The Aims of Autosegmental Phonology

John Goldsmith

In this paper, I shall discuss several aspects of an approach to generative phonology known as "autosegmental phonology." Autosegmental phonology shares with more traditional generative phonology a commitment to a formal account of phonological processes, and also a commitment to developing a formalism in which the common, expected, or "natural" developments in a language are represented in a formally simple way. What distinguishes autosegmental phonology from the Sound Patterns of English type of generative phonology is, first, the development of a multi-linear phonological analysis in which different features may be placed on separate tiers, and in which the various tiers are organized by "association lines" and a Well-Formedness Condition; and, second, analysis of phonological phenomena less in terms of feature-changing rules as such, and more in terms of rules that delete and reorganize the various autosegments, through the readjustment of the association lines.

The general program for research has gone in a number of directions, and I shall emphasize in this paper a few of these areas. In the first part (§1), an informal account of the original motivations for the auto
tamental treatment of suprasegmentals is presented. It deals with issues discussed in more detail in Goldsmith (1976b). In the second part (§2), I shall illustrate the power of an auto
tamental approach in dealing with an intricate corner of the tonal system of Igbo. In the third part (§3), some of the interesting and exciting suggestions made by Clements, McCarthy, Haiguchi, and others regarding the treatment of other suprasegmental phenomena in an auto
tamental way are discussed, and in the fourth section, (§4), I sketch some of the ways the general approach can deal with typically segmental assimilation phenomena. I try, furthermore, to motivate the existence of auto
tamental levels in languages classically considered to contain supers
gments, and even those which appear more traditional. Finally, in §5, I remark upon the view of phonology I see lying behind the auto
tamental approach, and how this view may be seen to differ from that lying behind various others of the theories presented at this conference.

1. American phonology has shown—not always, but at times—a peculiar rigidity in its conception of the "shape" of phonological repre
tations. One of the aims of auto
tamental phonology is to investigate the consequences of having structures in phonology more complex, or more articulated, than a simply linear string of segments. I shall discuss some of the tools offered, and some of the problems they can deal with.

The aim, then, of auto
tamental phonology is to deal with the consequences for generative phonology of multi-linear phonological analysis and representation. That is, we let go of the assumption that phono
tological and phonetic representations consist of a single string, or con
 casation, of segments. Instead, we set up underlying and surface forms consisting of parallel strings of segments arranged in two or more tiers. Features are distributed over the various tiers in the sense that no feature may appear on more than one tier. This somewhat richer phonological representation then serves as the basis for a more enlightening, and ultimately simpler, formal phonological analysis.

Part of this idea, certainly, is not new to linguistics. The Firthians are quite serious in their attention to prosodies, those units in the phono
tological analysis above and beyond the sequential "phonemic units," or segments, as we might call them. It seems to me that in their attention to such processes as vowel harmony and the complexity of tonal systems, and in their rejection of a strictly linear view of phonological representations, the Firthians are right on the mark. So too were Bernard Bloch (1948) and Zellig Harris (1944) in their discussions of the more complex possibilities of segmen
tation in their articles in Language. Apart from this major point of agreement with Firthians or proto-Firthians, the auto
tamental approach differs on at least two other important points. The first is the centrality of the distinction maintained in the auto
tamental approach among the notions of segment, feature, rule and association. This four-
way distinction does not correspond in any natural way to the concepts and constructs found in Firthian phonology. The notion of feature in the generative framework corresponds in the Firthian framework to...
the notion *prosody*—an element which furthermore plays the role corresponding to phonological rule and to "true tonal segments" (in our terms, autosegmentalized features).

But the only types of prosodies that correspond to autosegmental analyses are those in which the prosodies are phonetically homogeneous—which, as a review of the literature will show, is a small percentage of the extant prosodies. (For further discussion, see Goldsmith [in preparation].)

The second major difference between Firthian and autosegmental analysis lies in the emphasis, placed upon rules and their interaction with the Well-Formedness Condition. We shall see an example of this in section 2 below.

If there were several precedents for breaking away from a strictly linear representation, how this was to be done within the framework of generative grammar has been problematic. The clearest generative position on this is found in Chomsky (1955:29):

"(T)hough the representations that we construct on any linguistic level are multidimensional, we have not required that left-to-right order of representation correspond directly to temporal order in the represented utterance.... By accepting a linear system of representation, we rule out the possibility of certain kinds of discontinuity. If more general kinds of discontinuity than we can handle occur in language, a more general theory of representation will be necessary."

FN: In this study, suprasegmental features (pitch, stress, syntactic juncture) have not been seriously considered. Ultimately, of course, these phenomena must be incorporated into any full syntactic theory, and it may be that this extension still requires a more elaborate system of representation.

