Stress and the Cycle

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Stress and the Cycle

1. A Notation for Stress

A fundamental fact about stress is that not every phoneme in a string is capable of bearing stress. In this respect stress is quite similar to tone, for it is the case in tone languages that only certain phonemes in the sequence are tone-bearing. The work of the last decade by Williams (1976), Goldsmith (1976), and others on autosegmental phonology has made it clear that the tones must be represented as a sequence of units (segments) that is separate and distinct from the sequence of phonemes—in other words, that in tone languages phonological representations must consist of two parallel lines of entities: the phonemes and the tones. Thus, the autosegmental representation of a word in a tone language will characteristically have the form illustrated in (1), where entities on two parallel lines—the T(one) line and the P(honeme) line—are linked to each other in various ways.

```
(1)   ——— T1 ———— T2 ——— T3 ———— T4 ——
           |
     -P1 — P2 — P3 — P4 — P5 — P6 — P7 —— P8 ——
```

Since two parallel lines define a plane, we shall speak of the *tone plane* when talking about representations such as those in (1). In (1) the tone-bearing units on the P-line are P2, P4, P7, and P8. The fact that a particular tone is pronounced on a particular phoneme is indicated formally by drawing a line linking the phoneme to the tone. As illustrated in (1), more than one tone may be linked to a given phoneme and more than one phoneme may be linked to a given tone. Thus, T3 is linked to the two phonemes P4 and P7, and P7 is linked to the two tones T3 and T4. However, it is not necessary that each tone be linked to some phoneme or that each tone-bearing phoneme be linked to some tone. For example, T2 and P8 are without link.

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Given an autosegmental representation such as the one illustrated in (1), there is a straightforward way of capturing the fact that only some units in the string are tone-bearing: it is only these units that may be linked to tones; all other units in the string must be skipped over when tones are linked to phonemes.

Following such studies as Liberman (1975), Liberman and Prince (1977), Hayes (1980), and Prince (1983), we propose to treat stress by means of the same basic formalism as tone—that is, by setting up a special autosegmental plane on which stress will be represented and which we shall call the *stress plane*. A result that will emerge from this study is that the placement of stress reflects an organization of the sequence of stressable elements that is not concerned with the phonological or phonetic substance of these elements. From this viewpoint the stressable elements are mere positions, identified by their rank counted from right to left, or from left to right. In this respect stress crucially differs from tone, which is associated with units identified by their phonetic substance and which partakes of this phonetic substance. There is, therefore, no phonetic entity, no complex of features to which the stress-bearing phonemes are to be linked. Rather, following the lead of Liberman and Prince (1977), we designate the stressable phonemes in the string by supplying them with a particular diacritic mark, an asterisk.

We illustrate this in (2) with words from the Australian language Maranungku that has become well known to students of stress since Hayes drew attention to it in his dissertation (1980). In this language the vowels are stressable, whereas consonants are not. This fact is formally represented in (2) by placing an asterisk over every vowel.

```
(2)  *   * * * *    * * * * * *    line 0
     langkarateti   welepenemanta
```

Since the line of asterisks is represented on a separate autosegmental plane, the fact that only certain phonemes in the sequence are stressable can readily be captured by assigning an asterisk on line 0 in the stress plane only to these phonemes and not to the rest.

It is not an accident that the bottom line both in the tone plane and in the stress plane is constituted by the string of phonemes representing the words. In fact, all autosegmental planes intersect in a single line, which as a first approximation may be viewed as containing the phoneme strings of the words. Autosegmental representations are therefore three-dimensional objects of a very special type: they consist of a number of autosegmental planes (to be geometrically precise, half-planes) that intersect in a single line, the line of phonemes.[1]

To differentiate degrees of stress, lines are added to the stress plane. Thus, in

[1] It has been shown by McCarthy (1979), Archangeli (1984), Levin (1985), Lowenstamm and Kaye (1985), and others that the line of phonemes must be decomposed into a sequence of timing slots whose phonetic content is given by a sequence of autosegments. Since nothing in the discussion below hinges on this decomposition, we do not institute it in our representations except on a few occasions. This decision is made solely for reasons of expository convenience and does not reflect any doubts on our part about the central results of the work mentioned above.

Maranungku odd-numbered syllables are stressed and a special extra-heavy stress falls on the word-initial syllable. We represent the stress contours of the words in (2) as shown in (3). We refer to the patterns of asterisks and dots illustrated in (3) by the term *metrical grid*, which was first introduced by M. Liberman (1975).

```
(3)  *   . . . .      * .  .  .  .  .    line 2
     *   . * . *      * .  *  .  *  .    line 1
     *   * * * *      * *  *  *  *  *    line 0
     langkarateti    welepenemanta
```

A fundamental property of sequences of linguistic units—phonemes, morphemes, words, etc.—is that when such units are concatenated, it is not the case that all elements in the string are treated on a par, like beads on a string. Rather, sequences of linguistic units are composed of one or more constituents in each of which one element is especially marked, or made the head. We have argued elsewhere (see Halle (1984; 1985)) that the behavior of stress in cases where stressable units are deleted or inserted provides strong grounds for supposing that stress is a surface manifestation of a particular kind of constituent organization imposed on sequences of stressable phonemes. We propose, therefore, that the full representations of the words in (2) and (3) are as shown in (4), where the parentheses delimit the extent of the different constituents.

```
(4)  *     .  .  .  .      * .   .   .  .   .     line 2
     (*    .  *  .  *)     (* .  *   .  *   .)    line 1
     (*    *)(* *)(*)      (* *) (*  *) (*  *)    line 0
     langka rate ti        wele pene manta
```

Each metrical constituent must contain at least one element that is its head, which we have marked in (4) with an asterisk on a higher line; thus, the heads of the constituents of line 0 elements are marked by asterisks on line 1, and the heads of the constituents of line 1 elements are marked by asterisks on line 2. The location of the head is one of the variables that is determined by language-particular rules and that the speaker of a language must learn. As shown in (4), in Maranungku the heads of metrical constituents of both line 0 and line 1 are at the left end. In addition to such head-terminal constituents, there exist also bounded (ternary) constituents with nonterminal (medial) heads. (Ternary constituents are briefly discussed in footnote 2.)

We shall refer to the nonobligatory elements of a constituent as the *domain*. The extent of the domain is a second variable that is determined by language-particular rules and that must be learned by the speaker of the language. The choice is between two alternatives: the domain is either unbounded or bounded. In the case of unbounded constituents the domain extends either to the end of the string or to the nearest element that is marked as a constituent head by some rule of the language or is so designated in the underlying representation of the word. In bounded constituents the domain elements must be directly adjacent to the head. If a bounded constituent is not head-terminal, its domain may contain two elements, one on the right of the head, the other on its left. If a bounded constituent is head-terminal, its domain may consist of no more than one element.[2] Bounded constituents are universally constructed by a rule that is ordered with respect to other rules of the language. This rule applies iteratively either from left to right or from right to left and applies so as to respect previously assigned heads. We conjecture with Archangeli (1984) that the rule constructing bounded constituents is the only iterative rule that a language may have. If this conjecture is correct, then all apparently iterative processes in a language must involve the construction of bounded—that is, binary (or ternary)—constituents. The implications of this suggestion for the treatment of various assimilatory and dissimilatory processes require extensive investigation and are outside the scope of this article.

Given the notational apparatus just outlined, the stress pattern of Maranungku words is captured by means of the rules in (5).

(5) a. Stressable elements are vowels.
    b. Line 0 constituents are left-headed.
    c. On line 0 construct binary constituents from left to right.
    d. Line 1 constituents are left-headed.
    e. On line 1 construct an unbounded constituent.

The marking of the head in a constituent is governed by principle (6).

(6) In a left-headed (resp. right-headed) constituent the head is marked over the leftmost (resp. rightmost) asterisk in the line. In cases where the line contains no asterisks the head is placed over the leftmost (resp. rightmost) asterisk on the next line below.

We shall see below certain interesting consequences of this notational convention.

Consider next the stress pattern of Koya words, another set of facts made familiar by Hayes (1980). In this language stress goes on the vowel of every syllable with a branching rime as well as on the first syllable of the word. Moreover, there is extra-strong stress on the word-initial syllable. We capture these facts by means of the rules in (7).

(7) a. Stressable elements are vowels.
    b. Assign a line 1 asterisk to the vowels of syllables whose rime branches.
    c. Line 0 constituents are left-headed.
    d. On line 0 construct unbounded constituents.
    e. Line 1 constituents are left-headed.
    f. On line 1 construct an unbounded constituent.

[2] Davis (1985) and Levin (1985) have drawn attention to a number of languages where stresses are assigned to every third syllable. As Levin notes, such facts suggest that there are two kinds of bounded constituents that require the domain to be adjacent to the head. In the first type of bounded constituent the head must be terminal. (These are the binary constituents that are discussed in the present study and elsewhere.) Bounded constituents of the second type do not obey the requirement that their heads should be terminal; their domain may, therefore, include an element to the left as well as one to the right of the head. These ternary constituents therefore have the form of amphibrachs rather than of dactyls or anapests. Levin cites interesting evidence from Cayuvava, a South American language, in support of this amphibrach nature of ternary constituents. As the investigation of ternary constituents has barely begun, we have not included these in our discussion.

Given the rules in (7), a Koya word is assigned the metrical structure shown in (8). In (8) the Arabic numerals in the bottom line represent the consecutive stressable elements of the word; heads of syllables with a branching rime are marked by an arrowhead placed below the numeral.

```
(8)  * . . . . . . . .        line 2
    (* . * . . . * . .)       line 1
    (* *)(* * * *)(* * *)     line 0
     1 2  3 4 5 6  7 8 9
          ^        ^
```

A number of remarks must be made about the procedure for generating (8). Following a suggestion by Prince (1983), we allow asterisks to be assigned not only by rules that construct metrical constituents but by other rules as well. Thus, in (8) the line 1 asterisks over syllables 3 and 7 are assigned by rule (7b), and only the asterisk over syllable 1 is assigned by rule (7d), the rule that constructs the constituents. Previously assigned asterisks are respected when metrical constituents are constructed by rules such as (7d).[3] In addition, rules constructing metrical constituents cover all elements in the string, except, of course, those that are marked extrametrical. It is in consequence of this ''exhaustive coverage'' requirement that in our illustrative example (8) a constituent is constructed by rule (7d) over the first two syllables of the word.

All examples discussed to this point have involved languages where words have both primary and subsidiary stresses. There are, of course, numerous languages with but a single stressed syllable in each word. It might be thought that such languages have only one layer of metrical constituents and hence only one line of asterisks above line 0. Given the framework that has been developed to this point, only unbounded constituents can be constructed in these cases, for bounded constituents would generate more than one stress in longer words. But, if in these languages binary constituents cannot be employed and stress must be assigned by means of unbounded constituents, then it should also be the case that stress in such languages will fall on one of four syllables in the word. Either it can fall on the first syllable or on the last syllable, or, if these are marked extrametrical, it can fall on the second syllable or on the penultimate syllable. There is no machinery available to capture a fact such as that in Macedonian stress systematically falls on the antepenultimate syllable (Lunt (1952)) or the even more interesting fact first brought to our attention by P. Kiparsky (1973) with examples from Eastern Cheremis and subsequently documented by Hayes (1980) for languages as diverse as Classical Arabic, Chuvash, Hindi, Huasteco, and Dongolese Nubian that in these languages stress falls on the last syllable that has a full vowel, but in words where all syllables have only reduced vowels, stress falls on the first syllable.

Given the machinery presented above, it would be a straightforward matter to account for the location of main stress in Eastern Cheremis provided that there were also

[3] This procedure allows us to dispense with the diacritic mark *accent* that was used to account for facts of this sort in earlier studies.

subsidiary stresses on all full vowels. We could then postulate the rules in (9) and produce the stress patterns illustrated in (10).

