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1 Introduction

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1. Prosodic Morphology before the 1990s[1]

One who consults Chomsky and Halle's (1968) Subject Index for entries beginning with *pros* is referred exclusively to passages discussing *prosodic features*. This is just one manifestation of this book's explicit claim that hierarchy has no direct role in the study of sound phenomena. Even though the input to the phonological component (a separate morphological component, including a lexicon, became available only later[2]) includes rich hierarchical structures, in that it is the output of the grammar's syntactic component, these structures are flattened out in a so-called intermediate readjustment component, resulting in completely non-hierarchical, flat strings. These strings are sequences of sound-segments and non-segments. The individual sound-segments represent the "sounds" of a given morpheme or word in an abstract sense, through binary-valued phonological features. These features include the ones traditionally called "prosodic," such as [stress], [pitch] and [tone] (376–77), but they have no special status *vis-à-vis* other features, just as for instance "cavity features" ([anterior], [coronal], [back], etc.) have no special status. Non-segments are the boundary symbols and the syntactic brackets, such as those occurring between a stem and an affix, between two words, between two phrases, and so on. Roughly speaking the number of boundary symbols and/or brackets between two morphemes reflects their degree of "coherence" (or, conversely, their comparative degree of embedding in the syntactic tree), but this not a hard-and-fast rule: not only is it the task of the readjustment component to flatten out hierarchical structure, but some of the rules of this component are also allowed to manipulate (segments and) non-segments,

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More information

resulting in derived representations from which the original syntactic structure cannot any longer be automatically read off.[3]

In sum, two aspects of *SPE*'s position on the linear nature of a phonological representation are relevant here. First, with respect to sound segments: these are sequences of bundles of unstructured phonological features; this is what Goldsmith (1976a) has called the Absolute Slicing Hypothesis. Second, with respect to non-segments: these are part of the flat string, and they can be manipulated (by readjustment rules) and contextually referred to by the rules of the phonology. These two aspects are what Liberman and Prince (1977: 333) have called the *linear* nature of this account.

Nonlinear phonology of the 1970s is a reaction to these claims of the standard theory.[4] *Prosodic* phonology can be seen as a subbranch of nonlinear phonology, specifically that branch dealing with prosodic categories (although this narrowing down is not always maintained). In the research area of Prosodic Morphology, some of the interesting results of the study of prosodic phonology are applied to the study of morphology, in areas where the two appear to interact. Since morphology, in the sense of *word* formation, is now standardly assumed to be situated in the lexicon (cf. note 2), the prosodic categories typically employed in Prosodic Morphology are those from the word-level down, i.e. the mora, the syllable (and possibly some of its constituents, such as onset, nucleus, and coda), the foot, and the prosodic morpheme, and word.[5] Let us consider some examples.

Two major research areas within nonlinear phonology are *autosegmental* phonology and *metrical* phonology. Although both are hierarchical or three-dimensional, they differ with respect to the empirical material they focus on. Although there is no *a priori* or principled strict division of tasks between the two, autosegmental theory traditionally deals with phenomena such as tone (spreading) and various types of assimilation (prominently including vowel harmony), whereas metrical theory deals with syllable structure, stress, and rhythm. The first work to turn doubts about absolute slicing into a theoretical framework of spreading and assimilation phenomena is Goldsmith (1976b):[6] it introduces autosegmental phonology as a reaction to the linear *SPE* theory. As an illustration of the basic tenets of this framework, consider the following brief description of Igbo vowel harmony, comparing the *SPE* treatment with the autosegmental one by Clements (1976).

