings such as egn oygng.õrg.an, 'bitter onion,' fall after the second and even third consonant, even when these consonants are followed by vowels in the same word. And, Gibson (1956) observed that more than one vowel segment can co-occur within a single syllable, as for example in Pame where three vowels appear in the same syllable: ngwaoi, 'her (two) daughters-in-law' is monosyllabic.

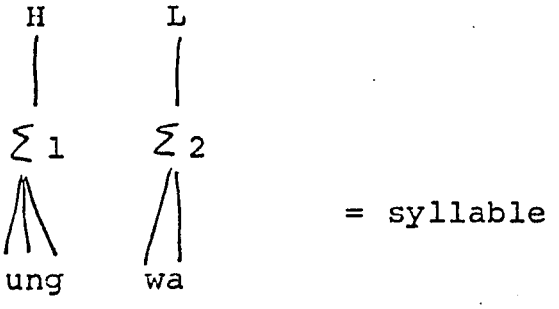
Anderson (1974) concluded, based on the inspection of languages such as the above, that syllable boundaries are variable depending on the language, yet they appear quite fixed in their particular language.

A similar position is taken in this chapter. In order for the syllable-structure analysis to be valid, what is required is: (1) for the vast majority of words in any given language, that all native speakers syllabify them in the same way: and (2) for any exceptions, that all native speakers treat them as exceptions. In other words, all that is required by the syllable-structure analysis is that, for any given language, there is a consistency and also that there exist tests - and

valid native speaker intuitions - for discovering what the syllable is. With this in mind, we can now return to Tiv.

Under a syllable-structure analysis, tone supra-segments are linked directly to syllables - not to segments. For example:

(136)



The fact that the specific segmental information immediately "dominated" by the syllables is irrelevant to the operation in question is reflected in the structural description of the linking operation. In other words, it is irrelevant to the prediction of the correct allomorphic tonal display across the verb stem that ung constitutes the segments of syllable 1 and that wa constitutes the segments of syllable 2. What is relevant is that the verb stem is bisyllabic. Therefore, we want the bisyllabic nature of the verb stem to be explicated in the structural description of the linking operation.

Observe in (136) that in the ayllable-structure model the bisyllabic nature of the verb-stem is

reflected in the structural description of the linking operation. Tones are linked not to segments. Rather, they are linked to the linguistically "relevant" syllables, which dominate these segments, and which function as distinct phonological units.

4.3. Hierarchical Constituent Patterning in the Syllable-Structure Model

The notion of "domination" in the syllable-structure model reflects the hierarchical-constituent nature of phonological organization. The model utilizes - as it will be shown - both hierarchical and co-constituent patternings. We will at present focus on the hierarchical patterning.

In order to elucidate hierarchical-constituent patterning, we will first consider how rules in the syntactic component operate. A syntactic rule applies when teh structural description for that rule is met. Consider, for example, the operation of the Passive Rule in English, which is formalized below:

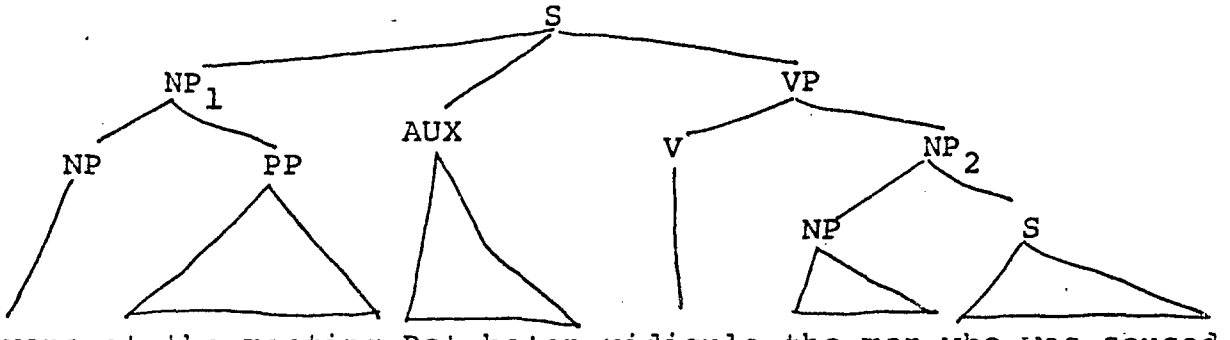
(137) PASSIVE RULE

$$X - NP - \underset{Aux}{[X} \quad \underset{Aux}{be+en]} - V - NP - Y$$

S.D.	1	2	3	4	5
S.C.	1	4	3	0	5 by 2

Consider now the operation of the Passive Rule for the sentence, The man who was soused was ridiculed by everyone at the meeting.

(138)



Everyone at the meeting Pst be+en ridicule the man who was soused.

s.d. 2 3 4

s.c. 4 3 0 by 2

For the operation of the Passive Rule in this sentence, specific information regarding those syntactic units which are dominated by NP_1 and NP_2 (i.e. NP, S, PP, etc.) is irrelevant to the operation of the rule, and this is formally reflected in the structural description of the rule (see (137) above).

Clearly, a formal analysis of the Passive Rule which would require in its structural description all of the possible rewrites of [NP,S] and [NP,VP] would fail to capture the linguistically significant generalization that it is the subject-as-a-unit and the object-as-a-unit which are being structurally rearranged and that the elements dominated by these NP's are not under-

going structural change.

(The parallelism with the Tiv data is obvious. It is the number of syllable units in the verb stem that predict the structural change. The segments dominated by these syllable units are not formally involved in the operation of the structural change.)

The Adjective-Insertion Rule similarly elucidates hierarchical constituent patterning, where the structural description of this rule requires not that NP units, but that units dominated by NP units take part in the structural change. In this case, the adjective is inserted before the N, which is dominated by NP.

As final examples, the syntactic rules for Relative Clause Formation and Compound Sentence Formation require the unit, S, to operate in the rules' structural change, and those units dominated by S, such as NP, VP, AUX, Det, N, etc. are irrelevant in accounting for the linguistically significant generalization that these rules aim at capturing. Note that in all of these cases, the structural information given in the rules' description dictates the specific syntactic level of organization on which the rule operates.

Consider now the phonological component, where a hierarchical organization is also evidenced. (The co-constituent nature of phonological organization will be explicated at length in Section 4.4. below.) In the phonological component - as in the syntactic component -

the structural description of the linguistic rule will determine the constituent level on which the rule will operate. The claim being made here is that the speaker-hearer has available more than one constituent level of phonological organization, and that these levels may be employed in deriving phonetic outputs.

We can now return to the Tiv example. Since it is the number of syllables that is relevant to the operation which will predict the correct allomorphic tonal display, the constituent level on which this rule will operate will be the constituent level on which the syllable is a phonological unit. Specific information regarding those phonological units which are dominated by the syllable (i.e. consonants and vowels) is irrelevant and thus the phonological operation will not operate on that level of phonological organization.

In summary, we have argued that for the Tiv Rule to operate on segments rather than on the syllable is logically equivalent (in terms of "complexity" to the Passive Rule in English operating on units dominated by NP's rather than on NP's.

Specifically, for the Passive Rule, a formally "simplified" analysis is derived by treating NP_1 and NP_2 as atomic syntactic units. Likewise, for the Tiv data, a formal "simplification" is derived by formally treating syllable 1 and syllable 2 as atomic phonological units.

A more formal exposition of the syllable-structure model is given in the Sections immediately below.

4.4. Formal Feature-Mapping Procedures in the Goldsmith version of Autosegmental Theory

Goldsmith, following essentially Chomsky's Logical Structure of Linguistic Theory, describes the formal procedures which map feature specifications onto segments. We should note that these procedures are identical to the formal mapping procedures of the standard theory (See Section 1.2. for additional details.)