A significant step was taken by William Leben (1973) and Edwin Williams (1976). Leben's and Williams' suggestion did not change the picture of phonetic representation as a linear sequence of segments—but not reverting to the Bloch-Harris position—but they did suggest that the representation underlying some particular sequence of "phonetic" segments could consist of two parts and quite independent sequences of pheme-type segments, one sequence providing the tonal information, the other sequence containing everything else. Naturally, to have a surface or phonetic representation that was entirely one-dimensional—that is, a simple sequence of segments—they each provided for "feature mapping," which joined two separate sequences of segments into one single linear sequence.

The autosegmental approach arose out of certain inadequacies that

John Goldsmith were brought to light explicitly and implicitly by Williams' and Leben's work. The most glaring problem was the nature of "contour-tonal" vowels—that is, vowels whose surface tone is rising or falling, a situation that can often be shown to be the result of a concatenation of Low and High level tones. How can a single segment carry or cause two tonal specifications in sequence? This was the first problem to resolve

Intimately related to this was the necessity of explaining the relationship of the left-to-right ordering inside the segment (if seemed) and the left-to-right order of segments themselves. A tonal assimilation occasioned by a Low tone that affects a High tone to its right, for example, will turn that High tone into a Rising tone for a Falling tone. (1) represents this as a strictly linear system would: but, strictly speaking, this way of representing a contour tone makes sense. We may look at the solution to this problem as a "boundary condition" on the solution to the first question, the representation of contour tones.

\[
\begin{array}{c}
V \\
\text{[ + high]} \quad \text{Co} \quad \text{[ + high]} \\
\end{array}
\]

Yet another problem in the theory of tonal representations (cf. Goldsmith 1975b) is what I have called "stabilization," and, rather interestingly, its import is apparent only within a generative framework. "Stabilization" refers to the resistance of the tonal features of a vowel to deletion, even when the vowel that bore the tonal features is deleted or desyllabified.

The resolution of these problems was the introduction of several parallel strings of segments in the phonological and phonetic representations, enriched in a significant way by "association lines"—lines which, at the phonetic level, indicate the "co-registration" of the different tiers of segments. A language in which tonal features are autosegmentalized will represent a bisyllabic word with a tone pattern High + Low as in (2); a rule that would cause the second syllable to assimilate to tone would modify (2), change the relative domains of the tonal and non-tonal segments, and produce, in turn, (3).

\[
\begin{array}{c}
CV \quad CV \\
H \quad L \\
\end{array}
\]

\[
\begin{array}{c}
CV \quad CV \\
H \quad L \\
\end{array}
\]

(3) represents, it should be clear, a bisyllabic word whose tone pattern is High-Falling.
This autosegmental representation automatically solves our first three problems. The contour-toned vowels are, as (3) suggests, those in which the association is not purely one-to-one; tone-spread rules that give rise to certain kinds of contour tones are the effect of a rule that adds an association line. We see such a change occurring between (2) and (3). We might note, furthermore, that the only rules which have the simple geometric property of adding an association line do, in fact, produce "natural"—that is, occurring—types of assimilation. Thus simplicity in the formalism does seem to match naturalness in the phonological system. Thirdly, stability of tonal features is the natural consequence of a rule deleting a segment on the tier consisting of non-tonal features (the upper tier, that is, in (2) or (3)). Now, in a language in which such an autosegmental representation is appropriate at the underlying level, two possibilities are open. Either the lexical entry for a word consists of a pair of strings of segments—much as in (2), but without the association lines—or else each tier might constitute a separate lexical entry. Thus two "morphemes" may in fact constitute the single underlying phonological level—one on the tonological tier, one on the non-tonological tier.

This kind of independent-minded behavior is familiar to linguists under the guise of "floating tones"—morphologically identifiable elements (a High tone, for example) whose position with respect to the syllables in the sentence is determined by the syntactic structure. That is to say, it can frequently be shown in tone languages that the tone pattern of a sentence is composed of the tonal patterns of the individual words in the sentence plus an additional tone, a morpheme which contributes only to the tonal pattern and not to the number or make-up of the syllables.

Conversely, it is often found in such tone languages that certain syllables are underlingly devoid of tone, and receive a tone only through the influence of their neighboring tone-lending syllables. In general, then, a language with N level tones has the potential of N + 1 types of morphemes, tonally speaking. In a language with N level tones, a syllable may underlingly be any of the N tones (or some concatenation of these) or it may be not marked for any tone. An interesting example of just such a situation is described in Wilkinson (1976).

Both of the cases described in the last two paragraphs, it should be clear, are examples of an underlying "mismatch" between the number of tonal segments and the number of syllabic segments—a difficult concept to deal with within a more familiar generative approach.