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In a vowel-harmony system characteristically all vowels within a word have the same value for a "harmonic feature." Usually, there can be identified within a word a source or trigger of the harmony, and there are two ways in which the pertinent feature value can spread throughout the word from this source. First, the feature can spread from the stem to all the affixes in a word; this is called symmetric or root-controlled vowel harmony. Second, the feature can spread from a fixed position (the leftmost or rightmost vowel of a certain quality) in one particular direction; this is called directional harmony. The West-African Igbo language has symmetric harmony, and the *SPE* account assumes a relatively complicated set of three separate ordered rules to capture it (Chomsky and Halle 1968: 378–79). On the other hand, Clements's account looks (at worst) like this:

(1) Associate

The question is how autosegmental phonology enables one to accomplish this extreme descriptive reduction. Some simple Igbo facts:

(2)	e-ke-le	"don't share"	a-zu-la	"don't buy"
	i-vu	"to carry"	i-lu	"to marry"

The property of Igbo harmony any analysis aspires to account for is that vowels in a word are either [+ATR] or [–ATR], i.e. they have or they have not an "advanced tongue root" (the underlined vowels in the lefthand words are all [+ATR]; this property is lacking ([–ATR]) from the vowels in the righthand words). An *SPE*-type derivational analysis with rules distinguishes three steps in this procedure. First, all affix vowels are specified [–H]. This is a completely arbitrary "diacritic" specification, which will have a phonological function only later in the derivation. Stems can be underlyingly specified either [+H] or [–H]. When the stem is intrinsically [–H] and all affixes are [–H] following the first step, we have already come a large part of the way towards accounting for harmony. When the stem is intrinsically [+H], however, a second rule specifies all vowels to the left and to the right of the stem (so: all affix vowels again) as [+H] as well. Finally, a third rule gives a phonological interpretation to the arbitrary feature [H]: it says that the feature actually means [ATR], and that [+H] corresponds to [+ATR] and [–H] to [–ATR]. Reconsider the data in (2), the righthand words first, since the state of affairs in these words is simple: the stems *-zu-* and *-lu-* are [–H]

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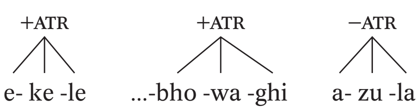
underlyingly, all affix vowels become [–H], and at the final stage the [–ATR] interpretation is provided. The lefthand words are rather where the action is: three consecutive operations ([–H] on affixes, spreading of [–H], and phonetic interpretation) result in words that have [+ATR] vowels only.

One interesting type of data Chomsky and Halle apparently did not have the opportunity to have a look at is the phenomenon of *opacity* in vowel-harmony systems. This means that certain vowels or certain affixes may block the spreading of the harmonic feature throughout the word: they interrupt the wave. In (3) below are some Igbo data (nonopaque vowels are in italics):

(3) a. ...-bh*o*-w*a*-gh*i* "put-begin-emph."
b. v*u*-si "distr.-carry"
c. ...-bh*o*-si-ghi "put-carry-emph."

(3a) is a case of perfect harmony, involving the suffixes -*wa* and -*ghi*. The second example, (3b), shows that the suffix -*si* exceptionally does not take part in harmony. The bottom form shows that the harmonic wave cannot reach the rightmost suffix -*ghi* across the exceptional suffix -*si*: it is as if, as well as being an exception, -*si* automatically has the property of inducing its own harmony, to the right. There is nothing in the linear account of (1) that hints at how this may come about, although opacity is a very common phenomenon in harmony languages.

What happens in an autosegmental account of these data? The crucial step in an autosegmental analysis can be compared to solving the puzzle of having to make three triangles with six matches: one is required to introduce hierarchy or multi-dimensionality. More specifically, we observe the "autosegmentalization," or "setting apart" of the harmony feature on a separate level or "tier." Autosegmental representations of regular cases of Igbo harmony look as in (4):

(4)


Such representations are derived from underlying forms in which the autosegment, as it were, floats over the vowel of the stem, and affix vowels are unspecified for the harmony feature, i.e., representations

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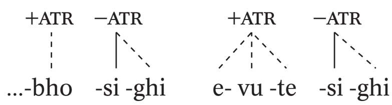
such as (4) without any "association lines" whatsoever, the latter being drawn as a result of the so-called Well-Formedness Condition (WFC) on autosegmental representations. This WFC is a universal, and has the following form:

(5) a. all vowels are associated to at least one autosegment
 b. all autosegments are associated to at least one vowel
 c. association lines may not cross
 d. association of unassociated autosegments precedes drawing lines from associated autosegments

The WFC derives (2) and (3) from (4), through (5a–b). The role of (5c–d) becomes clear from the way it allows opacity to be treated. An exceptional affix is underlyingly preassociated with its own harmony feature: in this way, [+ATR] can never reach vowels outside (to the left or to the right of) exceptional vowels, as association lines may not cross.

(6)


The correct direction of spreading (the dotted lines in (6)) follows from (5d). The language-specific information needed to trigger the procedure is that *-si* is an opaque (preassociated) suffix, and [ATR] is an autosegmental feature. All else simply follows from the universal WFC.

Then consider the next event, of crucial importance to this introduction. McCarthy (1979) applies the principles of autosegmental phonology to morphology, effectively establishing the field of Prosodic Morphology. He discusses the phenomenon of discontinuous affixation in Semitic morphological systems, specifically that of Arabic; in data such as those in (7) below, consonants play the role of stems (or *binyanim*) and vowels play the role of affixes.

(7)

katab	I	Perfective Active
kaatab	III	Perfective Active
ktabab	IX	Perfective Active
ukaatab	III	Imperfective Passive
kuutib	III	Perfective Passive
ktanbab	XIV	Perfective Active
aktanbib	XIV	Imperfective Active

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McCarthy first shows how a linear account, more specifically that of Chomsky (1951) (but all others have the same relevant formal properties), deals with the discontinuities in such output forms. Given consonantal stem patterns (C_1-C_2-C_3) and affixal vowel patterns (V_1-V_2), a transformational rule of the following sort is required in order to derive the linear sequence of consonants and vowels in the output, for the first form of (7):

(8) $C_1\text{-}C_2\text{-}C_3 + V_1\text{-}V_2 \rightarrow C_1V_1C_2V_2C_3$

Similar rules will be required for the other forms. But transformational rules are an extremely powerful device for morphology to incorporate (McCarthy 1979: 358):

(9) Morphological transformations potentially allow any arbitrary operation on a segmental string. For example, transformational morphological rules of this sort can freely move particular segments an unbounded distance within the word, copy all and only the vowels in a word, or reverse strings of finite length.

This is a strong incentive to look for alternatives, and one such alternative lies in the strategy of seeking an analogy between autosegmental phonological phenomena and the morphological one under discussion.

Thus, just considering the top two forms of (7), the stem consonants and affix vowels can be seen to be exactly the same (and in exactly the same order), with only a single difference residing in the number of vowels occurring in the forms. McCarthy proposes to deal with these two cases in the following fashion. In so far as the mix of vowels and consonants in a given *binyan* is unpredictable, the shape of the *binyan* is specified in a so-called "syllabic skeleton" or "template"; for the two forms under discussion these templates look as in (11b) below. Then, in an autosegmental manner, stem and affix "melodies" are each specified on separate tiers ((11a) and (11c), respectively), which in this case clearly have a morphological function. The WFC variant employed in order to establish the correct associations between template and melodies is that of (10). Notice the high degree of similarity between (10) and (5), which makes it desirable to assume a theoretical common denominator.