Goldsmith describes the procedures as follows:

> "Segments are atomic elements ordered linearly left to right; this simple and elegant hypothesis lies 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," we may then say, 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 (9).

(139) 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). $F_{voice}(S_{75}) = -$. All this amounts to saying that the first segment in the representation of pin in (9) is voiceless." (Goldsmith, 1976, page 22)

The autosegmental approach logically differs from the standard theory in that tonal features are not features of the vowel, as they are in the standard theory. Rather, they are features which constitute segments; and these tonal segments are "factored out to another level" - the autosegmental level. "The relation (of these tonal segments) to the vowel with which they become associated is merely one of simultaneity of time (Goldsmith 76:22).

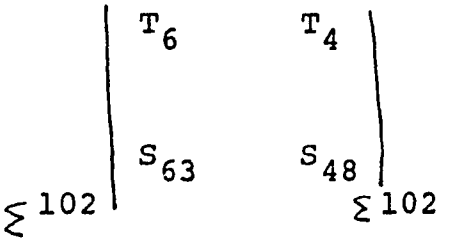
4.5. Formal Feature-Mapping Procedures in a Syllable-Structure Version of Autosegmental Theory.

Our approach is to logically extend Chomsky's formalism - as described in The Logical Structure of Linguistic Theory - to encompass the syllable as the phonological unit on which atomic segmental units are linearly ordered, and on which atomic suprasegmental units are linearly ordered. Such a model, as we shall see below, explicates the hierarchical-constituent, as well as the co-constituent organization of the syllable.

To elucidate: In our model, the hypothetical $\hat{ba}$ has the following representations at the underlying

phonological level:

(140)



where S represents the segment, T represents the tonal suprasegment and represents the syllable. The subscripts represent - as in the Chomskyian sense, described above (Section 4.4.) - primitive elements in the phonological vocabulary. The vertical lines represent the syllable boundaries.

A set of rewrite rules (141) and (142) formally defines the hierarchical constituent organization of Σ_{102}:

(141) $\Sigma_{102} \longrightarrow T_6 \quad T_4$

(142) $\Sigma_{102} \longrightarrow S_{63} \quad S_{48}$

where the elements to the right of the arrow represent the immediate constituents of the element to the left of the arrow.

Rewrite Rule (143) represents a coalescence of the simultaneously applied Rewrite Rules (141) and (142):

(143)
$$\Sigma_{102} \longrightarrow \begin{matrix} T_6 & T_4 \\ S_{63} & S_{48} \end{matrix}$$

Besides formally defining the hierarchical constituent organization within the syllable, Rewrite Rule (143) also defines the co-constituent relationship that exists between the segments and suprasegments of the syllable.

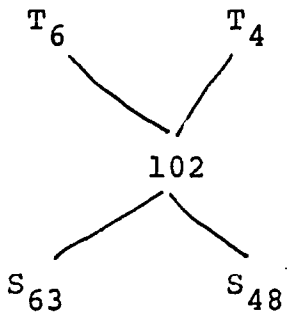
Specifically, Rule (143) states that $_{102}$ is composed of a string of segments ordered from left-to-right. It also states that Σ_{102} is composed of a string of tonal suprasegments also ordered from left-to-right. The simultaneous rewriting of Σ_{102} into the set of suprasegmental strings, and into the set of segmental strings results in the "intrinsic" linking of suprasegments and segments.

By "intrinsic" linking, we mean that linking is a logical consequence of the operation of the Regular Mapping Procedures of the Syllable-Structure Model, by which the co-constituent status of the strings of segments and suprasegments are formally defined. (This last point is in contradistinction to the association procedures of Goldsmith's version of autosegmental phonology, as we will show.)