(9) a. Stressable elements are vowels.
b. Assign line 1 asterisks to full vowels.
c. Line 0 constituents are left-headed.
d. On line 0 construct unbounded constituents.
e. Line 1 constituents are right-headed.
f. On line 1 construct unbounded constituents.

```
(10) a.  . . . . . . * . .          b.  * . . . . . . .      line 2
         (* . * . . . * . .)            (* . . . . . . .)    line 1
         (* *)(* * * *)(* * *)          (* * * * * * * *)    line 0
          1 2  3 4 5 6  7 8 9            1 2 3 4 5 6 7 8
               ∧        ∧
```

In (10a) syllables 3 and 7 are marked with an arrowhead to indicate that they have a full vowel. Rule (9b) then assigns asterisks to these syllables. Next rules (9c) and (9d) construct unbounded left-headed constituents on line 0 and assign an asterisk to the initial syllable. Finally rules (9e) and (9f) construct an unbounded right-headed constituent on line 1 and, in conformity with convention (6), assign a line 2 asterisk above the rightmost line 1 asterisk. Thus, the rules in (9) place main stress correctly, but they also incorrectly generate subsidiary stresses.

Once the problem has been put in these terms, the solution is all but self-evident: having constructed the representations in (10), we need only suppress the asterisks on line 1 in order to obtain the correct output. We achieve this by adding to (9) the rule (11).

(11) Conflate lines 1 and 2.

When two lines in a metrical grid are conflated, a constituent on the lower line is preserved only if its head is also the head of a constituent on the higher line. The effect of rule (11) is therefore to suppress all but the last constituent in line 0, which yields the desired output, as shown in (12). It is important to note in this connection that when constituents are destroyed, their heads are automatically eliminated, and vice versa.

```
(12)   . . . . . . * . .      line 2
      (. . . . . . * . .)     line 1
       * * * * * * (* * *)    line 0
       1 2 3 4 5 6  7 8 9
           ∧        ∧
```

The effect of eliminating a head is therefore different from the effect produced by deleting the element in the string to which headship is assigned. In the latter case the constituent structure is preserved and headship is automatically transferred to an adjacent element in the string. For example, Al-Mozainy, Bley-Vroman, and McCarthy (1985) show that in a Bedouin dialect spoken in the Hijaz, Saudi Arabia, vowel deletion triggers a systematic shift of the stress to the right. A similar shift of stress to the right as a result of deletion is discussed by Kenstowicz (1983) on the basis of facts from a Bedouin dialect spoken in the Negev. Both studies contain explicit arguments showing that the rules of stress assignment require the construction of left-headed binary feet (line 0 constituents), and this fact is responsible for the shift of stress to the right.

Stress shift resulting from vowel deletion is not always to the right, toward the end of the word. Lightner (1972) has shown that in modern Russian certain vowels, which he has termed *yers*, are deleted if followed by a non-yer vowel in the next syllable. The deletion of stressed yers results in stress being shifted toward the beginning of the word, as illustrated in (13), where the capital letter Q represents the stressed yer that has been deleted.

(13)	zajóm	zájQma	'loan' (nom., gen. sg.)
	sestér	séstQry	'sister' (gen., nom. pl.)

The examples just discussed show that stress does not render vowels immune to deletion. Moreover, as these examples show, deletion of a stressed vowel does not reduce the number of stresses in the word but rather shifts the stress from the deleted syllable to one of its neighbors. In a framework with metrical constituents this is to be expected; in a framework without metrical constituents, such as that advocated by Prince (1983), it is unexpected.

The next stress pattern to be reviewed here is that of the Indo-European proto-language. Kiparsky and Halle (1977) have argued that in this language—as well as in a number of other languages, both Indo-European and non-Indo-European—morphemes may or may not be "accented." We shall formally represent an "accented" morpheme by placing a line 1 asterisk in its lexical representation; an "unaccented" morpheme has no such asterisk. The location of word stress is governed by what Kiparsky and Halle (1977) have referred to as the *Basic Accentuation Principle* (BAP).

(14) Stress the leftmost accented vowel or, in the absence of accented vowels, the leftmost vowel.

The words of such languages therefore fall into two classes, those that have one or more "accented" morphemes and those that have no "accented" morphemes. We illustrate these two classes of words in (15a) and (15b). (In (15a) the fourth, sixth, and seventh positions represent inherently accented morphemes.) Their respective outputs are (15c) and (15d).

```
(15) a.  . . . * . * *      b.  . . . . . . .     line 1
         * * * * * * *          * * * * * * *     line 0
         1 2 3 4 5 6 7          1 2 3 4 5 6 7
               ^   ^ ^

     c.  . . . * . . .      d.  * . . . . . .     line 2
        (. . . * . . .)        (* . . . . . .)    line 1
         * * * * * * *          * * * * * * *     line 0
         1 2 3 4 5 6 7          1 2 3 4 5 6 7
```

To obtain this result, we propose the set of rules in (16).

(16) a. Stressable elements are vowels.
b. Line 1 constituents are left-headed.
c. On line 1 construct an unbounded constituent.
d. Conflate lines 1 and 2.

Applying rules (16b,c) to the representations in (15a) and (15b) yields the representations in (17).

```
(17) a.  . . . * . . .      b.  * . . . . . .      line 2
        (. . . * . . .)        (. . . . . . .)     line 1
         * * * * * * *          * * * * * * *      line 0
         1 2 3 4 5 6 7          1 2 3 4 5 6 7
```

Nothing needs to be said about (17a), since it is identical with (15c), the output form. Convention (6) generates representation (17b), which contains a gap in the asterisk column. Since no empirical difference is ever associated with the distinction between asterisk columns with and without gaps, we impose the convention that gaps in asterisk columns are automatically filled. Once this convention is applied, the correct output form is produced for the example (17b).

A comparison of the rules in (16) with those for all other languages discussed above shows that the major difference between the rules in (16) and those discussed earlier is that (16) contains no rule constructing constituents on line 0 elements, although (like the rule sets in the other languages) it does contain one constructing constituents on line 1. The inference may have been drawn from the discussion of the other languages that constituents on a higher line in the grid may not be constructed unless constituents have also been constructed on every lower line in the grid; that is, unless constituents have been constructed on line 0, constituents may not be constructed on line 1. The BAP rules in (16) constitute an example showing that this inference cannot be correct. We conclude that constituents may be constructed over any line in the grid even when no constituents have been constructed on any lower line.

The fact that (16) contains no rule constructing constituents on line 0 does not imply that the lexically assigned line 1 asterisks do not form constituents on line 0. In Russian, which is one of the languages that assign stress by the BAP (16), stress moves to the left when a stressed yer is deleted. By contrast, in Sanskrit, another language that assigns stress by the BAP, stress shifts to the right when a high vowel becomes nonsyllabic (*kṣaipra sandhi*) and hence loses its capacity to bear stress. We illustrate the Sanskrit (rightward) stress shift in (18).

(18)	nom sg.	dhenús	'cow'	devī́	'goddess'
	loc. pl.	dhenúṣu		devī́ṣu	
	but				
	instr. sg.	dhenvā́		devyā́	
	gen./loc. dual	dhenvós		devyós	

To explain these facts, it is necessary to assume that in Russian line 0 constituents are right-headed whereas in Sanskrit they are left-headed. To express this fact formally, we must add to the stress rules of these languages—that is, to the rules in (16)—the rule (19).

(19) Line 0 constituents are $\left\{ \begin{array}{l} \langle \text{right-headed} \rangle_{\text{Russian}} \\ \langle \text{left-headed} \rangle_{\text{Sanskrit}} \end{array} \right\}$.

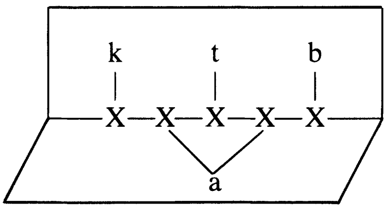
It should be noted, however, that at this time we have no argument, other than stress shift under deletion, for postulating line 0 constituents in Russian and Sanskrit. The situation here is thus somewhat less clear-cut than in the Bedouin dialects of Arabic briefly discussed above, where not only stress shift but also the distribution of secondary stresses requires the postulation of left-headed binary feet.

2. Stress and the Cycle

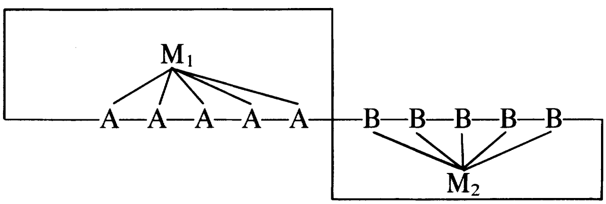
To this point we have considered only examples of noncyclic stress assignment. In this section we examine cases where stress is assigned cyclically. In attempting to deal with cyclic stress assignment, we have been influenced by the ideas of Kiparsky (1982a; 1983; 1984; 1985), Mohanan (1982), and other advocates of what has become known as Lexical Phonology, as well as by such critics of this approach as Aronoff and Sridhar (1983) and Sproat (1985). We adopt from Lexical Phonology the organization of phonological rules into a number of blocks called *strata* and allow a given rule to be assigned to more than one stratum. We also follow Lexical Phonology in distinguishing *lexical* from *postlexical* strata, but we see this distinction in the light of the interpretation proposed by Sproat (1985) as being one between phonological processes that are word-internal and phonological processes that are not limited to the word. A given stratum of rules must be specified as being *cyclic* or *noncyclic*. What primarily differentiates cyclic from noncyclic strata is the manner in which the rules in a stratum take account of the morphological composition of the string. As noted in Halle and Mohanan (1985), in a cyclic stratum "the relevant phonological rules apply to every morphological constituent . . . to the basic stem . . . as well as to every constituent created by morphological processes" (p. 66), whereas in a noncyclic stratum "the phonological rules . . . apply . . . only *after* all morphological processes" (p. 67). Moreover, *strict cyclicity* (see Mascaró (1978) and Kiparsky (1982a; 1983; 1984; 1985)) governs the application of rules in cyclic strata but not elsewhere.

We deviate from most proponents of Lexical Phonology in that, following Sproat (1985), we do not assign the rules of morphology—prefixation, suffixation, reduplication, compounding, etc.—to particular phonological strata. We assume rather that these rules are the province of a special component, which may be part of the syntax and will be referred to by the traditional term *morphology*. For us, as for SPE (Chomsky and Halle (1968)), morphology is distinct and separate from phonology. Morphology interacts with phonology in that it creates the objects on which the rules of phonology operate. We have argued that stress is represented on a separate plane from the rest of the phonological structure. It has been proposed elsewhere that other properties of morphemes, such as tone (Goldsmith (1976)) and syllable structure (Halle (1985)), are also to be represented on separate planes. Therefore, a morpheme will in general be represented by a family of planes intersecting in a central line. Given this formalization, the combination of morphemes into words will involve a combination of families of planes.

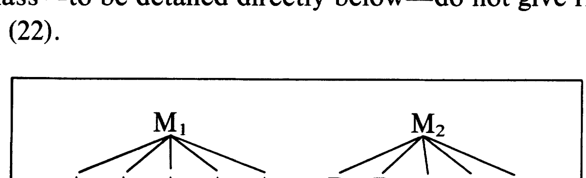
McCarthy (1986) has proposed that the separate autosegmental planes of Semitic morphology are the result of the fact that distinct morphemes must be represented on separate planes—for example, as in (20).

(20)


We propose to extend this idea to concatenative morphology as well. A sequence of morphemes will then be represented as in (21).