(10) a. each slot in the skeleton must be linked with at least one segment in the melody
b. linking lines must never cross

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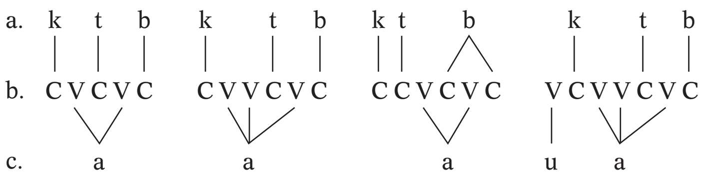
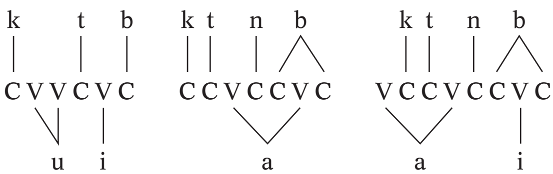
c. (unless otherwise stipulated) segments in the melody and slots in the skeleton are linked one-to-one from left-to-right
d. when a melody contains both linked and unlinked units, it is the latter that are spread to unfilled slots

Immediately including the next two cases of (9), representations for the first four forms look as in (11), after application of the WFC of (10):

(11)


We have seen that in vowel harmony, (vowels of) affixes may be prespecified as opaque, by prelinking them. Exactly the same technique is a useful device in the remaining cases of (7), which either have an unpredictable vowel pattern or a consonantal infix in an unpredictable position, or both at the same time:

(12)


Without prelinking, the infix could go anywhere with respect to the stem consonants; and left-to-right association predicts that similar vowels will cooccur on the righthand side rather than the (in these cases empirically correct) lefthand side. There are many more intricacies to these Semitic morphological systems (see the remainder of chapter 4 of McCarthy's dissertation, and example (23) below), but the claim seems justified that Prosodic Morphology, leaning heavily on the earlier results of nonlinear phonology, allows for both much more insightful and theoretically less powerful accounts.

As pointed out above, metrical phonology is a reaction to the analyses of the standard theory in the realm of stress, rhythm, and syllable structure. The earliest work in the nonlinear approach in these areas is represented by the mid-1970s Ph.D. theses by Liberman (1975) and Kahn (1976). Taking a syllable structure example from the latter, in fact one that has a classical structure: generalizations are lost when syllable

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structure is not directly available in phonological analyses (the position of the *SPE* theory is of course the reverse: there is no need for fear that generalizations are lost by not directly representing syllable structure). The argument for the syllable is two-pronged. First, in standard phonological analyses a rule like that in (13a) below expresses a generalization via the curly bracket notation which two separate rules would fail to capture. Second, however, the fact that an equally general, abbreviated rule pair such as that in (13b) does not occur very frequently (if at all), argues against the bracket notation as the correct generalizing device for these cases.

(13) a. $/r/ \rightarrow \Phi \ / \ \_\_\left\{\begin{matrix} C \\ \# \end{matrix}\right\}$ b. $/r/ \rightarrow \Phi \ / \ \_\_\left\{\begin{matrix} V \\ \# \end{matrix}\right\}$

If this is so, we need something to replace these curly brackets. In fact, cases of type (13a) remind one strongly of the traditional notion of "syllable"; consider data such as those in (14) regarding the process of *r*-loss in many varieties of English:

(14) /r/ lost:

b a r k b a r k e r b a r (# is...)

/r/ retained:

r e d M a r y c o r r e c t b a r ‿ i s

In *SPE* terminology, *r* is lost before a consonant or a word boundary (but the latter not in relatively fast speech). Such a statement implies curly brackets; however, these can be eliminated when we say directly that *r* is lost when tautosyllabic with a preceding vowel.[7]

Once we assume, on the basis of a phenomenon such as English *r*-loss, and others like it, that the syllable is part of the basic linguistic vocabulary, one of the questions that arises is whether perhaps, just as segments (insofar as the notion of "segment" survives an articulated theory of autosegmental phenomena[8]) are organized into syllables, syllables themselves are organized into higher units. The answer to this question has turned out to be an affirmative one, the relevant unit of organization one level up being the "foot." The earliest arguments for this unit can be found in Selkirk (1978, 1980) and Vergnaud and Halle (1978). This time consider the phenomenon of French *e-muet*: in this process, schwas are optionally deleted, as long as the output does not contain a triliteral consonant cluster.