A perhaps clearer representation of the output of

Rewrite Rule (143) is given below:

(144)



where the following "grammatical relations" are defined by the formalism:

Σ_{102} "dominates" (S_{63} & S_{48});	$[(S_{63}\ S_{48}), \Sigma_{102}]$
Σ_{102} "dominates" (T_6 & T_4):	$[(T_6\ T_4), \Sigma_{102}]$
(S_{63} & S_{48}) and (T_6 & T_4) are "co-constituents" of each other.	$\lvert (T_6\ T_4) \rvert$ $\lvert (S_{63}\ S_{48}) \rvert$

We observe in (144) that it is the syllable which acts as the fulcrum upon which segmental and suprasegmental displays are organized. In this model, the syllable is a formally-defined phonological unit.

To summarize thus far: In this model, Rewrite Rule (143) formally defines the constituent structure of the syllable; and the Chomskyian Feature-Mapping Principles, which we have extended to encompass suprasegmental as well as segmental units, formally assign feature specifications to these units.

Below is a partial "mapping derivation" for Σ_{102}:

TABLE I - Projection Mappings for Σ102.

For S_{63}, F_{cons} maps S_{63} to +;	$F_{cons}(S_{63}) = +$
	$F_{syll}(S_{63}) = -$
	$F_{son}(S_{63}) = -$
	$F_{cont}(_{63}) = -$
For S_{48}	$F_{cons}(S_{48}) = -$
	$F_{syll}(S_{48}) = +$
	$F_{back}(S_{48}) = +$
	$F_{round}(S_{48}) = -$
For T_6	$F_{hitone}(T_6) = +$
	$F_{lotone}(T_6) = -$
For T_4	$F_{hitone}(T_4) = -$
	$F_{lotone}(T_4) = +$

Given the above formalism, we can logically represent the pholonogical component in terms of sets of matrices, where a rully-specified matrix for $_{102}$ will

look like this:

(145)

$$\left\langle \begin{bmatrix} +\text{hi tone} \\ -\text{lo tone} \end{bmatrix} \quad \begin{bmatrix} -\text{hi tone} \\ +\text{low tone} \end{bmatrix} \right\rangle \begin{bmatrix} +\text{cons} \\ -\text{syll} \\ -\text{son} \\ -\text{cont} \\ +\text{ant} \\ +\text{voiced} \\ -\text{nasal} \\ -\text{strident} \end{bmatrix} \begin{bmatrix} -\text{cons} \\ +\text{syll} \\ +\text{low} \\ +\text{back} \\ -\text{round} \end{bmatrix}$$

where this output is the result of the applications of Rewrite Rule (143) and of teh Projection Mappings, outlined in Table I.

An alternate, yet formally equivalent, way of looking at the display is as follows:

(146)

$$\begin{bmatrix} +\text{hi tone} \\ -\text{lo tone} \end{bmatrix} \quad \begin{bmatrix} -\text{hi tone} \\ +\text{lo tone} \end{bmatrix}$$

$$\Sigma_{102}$$

$$\begin{bmatrix} +\text{cons} \\ -\text{syll} \\ -\text{son} \\ -\text{cont} \\ +\text{ant} \\ +\text{voiced} \\ -\text{nasal} \\ -\text{strident} \end{bmatrix} \quad \begin{bmatrix} -\text{cons} \\ +\text{syll} \\ +\text{low} \\ +\text{back} \\ -\text{round} \end{bmatrix}$$

Upon closer inspection of our model, which regards both the string of segmental units and the string of suprasegmental units as the simultaneous co-constituents of the syllable, we may observe the following structural symmetry in its formalism: those segments and suprasegments, which are formally analyzed as simultaneous co-constituents of the syllable, are each further analyzed into simultaneous co-constituents, this time, with distinctive features.

In a nutshell, each of the co-constituents of the syllable is further analyzed into co-constituents. A specific example of this follows.

We observe that the atomic phonological unit, Σ_{102}, consists of two sets of co-constituents - (ˊˋ) and (ba):

(147)
$$\Sigma_{102}$$
$$\left|\begin{array}{c}(\ \acute{}\grave{}\ ) \\ (ba)\end{array}\right|$$

Each of these co-sonstituents may be further analyzed onto co-constituents - the suprasegment into its prosodic (tonal, in this case) feature specifications:

(148) $\begin{bmatrix}+\text{hi tone} \\ -\text{lo tone}\end{bmatrix}$ $\begin{bmatrix}-\text{hi tone} \\ +\text{lo tone}\end{bmatrix}$

and the segment into its inherent feature specifications:

(149)

+cons	-cons
-syll	+syll
-son	+son
.	.
.	.
.	.