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A crucial problem that arises now for any generative approach of the sort we have been considering is this: what is the technical device that relates the two tiers of segments? So far we have made allusion to association lines and their function; but at this point, we should make clear their origin. We may assume that all association lines (on segments other than boundaries) are introduced at some point in the derivation after the underlying representation. This amounts to, in effect, saying that there are no association lines in the stored or underlying representation. And this, in turn, implies that all underlying representations are linear.

If underlying representations, then, contain no association lines, these association lines are first introduced by rule. The range of possible association rules is still undefined, but in African tone languages, for instance, it is clear that a major rule in this respect is mapping one tone per syllable, starting from the left (see Edmundson and Bendor-Samuel (1976), Williams (1976), Lebek (1973, 1977a), Goldsmith (1976b); for a forthcoming study of the interaction of accent and association rules, see Haraguchi (1976); on Sanskrit, May and Goldsmith (1975); on the interaction with the cycle, Elmslie (1976)).

A rather powerful convention—perhaps too powerful, actually—on derived forms was suggested in Goldsmith (1976a, b) and elsewhere, a convention called the "Well-Formedness Condition" (WFC). This convention has the effect of adding or deleting association lines at any point throughout the derivation. Stated informally (see Goldsmith (1976b) for a more unified statement), it reads:

Well-Formedness Condition
1. Each vowel must be associated with (at least) one tone.
2. Each tone must be associated with (at least) one vowel.
3. No association lines may occur.

One consequence of the WFC can be seen in (4). When a toneless suffix appears on a stem, the tone associated with the stem automatically has its domain extended to the suffix as well (cf. (5)).

(4) C V + C V + C V
      1 2

Such a Condition, it can be seen, would have the effect of placing floating tones on some vowel or other—of "docking" the floating tone, we might say. Certain additional principles—some language-specific, some
universal—may be necessary to effect the results required by the WFC.

In general, however, the autosegmental approach is not meant to deal
only with tone; other languages (for example, Guaraní) approach
naturalization in an autosegmental way, and other features (other than
the major class features) could be dealt with autosegmentally. 8

2. Let us look at a typical autosegmental analysis, based on data from
Igbo. A crucial fact about tone in Igbo is that there are three contrast-
ing tones: High, Low, and Drop (or Mid). High, Low, and Drop con-
trast after a High or Drop, but the three-way contrast is reduced to a
two-way contrast after a Low tone; in particular, High and Drop are
indistinguishable phonetically when they follow a Low tone. Further-
more, a Drop tone is distinguished from a High tone in that the Drop
tone is produced a pitch-step lower than a preceding Drop or High tone.
A High tone (N.B.) will be produced at the same pitch as a preceding
Drop or High. Schematically we can summarize this as follows:

\[ \begin{array}{c}
\text{High} \\
\text{High Drop Drop} \\
\text{High Drop High}
\end{array} \]

Williams (1976) used a certain tonal mutation in nouns (which we
shall call “Object Mutation”) in Igbo can be used as a diagnostic for
the presence of a (sometimes floating) H tone preceding these mutated
nouns. In Goldsmith (1976b) the analysis is deepened, and the Booting
tone is shown to account for an interesting set of alternations. Two
aspects are crucially “autosegmental”: first, positing a tonal deletion rule
feeding the Well-Formedness Condition, and second, derived structures
as in (7). Crucially, in one case (114 below), the domain of a Drop
tone is spread over two syllables, yielding a configuration as in (7).

\[ \begin{array}{c}
\text{CV} \\
\text{CV} \\
\text{D}
\end{array} \]

In a context after a High or Drop tone, it has the same phonetic render-
ing as a sequence of Drop+High syllables but it does not have the same
phonetic realization as a sequence of Drop + Drop syllables (cf. (6)).
Thus in (14), the spread of the domain of the Drop tone must be viewed

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autosegmentally, rather than as a segmental assimilation of tonal
features.

The relevant facts are these. (c) Each verb stem is lexically marked
as being underlyingly Low-toned or Non-Low. In the II Root pattern,
the pattern we shall consider, there appears a prefix /a/ (or in its harmonic
alternant). The tone of the prefix is underlyingly the cp-pitch of the tone
of the stem; thus, with Low-toned verbs, the prefix is High-toned, the
stem is Low-toned, and the suffixes to the verb are all High-toned—this
last being the effect of the “Booting” (affixal) H that Williams argues for.
Consider thus (8).

\[ \begin{array}{c}
\text{NP Subject} \\
\text{Prefix} \\
\text{stem} \\
\text{suffix}
\end{array} \]

(8) òbú \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \)
\( \text{H} \) \( \text{H} \) \( \text{H} \) \( \text{L} \) \( \text{H} \)

“Eze swept ...”