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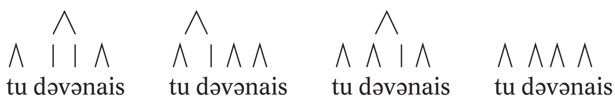
(15) a. souv(ə)nir   pass(ə)ra
     b. parvənir   soufflәra   *pa[rv-n]ir   *sou[fl-r]a
     c. (tu) dəvənais, dəv-nais, d-vənais   *[d-v-n]ais

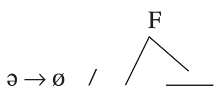
The linear analysis of Dell (1973) mentions exactly the required condition as a constraint on the possible outputs of the rule, but such an addition (i.e., a "derivational constraint") functions as a "violation of the otherwise Markovian character of phonological deviations [sic]" (Vergnaud and Halle, 1978: 32). A nonlinear account may run as follows. First, assume that full vowels have that property represented by a branching structure over them; second, assume that *schwas* count as full after two consonants, and optionally as full (or nonbranching) otherwise. Finally, a nonbranching syllable must be accommodated by its left neighbor into superordinate structure. One can easily make out that four structures will thus become available for the phrase *tu devenais*:

(16)



It is equally easy to see that the rule of *schwa* deletion can now be formulated, Markovianly, as in (17):

(17)



So much is clear: the name of the superordinate structure cannot be "syllable"; it is, rather, a sequence of syllables, organized in a particular fashion; it is the foot.[9]

Syllable and foot are now known as "prosodic categories," and the study of prosodic categories is a separate branch of (metrical) phonology. Lexical prosodic categories that have been added more recently are the mora (a unit of phonological "weight," especially in systems of stress and length) at a level lower than the syllable, and the (prosodic) word, as a unit in which feet are commonly organized. It may furthermore be useful to divide the syllable into the constituents of "Onset" and "Rhyme" (and the "Rhyme" into "Nucleus" and "Coda").

An extremely interesting phenomenon in which notions from autosegmental and metrical theory have been argued to team up, is that of

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"reduplication," i.e., the type of morphology in which affixation takes place by repeating either the whole stem or part of the stem in the derived form. Influential in this area has been Marantz (1982). Consider from that article reduplication data from Agta (a Philippine language) such as those in (18):

(18)	bari	"body"	bar-bari...	"my whole body"
	saddu	"to leak"	...sad-saddu	"to leak in many places"
	wakay	"lost"	...wak-wakay	"many things lost"
	takki	"leg"	tak-takki	"legs"
	uffu	"thigh"	uf-uffu	"thighs"
	ulu	"head"	ul-ulu	"heads"

Referring to McCarthy's analysis of Semitic *binyanim*, Marantz argues that the reduplicative affix is a complete melodic copy of the stem, but the shape of the copy is ultimately constrained by a (morphological) templatic condition on CV-sequences. In the case at hand, this template has the shape CVC. Association takes place from left to right (for prefixes and in the mirror image fashion for suffixes):

```
(19)  C V C + C V C V      C V C  + V C V
      | | |   | | | |        | |    | | |
      b a ri+ b a r i        u lu + u l u
```

An example in which the prosodic category of the syllable plays a role in a reduplication process is that of Yidin^y (Dixon 1977, Nash 1980, Marantz 1982: 453–56):

(20)	ḍimurU	"house"	ḍimu-ḍimurU	"houses"
	ḍaḍaman	"to jump"	ḍaḍa-ḍaḍaman	"to jump a lot"
	gindalba	"lizard"	gindal-gindalba	"lizards"
	ḍugarban	"to have an unsettled mind"	ḍugar-ḍugarban	"to have an unsettled mind for a long period"

Two observations are in order here. First, the reduplicative morpheme of Yidin^y is disyllabic, and second, this morpheme does not necessarily use a consonant to close the final syllable, even if the opportunity arises (**dimur-dimurU*). This is where Yidin^y also differs from Agta:

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