(21)


In view of the observations in the previous paragraph it should be obvious that each of the two planes drawn in (21) stands for the entire family of planes associated with the particular morpheme. McCarthy assumed that *every* morpheme is represented as a distinct plane (or family of planes). We depart from this suggestion by assuming that not all morphemes give rise to independent planes (families of planes). Morphemes of a certain class—to be detailed directly below—do not give rise to independent planes, as shown in (22).

(22)


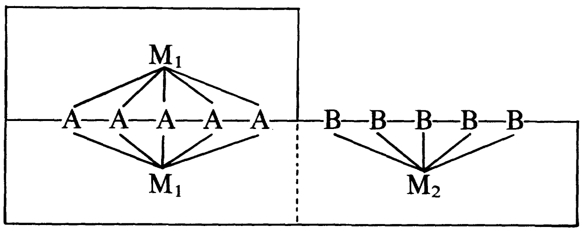
It has been observed that in many languages affixes fall into two major classes with regard to their interaction with the rules of phonology. Thus, Kiparsky (1982b) has shown that the suffixes of Vedic Sanskrit must be categorized as *dominant* or *recessive* in order to account for their stress behavior. Similarly, Siegel (1974) and Allen (1978) have shown that in English a distinction must be made between stress-sensitive suffixes such as

-ity, -al, -ous and stress-neutral suffixes such as *-ness, -hood, -ly*. Halle and Mohanan (1985) have argued that these distinctions in both Sanskrit and English correspond to the distinction between cyclic and noncyclic affixation. In English, for instance, a cyclic rule such as Trisyllabic Shortening, which is subject to strict cyclicity (cf. such underived forms as *ivory, dynamo, apricot*), is triggered only by stress-sensitive suffixes (such as *-ity* in *divinity*) but not by stress-neutral suffixes (such as *-hood, -ly* in *maidenhood, miserly*). We propose that the distinction between cyclic and noncyclic affixation is formally reflected in the morphology by the distinction between (21) and (22); that is, cyclic morphemes are affixed on a plane (family of planes) distinct from that of the stem, whereas noncyclic morphemes are affixed on the same plane (family of planes) as the stem.

We shall assume that the rules of phonology can operate only on a single family of planes. Following the suggestion of Younes (see McCarthy (1986)), we postulate that cyclic affixation is accompanied by a process that reduces several families of planes to one. In the event that a family consists of but a single plane, this reduction results in the "tier conflation" exemplified by McCarthy (1986).[4]

Plane reduction is not effected by simply aligning the affix plane with the stem plane, converting, as it were, a representation of the form (21) into one of the form (22). Rather, there is evidence suggesting that plane conflation is implemented by copying the content of the stem onto the plane of the affix, leaving the content of the stem plane intact and hence subsequently accessible to other rules. The cyclic copying process thus does not reduce the number of cyclic planes in the representation: it only changes the content of the plane of each cyclic affix by transcribing onto the affix plane the content (or part of the content) of the adjoining stem. (23) graphically illustrates plane conflation as it might affect (21).

(23)



The plane (family of planes) on the bottom of (23) is not identical with that shown in (22), which corresponds to the plane (family of planes) of noncyclic affixation. In the process of reduction not all information available in the family of planes is transferred. In particular, the information contained in the metrical grid is not automatically copied. The rules of the cyclic stratum then apply in the plane below the central line of phonemes in (23), and the operation is repeated for each cyclic affix in turn. If a noncyclic affix

[4] The conflation of lines in the metrical grid referred to in (16d) should, of course, not be confused with the conflation of cyclic planes discussed in section 2.

is adjoined to a stem ending (resp. beginning) with a cyclic affix, no new plane is created and the noncyclic affix is represented directly on the plane of the stem to which it is adjoined.

The empirical effect of this procedure is that stresses assigned on earlier planes are not carried over automatically to later planes. When such earlier stresses appear in the output—as they do in certain well-known cases in English, for example—this is invariably due to a special rule that copies asterisks from one stress plane onto another. The surface stress is read off from the grid of the latest plane, which is the plane of the entire word including all of its affixes, cyclic as well as noncyclic. Since noncyclic affixes are represented on the same plane as the stem to which they are adjoined, none of the phenomena accompanying cyclic affixation is observed there. In particular, in the case of noncyclic affixation the metrical grid of the stem generated by the cyclic stress rules is preserved and serves as input to the stress rules of the noncyclic stratum.

Finally, we have adopted from Lexical Phonology the organization of phonological rules into strata or blocks, but we have followed Halle and Mohanan (1985) in marking each stratum either cyclic or noncyclic. In response to the criticisms of Lexical Phonology by Sproat (1985) and others we have included in the different strata no rules of affixation. Consequently, our strata consist of phonological rules exclusively, and (as already remarked) we treat affixation rules in a component that is separate from the phonology.

Formally, we distinguish cyclic from noncyclic affixes not only by representing the two types of affix differently (see (20)–(22)) but also by the manner in which the rules of the phonology apply to strings containing the two types of affixes. The rules of the phonology apply in the familiar constituent-by-constituent fashion beginning with the innermost constituent (usually the root) and ending with the constituent embracing the entire word. When the affix heading a constituent is cyclic, the entire constituent is subjected to the rules of the cyclic stratum. The rules of the cyclic stratum are applied to each nested constituent in turn. Constituents headed by a noncyclic affix are skipped over in this procedure until the outermost constituent of the word or phrase is reached. At this point the rules of the noncyclic stratum are applied to the entire string.

We illustrate the preceding with the derivation of the stress contour of the English noun *ungrammaticality*, which has been the subject of much debate in recent years. Pace Pesetsky (1985), the noun can be given the morphologically and semantically justified constituent structure $_{c}[_{n}[\text{un-}_{c}[\text{grammat-ic-al}]_{c}]_{n}\text{ity}]_{c}$, where the subscripts *c* and *n* indicate that the affix heading the constituent is either cyclic or noncyclic. It was argued in Halle and Mohanan (1985) that the main stress rule of English is part of the cyclic stratum. Since in English stress rules are structure-building rather than structure-changing, the cyclic stress rule will apply to the innermost constituent and assign main stress to it, yielding (24a). As the next higher constituent is headed by the noncyclic prefix *un*, the stress assigned on the first cycle will not be deleted, nor will the cyclic main stress rule be applied. At this stage in the derivation we will therefore obtain the representation (24b). The addition of the cyclic suffix *-ity* will result in the deletion of stress assigned on the first cycle and the application of the cyclic stress rule. This will yield the representation (24c), from which the surface stress contour of the noun will be obtained by the subsequent application of rules of the noncyclic stratum.

```
(24) a.   .   *  .  .
          .   *  .  .
          *   *  *  *
         grammat-ic-al

     b.  .    .    *  .  .
         .    .    *  .  .
         *    *    *  *  *
         un-grammat-ic-al

     c.  .    .    .  .  *  . .
         .    .    .  .  *  . .
         *    *    *  *  *  * *
         un-grammat-ic-al-ity
```

In the following sections we illustrate in greater detail how these proposals account for the facts in a number of languages with cyclically assigned stress.

2.1. Vedic Stress

Our first example is Vedic stress as presented in Kiparsky (1982b) (see also Halle and Mohanan (1985)). As already noted, Kiparsky and Halle (1977) have shown that in Vedic—as in a number of other languages, Indo-European as well as non-Indo-European—the location of word stress is governed by the Basic Accentuation Principle (BAP) (14), a stress pattern accounted for by the set of rules in (16). Kiparsky has drawn attention to the fact that from the viewpoint of stress assignment the suffixes of Vedic must be divided into two classes: recessive and dominant. We have illustrated in (15c,d) and (17) how the BAP rules given in (16) apply in words that contain only recessive suffixes; in fact, in such words the placement of surface stress is governed completely by the BAP. This is not transparently the case in words that contain dominant suffixes. In such words the last dominant suffix determines the surface stress. In particular, if the last dominant suffix is underlyingly accented (has a line 1 asterisk in its underlying representation), the surface stress is located on this suffix; if the last dominant suffix lacks a line 1 asterisk in its underlying representation, the surface stress is invariably located on the initial syllable. Thus, in Vedic words formed with the underlyingly accented dominant suffix *-in-* stress falls on the suffix both when the stem has a line 1 asterisk and when it does not. We illustrate this in (25), where the stems *rath* and *mitr* differ in that only the former has a line 1 asterisk in its underlying representation, but where this difference in underlying representation does not result in a difference in surface stress: in both words surface stress appears on the underlyingly accented dominant suffix *-in*.

(25) rath + íṇ + e 'charioteer' (dat. sg.)
mitr + íṇ + e 'befriended' (dat. sg.)

In words where the last dominant suffix is underlyingly unaccented (without a line 1 asterisk) stress falls on the initial syllable regardless of the inherent accentual properties of the morphemes that follow it. We illustrate this in (26), where the stem ending with the last dominant suffix is enclosed in parentheses.

(26) a. (sár + as) + vat + i + vant 'accompanied by Sarasvati'
b. (práti + cyav + iyas) + i 'more compressed'
c. (cí + kar + ay + iṣa) + ti 'wants to cause to make'

(26a,b) contain only a single dominant suffix, which is underlyingly unaccented. This is self-evident for (26a) and becomes self-evident for (26b) as soon as it is realized that *prati* is a prefix and *cyav* is the verb stem.[5] In (26c) the stem *kar* is followed by two dominant suffixes, of which the first is underlyingly accented and the second is not. Since the last dominant suffix is underlyingly unaccented, the surface stress appears on the first syllable.

Halle and Mohanan (1985) have suggested that in order to capture these facts formally it must be assumed that dominant suffixes are cyclic, whereas recessive suffixes are noncyclic. In order to obtain correct outputs, Halle and Mohanan also had to postulate a rule that deletes any underlying or previously assigned stresses in position before a dominant suffix. Given the theoretical framework described above, such a rule is unnecessary. All that needs to be assumed is that Vedic has two strata of rules in its phonology, cyclic and noncyclic, and that the stress rules in (16) are assigned to both strata. Once this assumption is made, the rule deleting previously assigned stresses becomes otiose and can be dispensed with.

This simplification in the rules required to account for the facts of Vedic is significant, for it indicates that the modifications that have just been made in the theory are on the right track. If we had not adopted them, we would have needed the stress deletion rule, or, put differently, if we insist on maintaining the theory unmodified we will have to pay for this bit of theoretical obstinacy by having to add to the description the otherwise unnecessary Halle-Mohanan rule of stress deletion.[6]

We now investigate in somewhat greater detail the effects of the above theoretical modifications. Consider first the simplest cases, where an underlyingly accented stem

[5] The constituent structure given in (26b) is crucial for obtaining the attested stress on the initial syllable. If in place of the constituent structure in (26b) we postulated the structure (prati + ((cyav + iyas) + i)), there would be no plausible way of obtaining the attested initial stress short of assuming that the cyclic stress rule applies both before and after the noncyclic stress rule. As this is not a desirable move, the example (26b) must be taken as evidence against assuming that in Vedic, prefixes are attached in the outermost constituent, as has been suggested by Pesetsky (1979) for Russian and English.

[6] There are empirical differences between the theory developed here and that of Halle and Mohanan. Suppose that Sanskrit had accented prefixes that were cyclic. If such a prefix were adjoined to an accented stem, Halle and Mohanan's theory predicts that the prefix would lose its accent, whereas the present theory predicts instead that the element that would lose its accent is the stem. This consequence was pointed out to us by B. Hermans.

is followed by a single dominant suffix that is also underlyingly accented. Since dominant suffixes are cyclic, two metrical planes will be generated, one containing the stem alone and one containing the stem followed by the suffix. The application of the cyclic stress rules is subject to the principle of Strict Cyclicity.[7] Since stress is distinctive in Vedic—that is, a Vedic morpheme may or may not have stress in its underlying representation—Strict Cyclicity prevents the stress rules in (16) from applying to underived strings, in particular, to the innermost stem of a word. At the end of the first pass through the cyclic rules the stem will therefore retain unchanged the metrical grid of its underlying representation. However, when the stem is subsequently copied onto the plane of the first cyclic (dominant) suffix, asterisks above line 0 will not be copied. As a result, the contrast between underlyingly accented and unaccented stems is neutralized before dominant suffixes. A word of the sort under discussion here will therefore appear at the beginning of the second cycle in the form (27).

```
(27)  .  .    *     line 1
      *  *    *     line 0
       \/     |
       S      D
```

In (27) S represents a bisyllabic stem and D a monosyllabic dominant suffix that is underlyingly accented (as shown by the asterisk on line 1). It is obvious that the stress rules in (16) will assign a line 2 asterisk (main stress) to the dominant suffix.