Such structural parallelism has the theoretical advantage of unifying the explication of the theory's formal machinery.

The Syllable-Structure model formally distinguishes the status of the syllable from that of the segment and of the suprasegment, by means of the following Conditions on Mapping:

(150) Conditions on Mapping

I. Segmental and suprasegmental units are mapped onto the syllable concatenеously.

II. Distinctive features are mapped onto the segmental and suprasegmental units simultaneously.

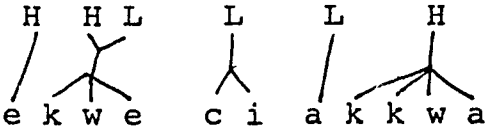
Observe that Condition I explicates Syllable-Structure organization, and that Condition II explicates Segment-Structure organization. We will elucidate this distinction in Section 4.6., immediately below and by so doing, we will also explicate the distinction between Syllable-Structure Rules and Segment-Structure Rules.

4.6. Syllable-Structure vs. Segment-Structure Rules in the Syllable-Structure Model

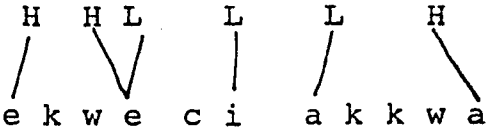
Additional support for the syllable as a phonological unit is presented in this section. First, it will be shown that by means of the Syllable-Structure Model, the distinction between Syllable-Structure Rules and Segment-Structure Rules is explicated. Second, it will be argued that a syllable-based model, such as the one that is being posted here, permits the explication of a formal symmetry that is not permissible in Goldsmith's version of autosegmental theory.

The mapping display within the Syllable-Structure version of autosegmental theory is presented in (151), and the mapping display within the Goldsmith version is presented in (152). The data is from Igbo (See Section 2.2.4.2.):

(151) Syllable-Structure Model



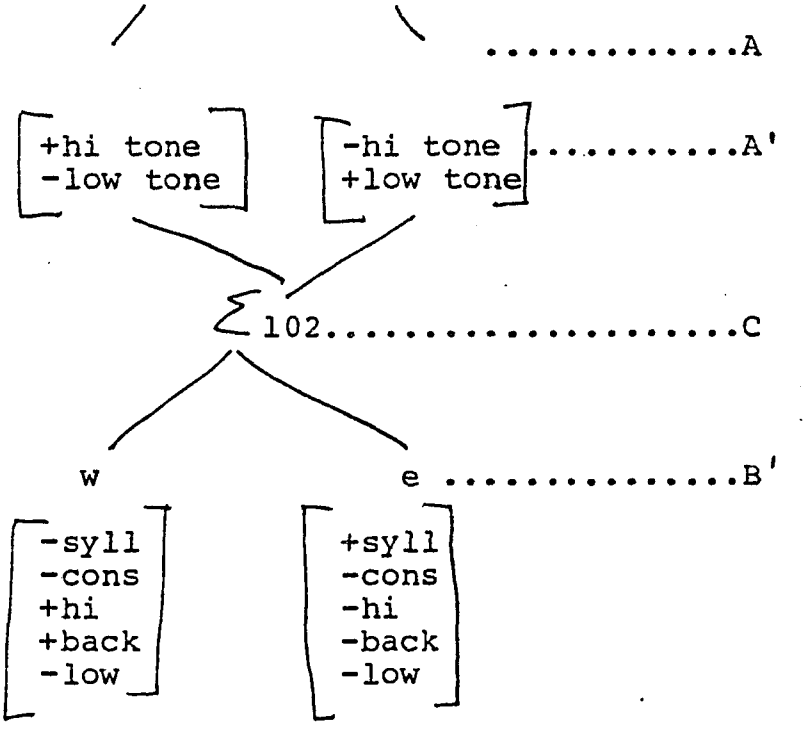
(152) Goldsmith Model



The important distinction between (151) and (152) is that tone is carried by the syllable in representation (151), and tone is carried by the autosegment which is then associated to the vowel in representation (152). The distinction between (151) and (152), it will be shown, is not trivial.