If no suffixes on the verb occur, the Stem L-tone and the suffixed H-tone
converge on a single syllable, as in (9). A role of Low-High simplification
is an easily motivated rule in Igbo, given transparent alternations elsewhere
in the language.

\[ \begin{array}{c}
\text{prefix stem suffix}
\end{array} \]

(9) òbú \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \) \( \hat{\text{a}} \)
\( \text{H} \) \( \text{H} \) \( \text{H} \) \( \text{L} \) \( \text{LH} \)

Verb

(10) Low-High Simplification

\[ \begin{array}{c}
\text{LH} \\
\text{LH} \\
\text{LH}
\end{array} \]

(The tone on the object \( \hat{\text{a}} \) in (9) actually changes to D due to the
role of Object Mutation mentioned above, but that is not directly relevant
here.) Thus the surface form of (9) is (11).

\[ \begin{array}{c}
\text{prefix stem} \\
\text{suffix}
\end{array} \]

(11) òbú òbú òbú òbú

(ii) When the subject NP ends in a High tone, the tone on the verb and
prefix is altered. In particular, the tone of the prefix is deleted; thus
the word of the prefix associates with the tone of the stem, through the
Well-Formedness Condition. Thus we find—totally exceptionally—
contrasts like those in (12) and (13), where the relevant independent
variable is the final tone of the subject NP.
Theorematical Approaches

(12) ỉ́ɛ́ + ɩ́ + ɜ́ + ɬ́ N.B.: z is
        H L H L H D Low-toned verb.
  Subject Prefix stem suffix
  NP   Verb

(13) ɗ́bá ɗ́+b ɗ́ ɬ́ H L H L H D

(14) Prefix Tone Deletion: Main Classes only
    H [verb
    L [prefix

(iii) The evidence that this schematic way—i.e., an autosegmental de-
     lation—is the correct way to view the alternation is quite strong. First, we
     may observe that the shift of the tone of the prefix from High to Low (as
     in (12)—(13)), triggered by the High tone on the subject NP, is matched
     by a shift of the prefix tone from High to Drop when there are no suffi-
     xes (and concurrently the stem appears to shift from Drop to High). This
     is illustrated in (15); compare it with (9) and (11), where the prefix
     tone does not delete. This shows clearly that although the final H of
     the subject NP triggers the tonal change in the verb prefix, it does not
     determine what the new tone will be. In fact, the tone of the prefix
     will simply be the tone of the stem, as determined by the Well-
     Formedness Condition.

(15) a. [y a] [a+b] a [a] [a]
    by Prefix
    Tone Deletion

  H L H L H D

  yá ɗ́+b ɗ́ ɬ
  H L L L L

  (The tonal accent marks over the syllables are the transcriptions given
  by Green and Iwge (1963), i.e., the best segmental interpretation of the
  tones.)

(iv) Actually, the case for viewing the domain of the tone of the
     verb stem as being the prefix as well as the stem in certain cases is even

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stronger. There are two further arguments. The first is based on the
fact that the Low-High combination on a single vowel (as in (9) and
(13)) simplifies to Low if the following tone is High (otherwise it
simplifies to Drop, of course). Again, this rule—let us call it "Floating
H Deletion" (cf. Goldsmith (1976b))—is clearly motivated as well by
the tonal properties of the nominal compound system; I will not re-
view that material here. The process is illustrated in (16)—(17). How-
ever, the effect of this rule is to create a rather striking contrast between
forms like those in (15) where the object NP begins with a Low tone,
and those in (18), where the object NP begins with a High tone; observe
the effect on the prefix tone in (18), precisely as expected.

(16) ɗ́n ɗ́ l ě[l ɗ́ ě
  H L H D

(17) ɗ́n ɗ́ l ě[l ɗ́ ě
  H L H D

(18) y a a+b ɗ́ ě[e
  H L H L H D

  H L H H D

  by rule (14)
  by Floating H Deletion

  yá ɗ́+b ɗ́ ě[e
  H L H D

  (v) We can find a second, rather different, reason to support this analysis
  of the tonal alternations of the verb-prefix as expressed in (14). All the
  examples we have viewed so far have involved inherently Low-toned
  verbs. In this same construction, High-toned verb stems may appear
  and, as (14) Prefix Tone Deletion predicts, the tone of the prefix again
  depends on the final tone of the Subject NP. The relevant facts are sum-
  marized in (19).