The example in (27) should be compared with the treatment of the minimally different string consisting of a stem and a recessive suffix. Once again Strict Cyclicity prevents the stress rules in (16) from applying to the stem since this is a nonderived environment and stress in Vedic is distinctive. Since the string contains no dominant suffixes, no cyclic metrical planes are generated; instead, the recessive suffix is copied onto the plane of the stem. The sequence of stem + recessive suffix is then subject to the stress rules in (16) assigned to the noncyclic stratum, and application of these rules yields the expected surface stress pattern. We have thus established that in Vedic the stress rules in (16) must be assigned both to the cyclic stratum and to the noncyclic stratum.

Consider now the case where more than one dominant suffix is adjoined to the stem. Since each cyclic affix creates a stress plane of its own and since stresses assigned on earlier planes are not carried over to later planes, the accentual properties of dominant suffixes other than the rightmost are irrelevant in the location of stress in Vedic words. Here again stress falls on the last dominant suffix if it is underlyingly accented, and on the word-initial syllable if that suffix is not underlyingly accented, because the only two possible input strings on the outermost cyclic constituent are (28a) and (28b).

```
(28) a.  .  .    .        *      b.  .  .    .        .      line 1
         *  *    *        *          *  *    *        *      line 0
          \/     |        |           \/     |        |
          S      D . . .  Dn          S      D . . .  Dn
```

[7] For a more detailed discussion of Strict Cyclicity, see Mascaró (1978) and Kiparsky (1984) and works cited there.

In (28a) the stress rules in (16) will assign stress to the syllable dominated by Dn; in (28b) they will assign stress to the word-initial syllable.

As noted previously, recessive (noncyclic) suffixes do not create new metrical planes but are represented on the same stress plane as the constituent containing the last cyclic suffix. Since in Sanskrit the recessive suffixes invariably follow the dominant suffixes and since the rules in (16) assign stress to the leftmost accented syllable, the accentual properties of the recessive suffixes can have no effect on the location of stress in words also containing dominant (cyclic) suffixes. In such words the noncyclic application of the rules in (16) will vacuously assign stress either to the word-initial syllable or to the last dominant suffix, where it was already placed on the last cyclic pass through the stress rules. The conflation rule (16d) eliminates the line 1 asterisks present in the lexical representation of inherently accented recessive suffixes.

By eliminating the rule of accent deletion required in the account in Halle and Mohanan (1985), we have shown that the peculiar stress assignment facts of Vedic are not due to an idiosyncrasy of this language but are rather consequences of Universal Grammar. If correct, this is a result of some significance.

Before leaving stress assignment in Vedic, we draw attention to an interesting difference between the stress pattern of Vedic and that of Lithuanian, another Indo-European language that, like Vedic, is known to have preserved important aspects of the stress system of the Indo-European proto-language. As shown in Kiparsky and Halle (1977), Lithuanian stress is governed essentially by the same set of stress rules as Vedic. The similarities are so great that for purposes of the present discussion we can assume that the rules in (16) are also valid for Lithuanian. It is traditional to distinguish four accentual classes in the Lithuanian nominal declension. As detailed in Kiparsky and Halle (1977), the stems of nouns in classes I and II have an underlying accent, whereas the stems of nouns in classes III and IV are underlyingly unaccented. Like Vedic, Lithuanian has both dominant and recessive suffixes, and as far as words without dominant suffixes are concerned, the two languages behave identically (that is, as described by the BAP (14)). As expected, Lithuanian dominant suffixes, like those of Vedic, eliminate contrasts in the previously assigned stress of the stems to which they attach, as shown by the fact that each derived noun in the first column of (29) belongs to the accentual class I regardless of the accentual class to which its root belongs. When the dominant suffix is underlyingly accented, like *-íen* in (29), surface stress is located on the dominant suffix without regard to the stress of the following recessive suffixes.

(29)	eln + íen + a	I	'venison'	cf. éln + ias	I	'stag'
	kišk + íen + a	I	'rabbit meat'	cf. kìšk + is	II	'rabbit'
	ož + íen + a	I	'goat meat'	cf. ož + ỹs	III	'goat'
	vilk + íen + a	I	'wolf meat'	cf. vil̃k + as	IV	'wolf'

The unaccented suffix *-en-* is also a dominant suffix, as shown by the fact that nouns derived with this suffix exhibit no effects in their stress pattern that might be attributed to the accentual class of the stem. As illustrated in (30), words derived with this suffix differ from those in (29) in that when it is followed by an unaccented recessive suffix such as dat. sg. *-ai*, the word stress falls on the initial syllable, whereas when it is followed by an accented recessive suffix such as nom. sg. *-a*, the surface stress falls on the recessive suffix.

(30)	Dat. Sg.	Nom. Sg.	
	éln + en + ai	eln + en + à	'deer skin'
	kìšk + en + ai	kišk + en + à	'rabbit skin'
	óž + en + ai	ož + en + à	'goat skin'
	vil̃k + en + ai	vilk + en + à	'wolf skin'

In sum, in both Vedic and Lithuanian, if the dominant suffix is underlyingly accented, the surface stress goes on the suffix. In Vedic, if the dominant suffix is underlyingly unaccented, the surface stress invariably goes on the word-initial syllable. By contrast, in Lithuanian, if the dominant suffix is underlyingly unaccented, surface stress goes on the word-initial syllable only if the recessive suffix(es) following are also underlyingly unaccented. If one or more of the following recessive suffixes are underlyingly accented, the surface stress goes on the leftmost of these, rather than on the word-initial syllable.

We can readily account for these facts, if we assume that in Lithuanian the stress rules are assigned only to the noncyclic stratum, whereas in Vedic the stress rules are assigned both to the cyclic stratum and to the noncyclic stratum. As shown earlier, the fact that a suffix is cyclic and that the stem to which it is adjoined must therefore be copied on the plane of the suffix is enough to ensure that all stresses—all asterisks above line 0—of the stem will be eliminated. Since in Vedic the stress rules are cyclic, on the last pass through the cycle the stress rules will place stress either on the (dominant) suffix or on the word-initial syllable. The subsequent application of the stress rules in the noncyclic stratum will be vacuous: it cannot change the location of the stress because the stress rules in (16) assign main stress to the leftmost syllable with a line 1 asterisk, and recessive suffixes in Vedic are added after (to the right of) all dominant suffixes. In Lithuanian, where the stress rules are assigned only to the noncyclic stratum, stress will be placed in accordance with the BAP (14) on the last dominant suffix if it is underlyingly accented (as in (29)). If the dominant suffix is underlyingly unaccented and there are other suffixes in the word with underlying accent, stress will be placed on the leftmost of these (as in the right column in (30)). Finally, if the dominant suffix is underlyingly unaccented and there are no other underlyingly accented morphemes in the word, surface stress will be initial (as in the left column of (30)).

2.2. *Cyclic Stress in Spanish and Damascene Arabic*

We have shown that the rules responsible for stress placement in Vedic must be part of both the cyclic stratum and the noncyclic stratum, whereas the stress rules of Lithuanian must be assigned solely to the noncyclic stratum. It is to be expected that there will be languages where the stress rules are exclusively part of the cyclic stratum. An example of such a language would be one that had a phonological rule sensitive only to stresses assigned on earlier passes through the cycle. Two languages that exemplify this situation—Spanish and the Damascus dialect of Arabic—are examined below.

2.2.1. Main Stress in Spanish. Spanish includes a rule of diphthongization that applies to certain stressed mid vowels (see Harris (1969)), as shown by the alternations in (31).

(31) pensámos	(1pl.)	piénso	(1sg.)	'think'
venímos	(1pl.)	viéne	(3sg.)	'come'
soltámos	(1pl.)	suélto	(1sg.)	'release'
olémos	(1pl.)	huéle	(3sg.)	'smell'

However, Spanish also includes forms such as those in (32), where the vowel is diphthongized even though unstressed.

(32) buenísimo	'very good'
pueblíto	'little town'
adiestrár	'to train (as in a craft or skill)'

To account for such forms, Harris (1969, 125–126) postulates that the rule of primary stress assignment applies cyclically. Vowels with cyclically assigned stress undergo diphthongization. Harris notes, however, that the stresses assigned before the last cycle do not surface. To account for this fact, Harris posits a rule that deletes all but the rightmost primary stress (p. 95). Such a rule is unnecessary within our framework. Once the assumption is made that the Spanish stress rule is assigned to the cyclic stratum, it follows automatically from the notion of cyclic metrical plane put forth above that stresses generated on previous cycles do not surface.[8]

2.2.2. The Stress Pattern of Damascene Arabic and the Rule of Stress Copy. A somewhat more complicated example of a language where the information about stress generated on earlier passes through the cycle is utilized by later rules is provided by Damascene Arabic. According to Bohas and Kouloughli (1981), in Damascene a noncyclic rule of schwa deletion does not apply to vowels that would have received stress during an earlier pass through the cyclic stress rules of the language. In Damascene a word has only a single surface stress, which is assigned to the final syllable if it is superheavy; otherwise to the penult, if the latter is heavy; otherwise to the antepenult. We propose to account for this distribution of stresses, which resembles that of Latin, by the set of rules in (33).[9]

(33) a. Vowels that are heads of rimes are stress-bearing.
b. Mark the last rime of the word extrametrical.
c. Supply a line 1 asterisk to the head of each branching rime.

[8] For a brief discussion of secondary stress in Spanish, see section 2.2.3.
[9] We assume that superheavy syllables have a heavy rime followed by a consonant that is not part of the rime. Since the rime in a superheavy syllable is thus not word-final, it loses its extrametricality at the point at which the stress rule applies.

d. Line 0 constituents are left-headed.
e. On line 0 construct bounded constituents from right to left.
f. Line 1 constituents are right-headed.
g. On line 1 construct unbounded constituents.
h. Conflate lines 1 and 2.

If we now assume that the rules in (33) are part of the cyclic stratum, they will correctly assign the stress in Damascene words. Since stresses assigned on earlier cycles are not carried over, the surface stress will be the one assigned on the last pass through the cyclic stress rules. Though not phonetically interpreted as stress, the asterisks assigned on earlier passes through the cycle must, however, be available for the schwa deletion rule to apply properly. Since Bohas and Kouloughli show that schwa deletion is noncyclic, we cannot utilize here a variant of the solution proposed above for Spanish. Instead, we postulate that Damascene Arabic is subject to the special asterisk copying rule (34).

(34) Copy the line 1 asterisks from the metrical planes of earlier cycles.

We assume further that this rule is assigned to the noncyclic stratum so that the asterisks it copies will appear on the metrical plane of the last pass through the cyclic stratum. The schwa deletion rule can then be ordered after (34) and stated quite simply as (35).

(35) Delete a schwa without a line 1 asterisk.

This procedure yields the correct results for schwa deletion but at a cost of generating a series of unattested secondary stresses (line 1 asterisks). They can be readily eliminated by postulating that the line conflation rule (33h) is assigned to both the cyclic stratum and the noncyclic stratum of rules; all other rules in (33) are assigned to the cyclic stratum exclusively. If in the noncyclic stratum (33h) is ordered after (35), the correct stress contours are readily generated.