For the sake of elucidation, let us carefully examine the formal matrix for the second syllable, we, in (153) by labelling the various phonological levels within the matrix:

(153)



(153) is not meant to be a formal operating representation for Σ_{102}. A is a shorthand for A', just as B is a shorthand for B'. These levels are being distin-

guished in order to elucidate a number of points.

Observe in (153) that the segmental units (at B) and the tonal units (at A) are the immediate operating units of the syllable (at C), as defined by our model. In the formal sense, both the segmental and tonal units are serially projected onto the syllable. Features of the segment (at B') and features of the suprasegment (at A'), on the other hand, are not formally organized in this manner. Rather, they are simultaneously-projected units of the segment and of the suprasegment, respectively. Therefore, the features of the segment and of the suprasegment operate along formally distinct lines from the immediate units of the syllable.

Such a formal setup results in some very interesting dividends for the theory. For one thing, it elegantly predicts and defines the <u>form</u> that various classes of phonological rules will take in the theory.

Since tonal and segmental units (at A and B, respectively) have formally equivalent projections onto the syllable, and since these projections are formally distinct from the projections of features onto the suprasegment and suprasegment (A' and B' respectively), we will predict that the <u>form</u> that the rules take, which undergo structural changes on A and B, will be formally equivalent to each other; yet they will be formally distinct from those rules operating on A' and B'. Also, the theory predicts that since the feature

projections onto A' and B' are formally equivalent, the form that rules will take, undergoing structural change on these levels, will also be formally equivalent.

Let us now return to the Igbo data, discussed in Section 2.2.4.2., and further analyzed in this Section in (151) and (152). Goldsmith does not formalize the statement of what we will call the Low-Tone Assimilation Rule. Its formal statement would be similar in spirit to our analysis, with one important exception, namely that in the Syllable-Structure analysis, tone is carried by the syllable, and in the Goldsmith analysis, tone is carried by the autosegmental level.

We will formally express the Low-Tone Assimilation Rule as follows:

(154) Low-Tone Assimilation Rule in Igbo

$$S\left[\left[\underset{NP}{X} - H\right]_{NP}\left[\underset{VP}{L} - Y\right]\right]$$

str. desc.	1	2	3	4	
str. chng.	1	23	3	4	Condition: 1 and 2 are not tone specifications on a pronoun.

where X represents any number of tone specifications within NP brackets, and where Y represents any number of

tone specifications within NP brackets, and where Y represents any number of tone specifications that may follow L. (53) in Section 2.2.4.2. represents a graphic application to the rule's structural description.

(154) which operates on A (as represented in (153)), is a "transformational" (or syntagmatic)-type rule, in that a string of elements (in this case, tonal suprasegments) is transformed into another string of elements. This sequential mapping of a string of tonal elements across the syllable in the Syllable-Structure Model (and across the autosegment "level" in the Goldsmith analysis) intrinsically predicts the operation of such "transformational"-type rules.

The form of Rule (154) is a direct reflex of the formal Mapping Procedures and Conditions on Mapping of the Syllable-Structure Model. Their form is equivalent to the form of syntactic transformational rules, where the units undergoing structural change are treated as indivisible units - even though these units may be further "broken down" into constituent units. (See Section 4.3. for a more detailed discussion of hierarchical constituent analysis and how it relates to the Syllable-Structure analysis.)