(19) a. Subject ends in Low tone:

  d́ɛ́ kɛ́l ě ɗ́n
  subject verb object
  b. ɗ́bá ɗ́l ɗ́k wá
  subject verb object

  (We have the same verb in both (19 a and b.)
Our analysis so far has led us to the conclusion that the tone pattern on the prefix is closest to its underlying form when the subject NP ends with a Low tone, and that the underlying tone on the prefix is deleted when the subject ends in a High tone; in this latter case, the prefix vowel reassociates with the vowel of a verb-stem by the Well-Formedness Condition. All that is left to observe is that this is precisely what we do in fact observe in (19) as well, on the assumption that the underlying tone pattern for High-toned verbs in this construction is as in (19a)—that is, Low tone on the prefix, Drop tone on the stem. (20) illustrates how (19b) derives from a structure like (19a) through the operation of (14) Prefix Tone Deletion.

(20) a. s d h a + c j + a + k w a
   L H D H D by (14) 0 object

Yields by Well-Formedness Condition:
   b. s d h a + c j + a + k w a (19b)
   L H D H D

3. The study of other systems traditionally called "suprasegmental" has proceeded in the autosegmental framework. Haraguchi (1976) (and similarly Goldsmith [1975a] though not based on a comparably broad base of detail), show how the Japanese system of pitch and accent can be assimilated to a system of analysis originally suited to fit the intricacies of African tone languages. Oster (in press) has recently proposed some simplifications of Haraguchi's survey in an elegant fashion. G. N. Clements has developed in several papers an autosegmental approach to traditional vowel harmony systems (Clements [1976a, b, c]). Such a treatment analyzes the harmonic feature—tongue-body position, tongue-root position, and so forth—as a feature on a separate autosegmental tier. The autosegment associates across the entire domain of the word by the Well-Formedness Condition, as in (21) (an example from Akan, from Clements [1976a]).

(21) # [+back] [+high] [+round] f [+high] [+back] [+round] 1 [+high] [+back] [+round] 1 [+high] [+back] [+round] 1 #

# [−adv. tongue root] #

The vowel harmony process in Akan, at (21) suggests, is harmony for the feature "advanced tongue root." This approach permits, and requires, a unified statement of harmony within the stem as well as across morpheme boundaries. We thus avoid an arbitrary separation of vowel harmony into intra- and extra-stem processes. By the same token, we do not have what Kiparsky (1969a) called "a phonological use of morphological features"; the harmony autosegment is indeed a purely phonological item. More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features." More appealing yet, we can provide a natural account for words with more than one harmony domain, a capability not even available, as Clements notes, to advocates of "phonological use of morphological features."
Theoretical Approaches

John McCarthy, in a very interesting paper (1977) on Arabic vocalism, has argued, in effect, for the latter position. He reviews the well-known findings of Classical Arabic verbal morphology, and capitalizes on the qualitative differences found between, on the one hand, the kind of alternation occasioned by inflection—limited to varying the vowel patterns in a rigidly fixed syllable pattern—and, on the other hand, the derivational processes that form the often idiosyncratic conjugation or "measures," processes that drastically alter the syllable structure as well as the number of consonants involved. Despite the vagaries of the derivational morphological process, however, the inflectional morphology remains constant across different forms ("measures").

Thus, in Classical Arabic, the vowel pattern for the Perfect Active is /a/-...but in this case, there may be two or three syllables in the root, depending on the measure (i.e., depending on the effects of the derivational morphology). The vowel in each syllable will be /a/; however, in the Perfect Passive, the final vowel will be /i/, preceded by one or two occurrences of /u/, depending on the syllable structure determined, again, by the derivational morphology. In this latter case, then, we find a vocalic melody pattern of /a i/, where /a/ has precedence in spreading. See (23), for example.

(23) \[ τυψυν \nu b \]

Forms determined by derivational morphology

\[ τυψυν = tāmũbth \]

McCarthy considers a range of similar examples, and points out the close parallel in both the form and the function found in the Arabic vowel system and the Tiv tonal system described in Goldsmith (1976a, b). Although the data is complex, the parallel he draws is quite convincing, as in his analysis in general, pointing to vocalic systems like that of Arabic as being precisely the logical link between harmony systems of the sort analyzed by Clements and the tonal systems described earlier.

4. The last subject I would like to touch on is double in nature. First, can we extend the autosegmental approach to processes of a more "local" nature—not provoking in the usual reckoning—and if so, how? Second, what kind of answer can be provided to the deeper question: why are some features, in some languages, autosegmental?