The introduction of stress copy rules such as (34) into a phonological description constitutes a significant modification of the theory, for it provides information to later rules about earlier stages in the derivation that otherwise would not be available to them. We believe that the facts of Chamorro (section 2.4), Lenakel (section 2.5), and, to a somewhat lesser extent, English (section 2.3) provide the required motivation for introducing limited transderivational power into the theory in this way.

2.2.3 Noncyclic Secondary Stress in Spanish. In the examples discussed to this point secondary stresses in the word were invariably assigned as a by-product of assigning main stress. Thus, in Koya, Maranungku, and other languages examined in section 1 the main stress was assigned to one of the syllables to which (secondary) stress had been assigned by a prior rule. There exist languages, however, in which secondary stresses in the word depend on the prior assignment of primary stress. Typically, in such languages subsidiary stress will be assigned to even-numbered syllables counting from the end of the word if main stress is located on the penult, but to odd-numbered syllables counting from the end if main stress is located on the last syllable. An example of this type of secondary stress distribution is provided by modern Spanish, as shown in Roca (1985), on which the following brief discussion is based. As illustrated in (36), subsidiary stresses in Spanish are placed on even-numbered syllables preceding the main stress of the word.

(36)	natùralìzación	nàturàlizár
	cònstantìnopòlitáno	constàntinòpolìtanísmo

We have noted that main stress in Spanish is assigned in the cyclic stratum. Since main stress in Spanish falls on one of the last three syllables of the word, we assume with Roca that it is assigned by a set of rules that are essentially identical with those in (33). Central among these are (33d,e), which construct left-headed constituents on line 0 from right to left. Obviously, the distributions of stresses in the words in (36) cannot be generated with the help of left-headed binary constituents constructed from right to left. Following Roca, we shall therefore assume that the rules of the noncyclic stratum of Spanish include a rule specifying that line 0 constituents are right-headed. In addition, we shall assume that the cyclic rule that constructs bounded constituents on line 0 is assigned to the noncyclic stratum as well.

In sum, Spanish must be supposed to include the following rules, which are assigned to the cyclic (*c*) and noncyclic (*n*) strata as indicated by the letter preceding the rule.[10]

(37)	a.	c	Line 0 constituents are left-headed.
	b.	n	Line 0 constituents are right-headed.
	c.	c/n	On line 0 construct bounded constituents from right to left.
	d.	c	Line 1 constituents are right-headed.
	e.	c	On line 1 construct unbounded constituents.
	f.	c	Conflate lines 1 and 2.

We have found that many languages include a pair of rules such as (37b,c) in their noncyclic stratum. It is therefore convenient to have a special term to refer to this pair of noncyclic rules, and we have adopted the word *Alternator* for this purpose.

2.3. *English Stress*

As noted, Damascene Arabic is subject to a rule copying stresses from earlier planes. Spanish is not subject to stress copying, but it is subject to the Alternator rule. Moreover, Vedic is subject neither to stress copying nor to the Alternator. An obvious question is whether there is a language that is subject to both stress copying and the Alternator. It

[10] The distribution of secondary stresses in the style of pronunciation of Polish described in Rubach and Booij (1985) strikingly resembles that of Spanish and is treated in essentially the same manner.

will hardly come as a surprise that the answer to this question is "yes." What may not be quite as obvious is that the prime example of this kind of language is English.

In the course of our research we have been interested to note that the specific proposals of Hayes (1980) concerning English stress can easily be translated into our framework. Hayes's most important result with regard to the treatment of English stress is that there are two stress rules rather than one. One of these, the English Stress Rule, is sensitive to rime structure and determines the placement of primary stress. The other, Strong Retraction, is not sensitive to rime structure and determines the placement of subsidiary stresses—completely in nonderived words, and partially in derived words. Hayes observes that "the English Stress Rule must precede Strong Retraction, because it [Strong Retraction—MH/JRV] begins its right-to-left binary count at the left boundary of the foot constructed by the English Stress Rule: compare *Apalachicola,* where the secondary stresses fall on even numbered syllables from the end, with *hamamelidanthemum,* in which they fall on odd numbered syllables from the end" (p. 158). This situation is identical with the situation described in section 2.2.3 for Spanish. We conclude, therefore, that Hayes's rule of Strong Retraction is a special case of the Alternator rule (37b,c). English differs from Spanish in its treatment of word-initial stress; in English the word-initial syllable is generally stressed except in special contexts where stress is deleted (for details, see SPE, pp. 110–126, and Halle and Vergnaud (in preparation)). The English Alternator rule must therefore read as follows:

(38) a. Line 0 constituents are left-headed.
b. On line 0 construct bounded constituents from right to left.

In discussing derived words with internal constituent structure, Hayes remarks that "the English Stress Rule and Strong Retraction differ in whether they must respect the boundaries of feet constructed earlier in the derivation: Strong Retraction obeys these boundaries, while the English Stress Rule obliterates earlier metrical structure" (p. 165). In the framework developed here, this difference would fall out automatically if the English Stress Rule were assigned to a cyclic stratum and the rule of Strong Retraction to a noncyclic stratum. But this is not all. Both the English Stress Rule and Strong Retraction construct binary constituents from right to left. We suggest, therefore, that they are the same rule—namely, rule (38)—which is assigned both to the cyclic stratum and to the noncyclic stratum. In the cyclic stratum (38) represents the English Stress Rule, whereas in the noncyclic stratum it represents Strong Retraction. The fact that only the English Stress Rule, but not Strong Retraction, is sensitive to rime structure is captured by postulating that in the cyclic stratum the stress rules—and in particular (38)—are preceded by a rule that supplies line 1 asterisks to syllables with branching rimes, whereas no such rule is assigned to the noncyclic stratum.

There is a further difference between the English Stress Rule and Strong Retraction. The English Stress Rule assigns but a single stress, whereas Strong Retraction assigns an unlimited number of stresses. We capture this difference by postulating that the cyclic stratum includes a rule of main stress (line 1 constituent) assignment as well as a rule conflating lines 1 and 2 in the metrical grid.[11]

It is well known that English stress is cyclic. This is shown by the fact that certain subsidiary stresses of English words reflect the main stresses that would have been assigned to their subconstituents if these had surfaced as full words. Some well-known examples are cited in (39).

(39) ìnstrumèntálity
èlèctrícity
ìnfèstátion
còndènsátion

When the Alternator rule (38) functions as Hayes's Strong Retraction, it is a noncyclic rule and applies after the last pass through the cyclic rules. Its effects will therefore be recorded on the same metrical plane as those of the last pass through the cycle. Since only a single syllable is stressed by our counterpart of the English Stress Rule, we must provide some additional machinery so that the Alternator will respect stresses assigned on previous passes through the cycle. We can readily achieve this result by postulating that, like Damascene Arabic, English is subject to the noncyclic rule of Stress Copy (40).[12]

(40) Copy the line 1 asterisks assigned on preceding cycles.

Words such as *instrumentality* and *condensation* will then emerge from Stress Copy with the metrical grid shown in (41).

```
(41)  .   .  .  * . .      .  .  * .      line 2
      (*  .  *  *). .     (.  *  *) .     line 1
       *  *  *  * * *      *  *  * *      line 0
      instrumentality    condensation
```

The line 1 asterisks in *instrumentality* represent the main stresses of the subconstituents

[11] An anonymous reviewer for LI has observed that "the theory predicts that only the strongest foot in a line may be constructed by a process distinct from that which constructed the other feet." S/he comments that "the authors fail to note that in Hayes's [1980] analysis of English word stress, the main stress is sometimes laid down by the 'noniterative' stress rule (the English Stress Rule, in words like *America*), and sometimes by the 'iterative' stress rule (Strong Retraction, in words like *assimilate*). Under the authors' theory we can only derive **assimiláte*." The reviewer is mistaken with regard to our analysis of *assimilate*. In Halle and Vergnaud (in preparation) we argue that these verbs with main stress on the antepenult do indeed emerge from the stress rules given here with final stress. They are, however, subsequently subject to a rule that moves main stress from the word-final syllable to the preceding stressed syllable. Consequently, these words do not constitute counterexamples to the theory advanced here.

[12] The LI reviewer mentioned in footnote 11 is also concerned about the potentially excessive power of the stress copy rules. S/he writes, "In principle, the copying rules might copy only secondaries assigned earlier and not the primaries . . . or copy the rightmost old stress; or copy the old stresses only in pentasyllabic words; etc." As noted in Halle and Vergnaud (in preparation), stress copying rules are subject to the universal constraint that they copy only and all line 1 asterisks. This constraint severely limits the power of such rules and thereby solves the problem raised by the reviewer.

instrument and *instrumental,* whereas those of *condensation* represent the subconstituent *condense*. The effects of applying the Alternator to the words in (41) are shown in (42).

```
(42)   .     .    .   .  . .       .    .    .   .
      (*     .    *   *) * .      (*    *    *)  .
      (*     *)  (*) (*)(* *)     (*)  (*)  (*   *)
       instru menta lity          condensation
```

As shown in (42), the Alternator adds a line 1 asterisk over the penultimate syllable of *instrumentality* and over the initial syllable of *condensation*. This extra asterisk in *instrumentality* is subsequently deleted by Poststress Destressing (see SPE, pp. 119–125).

In (43) we list in the order of their application the rules that have been mentioned in the preceding discussion of English stress.

(43)	a.	c	Supply a line 1 asterisk to vowels that are heads of branching rimes.
	b.	n	Copy line 1 asterisks from previous stress planes.
	c.	c/n	Line 0 constituents are left-headed.
	d.	c/n	On line 0 construct bounded constituents from right to left.
	e.	c	Line 1 constituents are right-headed.
	f.	c	On line 1 construct an unbounded constituent.
	g.	c	Conflate lines 1 and 2.
	h.	n	Delete stress in prestress and poststress position.

Again, the letter *c* or *n* preceding the rule indicates that the rule is assigned to the *cyclic* or the *noncyclic* stratum. The Alternator rules (43c) and (43d) are assigned both to the cyclic stratum and to the noncyclic stratum.

In concluding the discussion of English stress, we note that, like Vedic, English possesses two kinds of suffixes: cyclic and noncyclic. The cyclic suffixes affect the placement of main stress in the word, whereas the noncyclic suffixes do not. We illustrate this in (44) with the well-known contrast between words ending in *-ity* and words ending in *-ness*.

(44)	grammátical	grammaticálity	grammáticalness
	sólemn	solémnity	sólemnness

English differs from Vedic in that in Vedic noncyclic (recessive) suffixes determine stress placement except in words that also contain cyclic (dominant) suffixes, whereas—as shown by the stress contour of *solemnness,* which contains no cyclic suffixes—in English noncyclic suffixes have no effect on main stress placement. That the cyclic main stress rules of English must apply to underived stems is shown also by the fact that underived words have main stress just like derived words. At first sight, this might seem to point to a serious shortcoming in the important concept of Strict Cyclicity. This difficulty is only apparent, however, for (as noted in Halle and Mohanan (1985, 70)) word stress rules in English apply to underived words, because, unlike those of Vedic, the English stress rules are not structure-changing, but structure-building, and only structure-changing rules are prevented by Strict Cyclicity from applying to an underived stem. The stress rules are structure-changing in Vedic but not in English because stress (that is, line 1 asterisks) must systematically be indicated in the lexical representations of Vedic but not in those of English. It is this need for systematic recording of stress in the lexical representation of morphemes that makes stress rules structure-changing (that is, distinctive) in Vedic. In languages such as Spanish or English, where stresses need to be in lexical representations only sporadically, not systematically as in Vedic or Lithuanian, stress is not distinctive and the cyclic stress rules of English therefore apply freely to underived stems.