Now let us inspect rules such as Segment Deletion, Epenthesis and Metathesis. These rules are of the

class which operates on A (as represented in (11)), and they are also of the "transformational" (or syntagmatic)-type:

(155) Word-final Consonant Deletion Rule in French

C	#	C	
1	2	3	⇒
0	2	3	(Schane, 1976, p. 66)

(156) U-Insertion Rule in Hanunoo

#	C	C	
1	2	3	⇒
1	2 u	3	(Schane, 1976)

(157) Metathesis of Glottal Stop-Consonant in Hanunoo

V	-consonantal -continuant	C	V	
1	2	3	4	⇒
1	3	2	4	

(Schane, 1976, p. 67)

Rules (155-157) are formally equivalent to Rule (154). For each of these rules, segments or classes

of segments as a whole undergo structural change. For Rule (154) tonal segments undergo structural change; and for Rules (155-157) consonants or vowels undergo structural change.

An important point to emphasize for Rules (154) and Rules (155-157) is that specific information regarding the features of the tonal suprasegment or of the segment is irrelevant to the operation of the rule, and therefore is not required in the structural description of the rule.

Rules, however, which do require specific information regarding features of the segment or of the suprasegment are of a formally different class from those requiring specific information regarding segments of the syllable. These former rules are usually regarded as "pure" phonological (or paradigmatic)-type rules.

Two examples of this type of rule follow: The first is the Nasal Assimilation Rule of English:

(158) Nasal Assimilation

$$[+\text{nasal}] \rightarrow \begin{bmatrix} \alpha\ \text{anterior} \\ \beta\ \text{coraonal} \end{bmatrix} \Big/ \underline{\quad} \begin{bmatrix} \alpha\ \text{anterior} \\ \beta\ \text{coraonal} \end{bmatrix}$$

The units undergoing change, namely the "place" features of the nasal segment, are simultaneously-projected features of the segment (as on B' in (153)) and are not serially-projected segments of the syllable

(as on B in (153)). Therefore, the theory correctly predicts that the form which such a rule takes will be formally distinct from rules like (154) and (155-157).

Another example of the "pure" (or paradigmatic)-type rule is Mid-Tone Assimilation in Ewe, as discussed by Schuh (1978:237):

(159) Mid-Tone Assimilation in Ewe

$$\begin{bmatrix} -\text{low tone} \\ -\text{high tone} \end{bmatrix} \rightarrow [+\text{low tone}] / \_\_\_ [+\text{low tone}]$$

For this rule, the units undergoing change - namely the tonal feature specifications of the segment - are simultaneously-projected features of the segment (as on A' in (153)), and not serially-projected segments of the syllable (as on A in (153)). Therefore, the theory also predicts, correctly, that the form which such a rule takes will be formally distinct from rules like (154) and (155-157).

Thus, we have given additional examples which show that the form a rule takes is a logical reflex of its mechanical functioning within the system; i.e. form follows function.

At first glance, it seems paradoxical that (154) and (155-157) have equivalent rule forms, since (154) is a rule of tonological phonology, and (155-157) are rules of segmental phonology. One would expect, rather,

that the rules of (155-157) would have equivalent rule forms with (158) since these are all rules of segmental phonology.

The paradox, however, is only "apparent." The formal equivalence between rules operating on A and rules operating on B lies in the logically-sound basis that the units undergoing structural change in both these rule types are the linearly-ordered atomic units of the syllable. We call these rules Syllable-Structure Rules. The fact that the rules operating on B are of segmental phonology, and that the rules operating on A are of tonological phonology, is irrelevant to the essential relationship that we have shown exists between them.

Based on parallel argumentation, we may also explicate why rules of the form of (158) and (159) are formally equivalent. The formal equivalence between rules operating on A' and rules operating on B' lies in the logically-sound basis that the units undergoing structural change in both these rule types are the simultaneously-projected units of the segment. We call these rules Segment-Structure Rules. As in the argument above, the fact that rules operating on B' are of segmental phonology, and that rules operating on A' are of tonological phonology is irrelevant to the essential relationship that exists between them.