In Goldsmith (1976b) I offered some speculations on the second question. The general thrust of the approach was to suggest that the first stage in a child's acquisition of the phonology of a language was a stage in which the phonological features were independent, or in our terms, autosegmental. This would suggest one ought to find /\[^{\text{a}}\text{p}\]/ harmony processes in early speech, which is, as it well known, quite true. The point of the hypothesis, however, was not to analyze children's speech, although the recent work of Lin (1977) provides some striking support for this approach. The point, rather, was:

(1) those features or feature-complexes which may be autosegmental in the adult grammar;

(2) the process of language acquisition includes a task of "de-autosegmentalization" to, or use a less awkward term, restructuring of the phonetics into linear segments. Suppose that this is one of the tasks performed by the child: decreasing the number of independent features in the phonetics, and realizing, for example, that there is in the English phonological system an entity that we call an "s" that has both nasality and stophood as characteristics. If this is one of the child's tasks, then there is no reason to think that the de-autosegmentalization should bring the number of independent tiers down to the singular number one. Thus the very same language acquisition procedures may be employed by a child learning English, Igbo, or Guaraní, but the child learning Igbo, for example, will never be presented with a reason to learn its initial assumption that tone is an independent property (the traces of natural phonology become noticeably distinct here).

The general line of thought, then, is that the autosegmental status of tone in Igbo, or uncommon in Guaraní, or toneless position in Hungarian, is not a complex phonological process learned late in the process of language acquisition, but rather the systemization (making of significance of imposition of systematics, rules, and so on) to a stage through which all learners of all languages pass. Thus the learner of English passes through a vowel harmony stage, such a learner would have it wrong for English, and later de-autosegmentalize English vowels. If that child had been learning a different language, though, the child would have maintained that "hypothetical," not gone ahead to elaborate the independence of the tone position features from those represented in the other segments.

This general line of thought has a further consequence for research. There is no reason to believe that the past of language acquisition I have called "de-autosegmentalization"—that is, the child developing a more or less single, linear model or representation for a language like En-
glish—should occur entirely before the child acquires more familiar sorts of phonological rules. That is, the child could begin to derive rules of phonology for English, or whatever language, even at the point when the child’s model for the underlying structure of the language is auto-

segmental.

If we assume, moreover, that these intermediate autosegmental levels of representation are present even in the adult grammar, then this hypothesis about language acquisition will give us a new tool for approaching the description of the adult grammar, and likewise if this new description is supported by the facts, we will be more secure in pursuing our hypothesis about language acquisition.

Now, what sort of evidence would we look for in the adult phonological grammar? Much of the evidence for autosegmental analyses of tone languages, for example, derived from “morphological” arguments—that is, a “morpheme” could be argued to be present on one autosegmental tier but not another. Such arguments will not be possible here, because we are attempting to falsify, now, an autosegmental representation which is derived from an underlying linear system. What evidence could we look for?

Just as much of the clear evidence for underlying autosegmental phonology comes from the existence of (underlying) morphemes which are present on only one autosegmental tier, so here the evidence we would look for would be derived segments present on only one derived autosegmental tier. One common phonological process that typifies this sort of process is the $s \rightarrow h$ change, two instances of which we consider shortly.

As in the Igbo analysis, we try to show the naturalness of a large variety of phenomena when viewed as deletions.

To summarize, we are considering a model in which the number of autosegmental tiers (or “index”) at the phonetic level is greater than the number of them underlyingly. Schematically, this presents a picture like this:

(24) $\alpha \rightarrow F$, $\beta \rightarrow F$, $\gamma \rightarrow F$

Underlying Representation

<table>
<thead>
<tr>
<th>$\alpha \rightarrow F$, $\beta \rightarrow F$, $\gamma \rightarrow F$</th>
</tr>
</thead>
</table>

Phonological rules

---

 expansion in autosegmental index to maximin

\[
\begin{align*}
\alpha \rightarrow F, \\
\beta \rightarrow F, \\
\gamma \rightarrow F, \\
\delta \rightarrow F.
\end{align*}
\]

Further (autosegmental rules)

\[
\begin{align*}
\alpha \rightarrow F, \\
\beta \rightarrow F, \\
\gamma \rightarrow F, \\
\delta \rightarrow F.
\end{align*}
\]

One example of this sort of process is found in many dialects of Spanish. Here I will restrict my attention to a preliminary analysis of one specific dialect, one spoken in Buenos Aires. In this dialect, all $x's$ between a vowel and a consonant, roughly, are converted into $h$.

(25) $x \rightarrow h / (+xyl) \rightarrow (-xyl)$

This happens both inside a word ([posta] $\rightarrow$ [posta] “until”) and across word boundaries. Thus [dous] before a vowel, but [doupas] “two passengers”.

A restatement of (25) in terms of features fails to express the linguistic naturalness of this process. The fact that the $/s/$ becomes $h$ rather than $[l], [p], \text{or} [t]$ is left unexplained.