2.4. Transderivational Relationships in Chamorro

Chamorro phonology has been discussed in Chung (1983), from which all of our data and most of our major insights have been obtained.[13] Chung analyzed the interaction of Chamorro stress with several phonological processes and was led to conclude that phonology must give up the widely held assumption that cyclic rule application accounts for all transderivational relationships between complex words and their parts. She justly characterized this as "a surprising conclusion" (p. 65), for it affects one of the most basic principles of generative phonology. The rule of Stress Copy whose operation has been illustrated and justified in the preceding sections has limited transderivational power, for it makes accessible to postcyclic rules information about stresses assigned on earlier passes through the cycle, information that is otherwise not available to such rules. In this section we shall attempt to show that this limited transderivational power of Stress Copy and certain other characteristics of the theoretical framework developed here enable us to deal with the facts of Chamorro adduced by Chung, while maintaining the orthodox assumption that cyclic rule application accounts for all word-internal transderivational relationships.

The overwhelming majority of Chamorro words have main stress on one of the last three syllables.[14]

(45)	a.	píkaru	'sly'
		kúnanaf	'to crawl'
		dáNkulu	'big'
	b.	bilimbínis	'star-apple'
		inéksaʔ	'cooked rice'
		paníti	'to strike'
	c.	lugát	'place'
		peskadót	'fisherman'
		kafé	'cafe'

[13] We have also benefited from Kang's (1984) study and from personal discussions with him.
[14] We follow Chung's transcription except for replacing her *ä* and *ŋ* with *A* and *N*, respectively.

Chung observes that "words formed with suffixes are stressed on the penultimate syllable, whatever the stress of the words from which they are derived" (p. 39). This suggests that the basic stress rule of Chamorro assigns stress to the penult and that stress on the antepenult and the ultima is due to special lexical properties of the words in question. Specifically, we shall assume that words such as those in (45a) are subject to a rule that marks their last syllable extrametrical. By contrast, end-stressed words of the type illustrated in (45c) have in their underlying representation a line 1 asterisk on the last syllable. The basic stress of Chamorro words will then be assigned by the complex of rules in (46).

(46) a. Stressable elements are vowels.
  b. Line 0 constituents are left-headed.
  c. On line 0 construct binary constituents from right to left.
  d. Line 1 constituents are right-headed.
  e. On line 1 construct an unbounded constituent.
  f. Conflate lines 1 and 2.

Chamorro possesses a number of prefixes (for a list, see Chung (1983, 40, fn. 6)) that attract the word stress.

(47)	mímantìka	'abounding in fat'	(mantíka 'fat')
	Ápanìti	'to strike one another'	(paníti 'to strike')
	sénmàypi	'very hot'	(máypi 'hot')

If it is assumed that these prefixes are cyclic and accented, they will, like the dominant suffixes of Sanskrit, cause stresses assigned on earlier cycles to be deleted. Thus, the first form in (47) will appear at the input to the second pass through the cyclic rules as shown in (48).

```
(48)   *    .  . .   line 1
       *    *  * *   line 2

       mi + mantika
```

Clearly, the rules in (46) would yield the required output with main stress on the initial syllable, provided that rule (46c) were blocked on this pass. It would seem that this should be a consequence of Strict Cyclicity. In the theory developed here a constituent construction rule such as (46c) introduces metrical brackets iteratively from right to left. Since the substring over which the first application of the iterative rule (46c) must apply contains no new material added on this cycle, the rule is blocked by Strict Cyclicity. Since (46c) is an iterative rule, the blocking of its first application results in the blocking of the entire construction process. This proposal implies that in forms with two or more cyclic accented prefixes the stress will surface on the first prefix. (For details, see Halle and Vergnaud (in preparation).)

To this point we have limited our attention to the placement of main stress and have systematically eliminated from consideration the fact that in addition to main stress, Chamorro words have secondary stresses. Chung reports (p. 42) that "syllables which bear secondary stress in complex words bear primary stress in the corresponding non-complex (or less complex) ones" and that "the syllable immediately before the primary stress never exhibits secondary stress." She proposes to account for these facts by the twin assumptions that stress assignment is cyclic and that "a later Destressing rule affects syllables immediately preceding a primary stress." To capture these insights, we shall assume that the main stress rules in (46) are part of a cyclic stratum. In the framework developed here stresses assigned on earlier passes through the cycle are not automatically carried over to later planes. Since in Chamorro, as in English, stresses assigned on earlier passes through the cycle appear on the surface, we assume that, like English, Chamorro is subject to the rule of Stress Copy (49).

(49) Copy the line 1 asterisks assigned on preceding cycles.

In addition, as Chung notes, the rule of Stress Deletion (50) is required.[15]

(50)
$$\begin{array}{ll} \qquad\qquad\quad (*) & \text{line 2} \\ * \rightarrow \emptyset \,/\, \underline{\quad}\; * & \text{line 1} \end{array}$$

We then account easily for examples such as those in (51) and many others cited by Chung.

(51)	a.	inéNNulu?	'peeping'
		inèNNuló?ña	'his peeping'
		inèNNulu?níha	'their peeping'
	b.	kwentúsi	'to speak to'
		Ákwentùsi	'to speak to one another'
	c.	néNkanu?	'food'
		mínèNkanu?	'abounding in food'

As these examples show, stress assigned on earlier cycles is preserved both in the case of suffixation and when stress-attracting prefixes are adjoined.

In addition to stressed prefixes, Chamorro has unstressed prefixes. Chung remarks that words formed with such prefixes "are stressed on the same syllable as words from which they are derived" (p. 39); that is to say, in such words "the next-to-last layer determines the result" (p. 41). She provides (p. 41) the very important derivation (52),

(52)	túgi?	'to write' →
	tugí?+i	'to write to' →
	Á+tugi?+i	'to write to one another' →
	man+Á+tugi?+i	'to write to one another (pl.)'

which shows that main stress remains on the stressed prefix to which it was assigned before the unstressed prefix was added.[16] Thus, unlike the adjunction of suffixes and

[15] As stated in (50), the rule will delete secondary stress also if followed directly by a syllable with secondary stress. This extension is motivated by the stress contours of *pùtamunéda* and *inèNNulu?níha* discussed in section 2.4.

[16] The rules postulated here predict that the surface form will have a secondary stress on the penult. The form cited by Chung does not contain a secondary stress.

stressed prefixes, the adjunction of unstressed prefixes does not trigger a reapplication of the main stress rules. These prefixes are therefore stress-neutral. We shall formally capture this fact by postulating that, like the stress-neutral suffixes of English and the recessive suffixes of Vedic, the unstressed prefixes of Chamorro are noncyclic. Adding such a prefix to a word therefore does not create a new stress plane and such prefixes have no effect on the placement of stress.

Chung remarks (p. 42) that "not all secondary stresses in Chamorro correspond transderivationally to the primary stress of some smaller word" and illustrates this with examples such as those in (53).

(53)	magágu 'clothes'		màgagú-ña	'his clothes'
	kadúku 'crazy'		màn-kadúku	'crazy' (pl.)

Chung suggests that secondary stress in these words is due to a special noncyclic stress rule. The situation in Chamorro is similar to the one encountered earlier in English. As in English, postcyclic alternating stress in Chamorro is assigned by a rule that constructs bounded left-headed constituents and thus resembles a part of the main stress rule (see (46b,c)). Chamorro differs from English in that the Chamorro noncyclic Alternator rule constructs constituents from left to right, whereas the cyclic rule (46c) applies from right to left. As pointed out to us by D. Steriade, the evidence showing that the Alternator rule in Chamorro must apply from left to right is provided by the forms *pùtamunéda* 'wallet', which according to Chung has primary stress on the penult and secondary stress on the initial syllable, and *inèNNuluʔníha* 'their peeping', which has primary stress on the penult and secondary stress on the second syllable. If the Alternator rule applied right to left, the stress pattern of these words could not be generated. As *putamuneda* has no internal constituent structure, Stress Copy will not add stresses in addition to that assigned to the penult by the main stress rule. The Alternator rule (54i) below will then assign line 1 asterisks to the initial and third syllables of the word, yielding *pùta-mùnéda*. The stress on the third syllable, however, will subsequently be deleted by Stress Deletion (50). In *ineNNuluʔ-niha* 'their peeping' the cyclic stress rules and Stress Copy (49) will assign secondary stress to the second syllable and main stress to the penult. Assuming that the Alternator rule is ordered after Stress Copy, the application of the Alternator will result in stresses on the first syllable and on the antepenult. These stresses, however, will be eliminated by the subsequent application of Stress Deletion (50).

In (54) we list the rules developed to this point and indicate by the letters *c* and *n* the stratum to which the rule is assigned.

(54)	a.	c/n	Stressable elements are vowels.
	b.	n	Copy the line 1 asterisks assigned on preceding cycles.
	c.	c/n	Line 0 constituents are left-headed.
	d.	c/n	On line 0 construct binary constituents from $\langle$right to left$\rangle_c$ $\langle$left to right$\rangle_n$.
	e.	c	Line 1 constituents are right-headed.

f. c On line 1 construct an unbounded constituent.
g. c Conflate lines 1 and 2.
h. c Clash Deletion (50).

We now come to the most interesting part of Chamorro phonology: the interaction of the stress rules with four segmental rules. The first of these rules is the *gemination* rule that closes the syllable bearing main stress and is triggered by a small number of word-final suffixes listed by Chung in footnote 7, all of which are of the form CV in their underlying representation. Chung writes, "The conditions on Gemination are, first, that the word must contain a stressed closed syllable; and, second, that the syllable immediately preceding the suffix must be open. What the rule does is close this syllable by doubling the initial consonant of the suffix." We illustrate this with the words in (55).

(55)	a.	déddigu	'heel'
		dèddigómmu	'your heel'
	b.	maléffa	'forgetting'
		màleffámmu	'your forgetting'
	c.	hígadu	'liver'
		hìgadúña	'his liver'
	d.	cincúlu	'fishing net'
		cìnculúmu	'your fishing net'

These facts can be readily accounted for by assigning Gemination to the noncyclic stratum and ordering it after Stress Copy (54b) and before the Alternator (54d). Our account diverges here from Chung's in that Chung has no rule of Stress Copy because in her framework, as in the framework of SPE, stresses assigned on earlier cycles are automatically carried over to later cycles. Since we have given evidence (see especially section 2.1) that cyclically assigned stresses are not carried over, our account requires the rule of Stress Copy (54b). We will argue that it is this difference that forces Chung to the radical conclusion quoted earlier that there exist transderivational relationships not accounted for by cyclic rule application. Once Stress Copy is admitted, the need for transderivational power in the rules disappears. We state Gemination informally as follows.

(56) Geminate the initial consonant of certain word-final suffixes if the suffix adjoins a vowel-final stem and if the stem contains a stressed closed syllable.

In (55a) Gemination applies to the string *dèddigú-mu,* where stress on the closed syllable triggering the process is assigned by Stress Copy (54b). Since the Alternator is ordered before Clash Deletion (54h), the proposed ordering will also account for the facts in (55b). In (55c) Gemination does not apply because the input string *hìgadú-ña* does not contain a closed syllable. In (55d) the input string is *cincùlú-mu,* where the closed syllable is stressless and can therefore not trigger Gemination.

A number of particles and affixes (including an infix) containing a front vowel trigger Umlaut—that is, fronting and unrounding of the vowel—in the following syllable as illustrated in (57).