The Syllable-Structure Model, as developed in this

chapter, logically permits the elucidation of the essential relationship. The standard theory does not - due to the logical impossibility of rules such as (154) to operate within the theory. The Goldsmith version of autosegmental theory does not formally view tone as carried by the syllable. Therefore, under the Goldsmith analysis, the explication of the essential symmetry operating on A' and B' and on A and B, is lost.

4.7. Additional Phonological Evidence for the Syllable in Kinyarwanda

We will now re-inspect, from a different perspective, the Kinyarwanda data (See Section 2.4.2.2.) where the data to the left represents a fully-specified underlying representation and the data to the right represents the phonetic output:

(160)	(a)	a-ga ífi	a-gá-fi
	(b)	u-ru-ífi	u-ru-fi
	(c)	a-ka-índa	a-ká-da
	(d)	u-ru-índa	u-rú-da

We argued that two major operations take place in deriving the final phonetic outputs. First a Tone Anticipation Rule (TAR) applies:

(161) (b) u-ru-ifi → (TAR) u-ru-ifi

L L H L L H L L

(c) a-ka-inda —(TAR)→ a-ka-inda

L L H L L H L L

Next, a deletion operation applies deleting both the L-tone and the vowel associated with it for cases such as (162b); and the deletion on n as well for cases such as (162c):

(b) u-ru-ifi —(i-del.) (L-del.)→ u-ru-fi

L H L L L H L

(c) a-ka-inda —(i-del.) (n-del.) (L-del.)→ a-ka-da

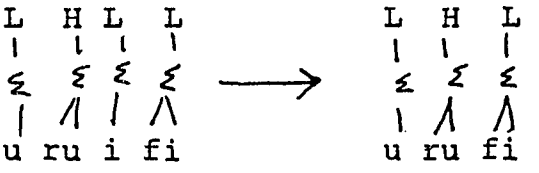
L H L L L H L

We observe that under an analysis of this data utilizing the Goldsmith version, where tone is associated with vowels, the deletion process requires for cases such as (162b) the operation of two separate rules; and that it requires for cases such as (162c) the operation of three separate rules.

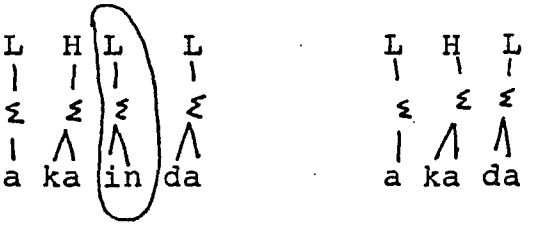
Observe however that under a syllable-structure analysis in which tonal units and segmental units are constituents of the syllable, the deletion process requires the operation of only one rule - that of

Syllable deletion.

(163) (b)



(c)



The syllable-structure analysis permits the explication of the linguistically significant generalization that what is being deleted is the syllable-as-a-whole (See circled item in (163c)). This is captured in a syllable-structure analysis by a single rule.

The Goldsmith version however dies not formally permit this linguistically significant generalization to be expressed. Instead, separate rules must apply to the tonal domain and to the segmental domain. Such an analysis is clearly more costly to formulate.

In conclusion, we have demonstrated that an analysis in which the syllable is formally treated as an independent phonological unit provides for a more descriptively adequate analysis of the data and also "simplifies" the phonological description of the data (in that clearly fewer rules need to be posited).

4.8. Conclusion

In this chapter, a preliminary investigation into the formal operating procedures of tonological phenomena in a syllable-based model has been explicated. Such a model, it is maintained, incorporates an extension of Chomsky's projection mappings - as described in The Logical Structure of Linguistic Theory - to encompass the syllable as the phonological unit on which atomic segmental units are linearly ordered, and on which atomic suprasegmental units (read tone) are also linearly ordered. This model logically employs hierarchical- and co-constituent analyses of phono/tonological organization, and it formally distinguishes the status of the syllable from that of the segment and of the suprasegment, by means of the proposed Conditions on Mapping.

In support of the model, a number of strong arguments have been presented which maintain that a more unified analysis of tonological data is derived from treating the syllable as an independent phonological unit.

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