If we say, on the other hand, that the $h$ derived from the $/s/$ does not have the same segmental status as the $h$ in English, but is rather derived only after the autosegmentalization of the various features occurs, then a different picture emerges. The segmental process in (25) becomes a deletion of the supra-glottal features instead, and the laryngeal features of the $/s/$ are all that remain. Reassociation of the now-floating $h$-
autosegment follows. In the derivations that follow, we consider res-
association to the left.

(26) a. [− high] + anterior + cor + spr gl
   + back + coronal + strid + syl
   + crp gl

Underlying: [− syl] + anterior + cor + spr gl
   + back + coronal + strid + syl

Autosegmentalization

b. [− high] + anterior + cor + spr gl
   + back + coronal + strid + syl
   + crp gl

oral

laryngeal [spread glottis] [+ spread glottis] [− spread glottis]

/− s-deletion/ 1

[− syllabic] + high
   + back

[− spread glottis] [+ spread glottis] [− spread glottis]

I am assuming at the moment that the rule deleting the oral "s" seg-
ment also explicitly specifies the resassociation of the laryngeal seg-
ment. There is much variation between dialects as to whether that seg-
ment resassociates leftward or rightward, and some even with this dialect.
Even under these limited conditions, however, we do find some significant ad-
vantages to this view of the process.

If the vowel preceding the underlying /s/ is an /i/, there are two pos-
sible allophones of the /i/, the metathetical highly tense, high front vowel
found in the other occurrences of /i/, and a slightly laxer version I shall
represent as /i/. Now, although i and I vary freely before s-plus-
cominant, h is not the surface form of /s/ after the tense /i/. In fact, we
get the surface variants as follows:

(27) /s/te/ /simmo/
   /s/te/  4 /simmo/ [mi/mo] [mihmo]

After /i/, not surprisingly, the tongue maintains its position throughout
the period, just as (26c) asserts it should. Consequently, the unvoiced

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flow of air causes turbulence at the tongue blade when it is in the /i/
position.

The point of all this is simply that representation (26c) says all that
need be said. In particular, there is no need to add an additional rule
turning /i/ into /[e] after /i/—in reality, once the deletion of the oral
autosegment was effected, the phonetic realization of a structure like
(26c) was a fait accompli. Only one last point should be emphasized:
the fact that the turbulence occurs at the tongue blade after /i/ and
not /e/ is not a fact expressed formally in the phonological grammar at
all; it is a consequence of the articulatory phonetics. This presents a good
illustration of how some facts of phonetics may best be excluded from
phonology, whereas others—like which articulatory organs are rela-
tively independent and thus may be autosegmental—are of great
significance to phonology.

A very similar analysis has been proposed by Hroakdur Thrainsson
(1978) for Icelandic. He reviews the facts concerning the well-known
"presappraisition" of stops in certain contexts, and argues persuasively
that the pre-aspirated stops are synchronically, as well as diachronically,
derived from geminate tense stops. The first of the two stops, however, is
weakened to an [h]—giving the impression of presappraisition.

In the case of Icelandic presappraision, we could... say that the
laryngeal articulatory gesture for the phonologically long or geminate
stop is made at "the correct" point in time—i.e., when the first half of the
stop is to begin—whereas the supralaryngeal articulatory gesture,
namely the oral closure, is not made until the second half of the phono-
logically long or geminate stop begins. In other words, we have to get
from a phonological sequence of two fully specified stops, as it were, to
a sequence where the first member is only specified for the appropriate
laryngeal features. What this means, then, is that the phonological
rule of presappraisition has to wipe out or delete the set of supralaryngeal
features for the first half of the stop and leave only the laryngeal
feature specifications... But is there any way of adequately formular-
ing a rule of this kind within a generative framework? The answer
is yes. The theory of autosegmental phonology offers a rather neat way
of doing this... Thus it seems that in some cases a certain subset of
the phonological features composing a phoneme can behave as a unit. I
want to argue that presappraisition in Icelandic is just such a case (Thrins-
son, p. 35).

At this point, just how these kind of analyses would be integrated into
a more general view remains to be determined, but the convergence of these
last two proposals seems to me to indicate a very promising direction.
5. CONCLUSIONS

In distinguishing autosegmental analysis from more traditional types of generative phonology, the emphasis here has been on the more articulated types of phonological structure proposed by autosegmental theory, disallowed by Sound Pattern of English postulates. On the other hand, this should not be taken as an attempt to refute the SPE tradition; Sound Pattern itself is clearly a working paper, a summary of results and hypotheses offered by some working phonologists at a certain point of time. Suggestions that there is a "congealed...[and] classically dogmatic" consensus in post-Sound Pattern phonology (to use Roger Lass' [1976] phrase) I find quite unrealistic. Generative phonology, quite to the contrary, has been quite supple; and I submit autosegmental theory as a proposal, which, if correct in all the ways I have suggested here, will revile in some radical ways the generative view of phonology, while remaining essentially within the general view of the goals of phonology spelled out in Sound Pattern.