(57) a.	gúmaʔ	'house'
	i gímaʔ	'the house'
	sóNsuN	'village'
	i séNsuN	'the village'
b.	púgas	'uncooked rice'
	mí-pìgas *or* mí-pùgas	'abounding in uncooked rice'
	gúmaʔ	'house'
	i gìmaʔ-níha *or* i gùmaʔ-níha	'their house'

As is clear from comparing (57a) and (57b), Umlaut is obligatory if the syllable bears main stress but optional if the syllable bears secondary stress.[17] If Umlaut is assigned to the noncyclic stratum and ordered before Stress Copy (54b), it will affect only vowels with main stress. On the other hand, if Umlaut is ordered after Stress Copy, it will affect vowels with main stress as well as vowels that had main stress on an earlier cycle. To account for the optionality of Umlaut we assume that there is a local indeterminacy in the ordering of two noncyclic rules: in some cases the order is Umlaut—Stress Copy, in other cases the order is Stress Copy—Umlaut. Since in all cases Umlaut is ordered before the Alternator, it will never apply to syllables whose secondary stress is supplied by the Alternator. This is illustrated in (58).

(58) a.	pùtamunéda	'wallet'
	i pùtamunéda	'the wallet'
b.	pulónnun	'trigger fish'
	i pùlulónNa	'his trigger fish'

Kiparsky (1986) has proposed to deal with these facts by postulating that Umlaut is assigned obligatorily as the first rule of the noncyclic stratum, but that optionally it may also be assigned as the last rule of the cyclic stratum. In the former case it will apply only in syllables with primary stress, because since Umlaut is the first rule in the noncyclic stratum the only syllable bearing stress at the point of application of the Umlaut rule will be the one with main stress. When Umlaut is optionally assigned as the last rule of the cyclic stratum, it will apply to every syllable that is assigned (primary) stress by the cyclic stress rules. Since in the noncyclic stratum Umlaut is ordered before the Alternator rule (54d), it will never apply in syllables that receive stress from the Alternator rule, as shown by the examples in (58).

This alternative is not readily available in the framework developed in this study, where the familiar linear order of rules put forth in SPE is complicated by the fact that each rule may be assigned to one or more strata. (For justification, see Halle and Mo-

[17] Chung states that optional Umlaut is a feature of the Saipan dialect, "though there is some slight general preference for the nonfronted forms" (p. 46, fn. 10).

hanan (1985).) As a consequence, a rule R_1 ordered before R_2 will consistently apply after R_2 if R_1 is assigned to a later stratum than R_2. For example, in both English and Chamorro (see (43) and (54)) Stress Copy is ordered before the stress rules. Since in both languages Stress Copy is assigned to the noncyclic stratum and the primary stress rules ((43e–f) and (54e–f), respectively) are assigned to the cyclic stratum, Stress Copy in both languages will consistently apply after the rules locating the primary stress. In view of this, if (following Kiparsky's proposal) we were to capture the Chamorro Umlaut vacillation by ordering Umlaut optionally as the last cyclic or as the first noncyclic rule, we would have to order Umlaut after all stress rules in the former case, whereas in the latter case we would have to order Umlaut before all stress rules. The account of the Umlaut vacillation would therefore involve two separate indeterminacies. On the one hand, there would be an indeterminacy regarding whether Umlaut is cyclic or noncyclic. Concomitantly there would be a second indeterminacy regarding whether Umlaut is to be ordered before or after the stress rules: when assigned to the cyclic stratum, Umlaut must be ordered after the stress rules; when assigned to the noncyclic stratum, before them. We have adopted the account presented above because (as noted) it involves but a single indeterminacy: the ordering of Umlaut before or after Stress Copy.

Another phenomenon in Chamorro that shows a type of optionality similar to that of the Umlaut rule and therefore presents the same sort of challenge to the theory of phonology is vowel lowering. We believe that Chung's treatment of the facts of vowel lowering can be improved somewhat, and our exposition of this phenomenon will therefore deviate more markedly from hers.

The basic generalization to be captured here is characterized by Chung as follows: "Non-low vowels surface as mid in stressed closed syllables, and as high elsewhere" (p. 46). To capture this generalization formally, we follow Chung in postulating the rule (59).

(59) Stressed vowels become [−high] in closed syllables.

We allow both high and mid vowels in underlying representations, but we assume that mid vowels are marked whereas high vowels are unmarked. Mid vowels appear in underlying representations only in words where they could not be accounted for by rule (59)—that is, in words such as those in (60) where rule (59) is inapplicable.

(60)	kósas	'things'
	néni	'baby'
	bóti	'boat'
	pakéti	'pack of cigarettes'

It is here that we deviate from Chung's analysis. Chung deals with these words by complicating her equivalent of rule (59) so that in lexically marked cases the rule will lower stressed vowels everywhere, not only in closed syllables. We do not feel this move is justified, for it obscures the fact that in a subpart of the Chamorro lexicon (that part borrowed from Spanish) the contrast between [+high] and [−high] is distinctive. We shall assume therefore that words such as those in (60) have mid vowels in their underlying representation, and we can then keep (59) intact. We also represent with mid vowels the stressed prefixes *sen* 'very', *gof* 'very', and *keʔ* 'to try, be about to', for these prefixes never surface with a high vowel, even in open syllables.

We again follow Chung in the treatment of the handful of words with high vowels listed in her example (42), which exceptionally fail to undergo rule (59) despite meeting its structural conditions. Such words are marked as lexical exceptions to (59).

A potential problem with this approach is that it fails to account for the fact that nonlow vowels in some of the words in (60) do optionally alternate with high vowels. Thus, Chung cites both *niníhu* and *neníhu* as alternants for 'my baby'. We propose to deal with these cases by postulating an optional raising rule that is ordered after Clash Deletion (54h).

(61) Nonlow vowels become [+high] immediately before main stress.

The need for this rule is independently motivated by the fact noted by Chung that /kupblin/ 'cash' shows height alternations when a monosyllabic suffix is adjoined but appears only with a nonhigh vowel when a bisyllabic suffix is added. Thus, Chung cites both *kobblékku* and *kubblékku* as admissible variants for 'my cash' (p. 52), but specifically admits only *kòbblinmámi,* and not *kùbblinmámi,* for 'our (excl.) cash' (p. 55). On Chung's account Vowel Lowering "obligatorily affects vowels which bear secondary stress, and which would have primary stress if the word were decomposed into its parts" (p. 48). To deal with the forms under discussion, Chung proposes the special provision that Vowel Lowering applies optionally to "vowels which are destressed, because they occur to the immediate left of the primary stress, but which would bear primary stress if the word were decomposed into its parts" (p. 48). However, this optional case of height alternation differs from "true" instances of Vowel Lowering in that it applies to vowels in both open and closed syllables, whereas otherwise Vowel Lowering is restricted to closed syllables (and, on Chung's account, to lexically marked forms). Since rule (61) applies without reference to syllable structure, the forms under discussion are handled straightforwardly on the account proposed here.

A desirable by-product of the proposed account is that it simplifies considerably the treatment of the rest of the vowel lowering facts. We find now that Vowel Lowering applies obligatorily if the syllable bears main stress or secondary stress supplied by Stress Copy (54b); it applies optionally if the stress is supplied by the Alternator rule (54d). The optional alternation before main stress need not be considered here, since it is already dealt with by rule (61). The case of optional Vowel Lowering thus appears to parallel closely that of Umlaut, and it might seem that it should be dealt with in parallel fashion—that is, by admitting an indeterminacy in the order of a pair of rules. In the case of Umlaut the indeterminacy involves the Stress Copy rule (54b), whereas in the case of Vowel Lowering the indeterminacy involves the Alternator rule (54d).[18]

Chung observes that in Chamorro geminate consonants are optionally degeminated

[18] For some discussion of such local indeterminacies in rule ordering, see Anderson (1974, chap. 10).

"when these are not immediately preceded by stress" (p. 55). All of her examples, however, are instances of degemination before main stress. We therefore propose that Chamorro is subject to the optional noncyclic rule of Cluster Simplification (62).

(62) Degeminate consonants before stress.

Chung observes further that "non-low vowels are always high in (unstressed) syllables opened by Cluster Simplification" (p. 56). This fact can be readily captured by ordering Cluster Simplification, an optional rule, before Vowel Lowering. Since Vowel Lowering applies only to closed syllables and since Cluster Simplification opens closed syllables, this ordering will correctly ensure that Cluster Simplification always bleeds Vowel Lowering. In Chung's account is is necessary to assume either that Vowel Lowering (and Umlaut) apply cyclically in some derivations and noncyclically in others, or that Vowel Lowering (and Umlaut) include transderivational conditions. Chung shows that the former hypothesis is not compatible with the fully justified assumption that Cluster Simplification is a noncyclic rule. This result leads her to conclude that transderivational conditions must be allowed in phonological rules.

In the framework developed here the effect of transderivational constraints is obtained by assigning Vowel Lowering to the noncyclic stratum and ordering it after Stress Copy. The optional application of Vowel Lowering to syllables stressed by the Alternator (54i) can be captured by stating that Vowel Lowering is freely ordered with respect to the Alternator rule.

With the modifications outlined above it has been possible for us to maintain the well-motivated constraint that cyclic rule application accounts for all transderivational relationships between complex words and their parts. We conclude this section by listing the rules of the noncyclic stratum of Chamorro as developed above.

(63) a. c/n Stressable elements are vowels.
b. n Umlaut
c. n Copy the line 1 asterisks assigned on preceding cycles. (54b)
d. n Gemination (56)
e. n Cluster Simplification (62)
f. c/n Line 0 constituents are left-headed.
g. n Vowel Lowering (59)—optional
h. c/n On line 0 construct binary constituents from $\langle$right to left$\rangle_c$ $\langle$left to right$\rangle_n$.
i. c Line 1 constituents are right-headed.
j. c On line 1 construct an unbounded constituent.
k. c Conflate lines 1 and 2.
l. n Clash Deletion (50)
m. n Raising (17)—optional

As previously discussed, there are two indeterminacies in the rule order, both involving adjacently ordered rules: Umlaut may optionally be ordered after Stress Copy, and Vowel Lowering may optionally be ordered after the Alternator rule (63h).

2.5. *Stress in Lenakel*

As we have seen, in English the Alternator (rules (43c,d)) is assigned to both the cyclic stratum and the noncyclic stratum, but the rule of stress copy (40) is assigned only to the noncyclic stratum. The Austronesian language Lenakel has a rule of stress copy that must be assigned both to the cyclic stratum and to the noncyclic stratum. The Lenakel data discussed below have been taken from Hammond (1984), which in turn is based on Lynch (1974; 1978). In Lenakel, main stress is located on the penultimate syllable in the large majority of words and on the final syllable in a class of specially marked words. As in a great many other languages, in Lenakel the main word stress is preceded by a series of subsidiary stresses. In nouns these fall on every even-numbered syllable preceding the main stress; in verbs they fall on odd-numbered syllables preceding the main stress, except for the syllable immediately preceding main stress. Examples are given in (64).[19]

(64)	a.	lÈdubɔ̀lugálUk	'lungs' (loc.)
		kayÈlawÉlaw	'kind of dance'
	b.	kə̀namargə́nim	'they have been pinching it'
		tɨ̀nagàmyasɨnə́vɨn	'you will be copying it'
		nàdyagàmEdwàdamnímɔn	'why I am about to be shaking'

We have assumed that main stress is assigned by the set of rules in (65). As above, the letters *c* and *n* preceding the rule indicate whether the rule is assigned to the cyclic stratum, the noncyclic stratum, or both.

(65)	a.	c/n	Stressable elements are vowels.
	b.	c/n	Line 0 constituents are left-headed.
	c.	c/n	On line 0 construct bounded constituents from right to left.
	d.	c	Line 1 constituents are right-headed.
	e.	c	On line 1 construct an unbounded constituent.
	f.	c	Conflate lines 1 and 2.