On the other hand, I do disagree with a number of the papers presented at this conference on some basic points, even holding aside questions of immediate empirical adequacy (but cf. Goldsmith in preparation c).

There is a view that has been repeatedly voiced at this conference to the effect that falsifiability is, or should be taken as, a measure of a theory's adequacy and success. As such, this seems to me to be a mistaken view, possibly arising as a misinterpretation of the by-now conventional wisdom of Karl Popper. Popper was only defending the view that falsifiability is one criterion to be used in separating science from non-science, not in choosing between approaches to a subject. If occasionally it is said that even the falsifiability measure chooses between two theories "all other things being equal," it can be said only in irony since other things never are. In any event, "falsifiability" is a sophisticated notion itself, for it surely cannot be taken in the obvious sense of producing counter-examples. Falsification at best can only be done by alternative theories, and just what the "logic" of competition between theories is is still open to considerable controversy (for some skeptical views, see Lakatos [1970] and especially Feyerabend [1975]). At all events, it is by no means obvious that the ease with which a theory can be destroyed—that we might call its "moribundity index"—is simultaneously a measure of its strength. Slightly altering Feyerabend's (1970) apt phrase, the strength of a theory might well be measured by the degree to which "the principle of fecundity" (retaining a theory despite confounding evidence) is successfully repealed by; but this raises difficulties concerning the notion "success" which we cannot go into here.

So much for the notions of falsifiability and vulnerability. I would mention a second viewpoint, one which contends that the plausibility, attractiveness, and in the end the value of any theory of phonology depends on its ability to deal with a language comprehensively and in depth. That is, a theory—as opposed to a specific analysis—should lend itself to, and indeed provoke, a full-scale investigation of the details of language systems, not just considerations of a few scattered facts in various languages. When is the investigation "full-scale"? When it reveals something unexpected, surprising, and remarkable about the nature of the language being looked at, I would say. In sum, I think that the criteria for choosing a theory have little to do with falsification directly. Rather, we must adopt a theoretical viewpoint which allows for the elegant interaction of hypothesis and data that has typified science. Of course, to the extent that the hypothesis and the data must mesh to be elegant, falsification plays a role—but very much a secondary one.

Returning to phonology, we have seen that autosegmental representation provides to generative phonology one way to incorporate some more traditional and phonetically-based notions. On the other hand, as the example in section 2 has shown, it allows for revealing analyses of "suprasegmental" elements using basic techniques of generative phonology.

Whatever gains have been achieved result from the enriched descriptive power of the formalism, we should note. I have no doubt that the potentials of the formalism are not yet exhausted, and that where even a multi-tiered approach is too weak to approach the facts, a further enrichment of the formal devices can and must be developed—as, for example, that proposed by Sigurd (1972), Liberman (1975), and Liberman and Prince (1977). In short, one important way to advance phonology is to open the formal footnotes as wide as possible. I think we need not worry about drowning in any consequent torrent of formal gadgets; as ever, the ides and unless formulations will eventually drown themselves. The good ideas can take care of themselves.

NOTES

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CHAPTER NINE

Siddha and Asiddha
In Pāñinian Phonology

S. D. Joshi and Paul Kiparsky

What is a grammar of Sanskrit written around 500 B.C. doing on the agenda of a conference on current linguistic theories? We shall try to demonstrate that Pāñini's grammar poses both a theoretical context and a contemporary relevance which make it more than just a chapter in the history of linguistics. The grammar includes a generative phonology of a depth and exhaustiveness to which no modern generative phonology has yet come close, which is moreover integrated with a fully worked out generative syntax and morphology, in a system of 4000 formalized rules based on very specific and elaborate principles of linguistic description. True, only a relatively small part of these underlying principles themselves are stated among the rules of the grammar. The rest must be deduced from the structure of the system and the way in which the facts of Sanskrit are analyzed there, a task which was begun by the traditional commentators and continued by modern scholars, but still remains to be carried out to the end. Thus, while the text itself is long on analysis and short on theory—just the opposite of a typical modern contribution to linguistics—it nevertheless presupposes and reflects what can be construed as a theory of grammar (though naturally differing from generative phonology in being arrived at on the basis of one language only, and in having no psychological premises). As for its contemporary relevance, this springs from the fact that very little in its phonological and syntactic analysis of Sanskrit has to our knowledge yet been superseded, the various partial efforts at synchronic reanalysis having evidently so far not led to any major revision. (Of course, Pāñini's grammar continues to be the basic analysis of Sanskrit accepted by traditional scholars in India to this day.)