We have assumed moreover that the noncyclic Alternator rules for nouns in Lenakel are identical with (65b,c); in other words, as in English, these two rules are assigned both to the cyclic stratum and to the noncyclic stratum of the morphophonology. As Hammond notes, this proposal works perfectly in the case of words with an even number of syllables. In the case of words with an odd number of syllables the rules given above

[19] In the transcription of Lenakel words the capital letters represent lax variants of the vowels. Palatalized /d/ has been represented by the digraph *dy*. Additional diacritics in Lynch's transcriptions have been omitted. The omitted diacritics represent phonetic properties that are in no way involved in the phenomena of interest here.

predict that the Alternator will place stress on both the first and the second syllables of the word as illustrated in (66).

```
(66)   . . . . . * .                 .   . .   . .   * .
       (. . . . . * .)   -------->  (*   * .   * .   * .)
        * * * * * (* *) Alternator (*) (* *) (* *) (* *)
        1 2 3 4 5  6 7              1   2 3   4 5   6 7
```

To eliminate this unattested stress clash, we postulate, following Hammond, the rule of stress deletion (67).

(67) Delete a line 1 asterisk if followed directly by a line 1 asterisk.

Examination of the verbal forms with an odd number of syllables, such as *kə̀namargə́nim* 'they have been pinching it' in (64b), shows that the suggested procedure won't work, for, as already noted, in verbs secondary stresses fall on odd-numbered syllables preceding the main stress except for the immediately pretonic syllable. The minimal change in the rules already postulated that will produce this result is to modify rule (65c) as in (68), where the parenthesized portion of the formulation applies *only in the noncyclic stratum*—that is, when the rule functions as the Alternator.

(68) On line 0 construct bounded constituents from right to left (in nouns, and from left to right in verbs).

This new version of the Alternator will then assign line 1 asterisks to nouns as shown in (69a) and to verbs as shown in (69b).

```
(69) a. . . . . . * .     b. . . . . . * .
        * * . * . * .        * . * . * * .
        * * * * * * *        * * * * * * *
        1 2 3 4 5 6 7        1 2 3 4 5 6 7
```

The asterisk deletion rule (67) will apply to these representations and eliminate the left one of two adjacent asterisks (here, the line 1 asterisks above position 1 in (69a) and above position 5 in (69b)). In addition to words with penultimate main stress Lenakel has a class of words with final stress, as shown in (70). The obvious way to deal with these words is to postulate that they contain accented morphemes, which, in their underlying representation, have a line 1 asterisk over their last (or only) syllable. The rules stated above will then apply in their normal fashion and place main stress on the final syllable.

(70)	r-ɨ̀s-gən-án	'he didn't eat it'
	r-ɨ̀m-Edy-áw	'he arrived'
	r-ɨ̀m-asOw-yáw	'he went north'

Hammond points out that, when two such lexically marked morphemes occur next to each other, the second loses its stress and main stress surfaces on the penult, as shown in (71a). However, as shown in (71b), when the sequence contains three lexically marked morphemes, main stress is final and only the penultimate suffix surfaces without stress.

(71)	a.	r-ɨ̀s-Edyáw-an	'he didn't arrive'
		r-ɨ̀m-Edyáw-yav	'he arrived in the north'
	b.	r-ɨ̀s-Edyàw-yav-án	'he didn't arrive in the north'

We can obtain these results if we assume that, when suffixed to a stem with final main stress, a lexically supplied asterisk is deleted. To account for the fact that, in a sequence of three lexically supplied asterisks, only the penultimate is deleted, we must assume that the affixes are cyclic and that the rule deleting such asterisks applies cyclically. The cyclic rule of asterisk deletion required here is a different rule from the noncyclic asterisk deletion rule (67), for it deletes a following, rather than a preceding, asterisk. We formulate it as follows.

(72) Delete a word-final line 1 asterisk, if preceded directly by a line 1 asterisk.

The formulation in (72) raises a question about the procedure suggested above. We have stated that information about stress assigned on previous cycles is not in general available on subsequent cycles. It is obvious that this condition would prevent us from obtaining the correct results in the present instance because there would never be more than one stressed vowel on a cyclic stem plane. We must therefore circumvent this restriction in some way. We propose to do this by adding to the cyclic rules of Lenakel the asterisk copying rule (73), which is identical with the stress copying rule (43b) of English.

(73) Copy line 1 asterisks assigned on preceding cycles.

Because Subjacency restricts the application of cyclic rules to the plane generated on the immediately preceding cycle, only a single asterisk will be copied on each pass through the cyclic rules; as in English, however, when assigned to a noncyclic stratum, the copy rule will copy all previously assigned asterisks, since noncyclic rules are not restricted by Subjacency. As we shall see, this result holds also for Lenakel.

According to Hammond, in Lenakel tense and lax vowels are in near complementary distribution: "High vowels are tense in open syllables and lax in closed ones. Mid vowels are lax before consonants and tense otherwise" (p. 7). To capture this fact formally, we assume that the language includes a vowel tensing rule that applies in open syllables subject to certain further conditions.

In addition to vowels with a predictable distribution of tenseness, Lenakel has tense vowels in contexts other than those subject to the tensing rule. Thus, the stressed vowels in (74a) are tense, although in closed syllables the tensing rule does not apply, as shown in (74b).

(74) a.	asís	'to swell up'	amnúm	'to drink'
	abgén	'to be jealous'	yElmów	'salt water eel'
b.	kÍn	'a kind of worm'	sÚk'	'spear'
	Élmas	'to frighten'	tɨgÓmgOm	'branches'

To account for the examples in (74a), we shall assume that, in Lenakel, there are words that have tense vowels in their lexical representation.

A fact of special interest is that lexically tense vowels attract stress. For instance, as shown in (74a), words with lexically tense vowels in their last syllable have final stress, although normally Lenakel words have penultimate stress. To account for this, we postulate rule (75), which applies before the cyclic stress rules.

(75) Supply a line 1 asterisk to tense vowels.

Citing the examples in (76), Hammond observes that the vowels we have characterized here as lexically tense interrupt the alternating pattern of stresses.

(76) nɨ-gì-níl-ar 'their hearts'
nɨ̀-man-sì-níl-ar 'their bottoms'

The morphemes /gi/ and /si/ have lexically tense vowels, and we can account for their stress by assigning rule (75) to the noncyclic stratum (it is already assigned to the cyclic stratum in order to guarantee main stress on the final syllable in words like those in (74a)). These forms also show that (75) must be ordered before the rules that construct metrical constituent structure—namely, the Alternator (65b,c). Consequently, the two forms in (76) would appear after the application of the Alternator with the stress grids given in (77).

```
(77)   .  .  *  .            .    .    .  *  .
      (*  *  *  .)          (*    .    *  *  .)
      (*) (*) (* *)         (*    *)  (*) (* *)
      nɨ- gi- nil-ar        nɨ-man-si- nil-ar
```

There is a problem with the forms in (77), however. These forms would undergo the noncyclic asterisk deletion rule (67) and would then surface with incorrect stress contours. In particular, the deletion rule would remove all line 1 asterisks in /nɨginilar/ and the asterisk over /si/ in /nɨmansinilar/. But, as noted already, lexically tense vowels are not subject to the asterisk deletion rule (67). This rule must therefore be reformulated as follows.

(78) Delete a line 1 asterisk if followed directly by a line 1 asterisk, provided that the asterisk to be deleted dominates a lax vowel.

If this rule is ordered before the rule tensing vowels in open syllables, the correct output is produced.

We conclude this section by listing in the order of their application the Lenakel rules discussed above.

(79) a. c/n Stressable elements are vowels. (65a)
b. c On each stress plane copy the line 1 asterisk assigned on preceding cycles. (71)
c. c/n Supply a line 1 asterisk to tense vowels. (75)
d. c Delete a word-final line 1 asterisk, if preceded directly by a line 1 asterisk. (72)

e. c/n Line 0 constituents are left-headed. (65b)
f. c/⟨n⟩ On line 0 construct bounded constituents from right to left ⟨in nouns, and from left to right in verbs⟩. (65c)
g. c Line 1 constituents are right-headed. (65d)
h. c On line 1 construct an unbounded constituent. (65e)
i. c Conflate lines 1 and 2. (65f)
j. n Delete a line 1 asterisk if followed directly by a line 1 asterisk, provided that the asterisk to be deleted dominates a lax vowel. (78)
k. n Tense nonlow $\langle\text{nonhigh}\rangle_a$ vowels in open $\langle\text{nonfinal}\rangle_b$ syllables. Condition: if a, then b.

3. Concluding Remarks

The theoretical framework described above derives directly from the metrical grid proposed in Liberman (1975) and further elaborated in Prince (1983). The basic difference between Prince's notation and ours lies in our respective conceptions of the nature of stress. Implicit in Prince's article is the view that stress is yet another phonetic property of languages. Thus, stress is the result of three kinds of rules: QS (quantity-sensitive rules), ER (end rules), and PG (perfect grid rules that lay down the alternating patterns of stresses). Each type of rule has properties of its own that are not shared by the others, and none of them derives from more basic properties of languages. By contrast, on our view stress is the reflex of the way languages concatenate elements. There are reasons to suppose that when linguistic elements are concatenated in a sequence, this is invariably done by means of constituent structure, that is, by organizing the elements into *constituents,* in each of which one element—usually the first or the last—is marked as the *head.* It is this marked element that commonly, but not universally, is phonetically interpreted as stress. An immediate consequence of this is that the phenomena captured by Prince's three types of rules are to a great extent seen to share common properties. We have shown that, except in the case of ternary constituents, constituent construction implies that stress will be assigned to the element at one or the other end of the string. As a result, there is no class of end rules in our framework. Moreover, we have discussed elsewhere (Halle (1985) and Halle and Vergnaud (in preparation)) changes in the stress contours of words occasioned, on the one hand, by elision and, on the other hand, by epenthesis of stress-bearing elements. In both cases the changes are predictable from the independently motivated constituent structure of the sequence. In a notation such as that proposed by Prince, where metrical constituent structure is eliminated by hypothesis, this important class of phenomena cannot be dealt with in a principled manner.

We have gone beyond other theories of stress known to us in making precise the autosegmental character of stress. In particular, we have proposed that metrical structure must be represented on a separate autosegmental plane. We have suggested that a separate autosegmental plane must be constructed for each cyclic affix, and we have argued that in the unmarked case the information about stress assigned on earlier planes is not carried over automatically to later planes. The latter suggestion is strongly supported by facts from languages like Vedic and Spanish, where stress assignment is clearly cyclic, yet where none of the stresses assigned on an earlier cycle is phonetically actualized. This suggestion is, of course, independent of our proposal to represent each cyclic affix on a separate autosegmental plane.

Spanish differs from Vedic in that in Spanish the main stress of the word is preceded by an alternating sequence of secondary stresses. These secondary stresses do not reflect stresses assigned on earlier cycles and are generated by a special rule of metrical constituent construction we have referred to as the Alternator rule. In the more marked cases, such as English, Chamorro, and Lenakel, the Alternator respects the heads of constituents constructed on earlier passes through the cyclic rules. Since information about stresses assigned on earlier planes is not automatically carried over to later planes, a special rule copying this information onto later planes must be postulated. We have attempted to show that in English and Chamorro the copying rule is noncyclic, whereas in Lenakel it is both cyclic and noncyclic. The rules that copy stresses assigned on earlier cycles have a modicum of transderivational power, for they make available information about earlier stages in the derivation that is not otherwise available. We have tried to show that this restricted amount of transderivational power suffices to deal with the complex facts of Chamorro, which led Chung (1983) to conclude that it is necessary to admit rules with full transderivational power in phonology. This allows us to retain the desirable restriction that cyclic rule application accounts for all transderivational relationships encountered in phonology.

In Damascene Arabic there is no pattern of subsidiary stresses in the word, yet syllables that were stressed on earlier cycles are immune to the noncyclic rule of schwa deletion. We captured these facts by stating that the phonology of Damascene Arabic does not include the Alternator rule; instead, it does include a copying rule that records earlier stresses. Thus, there is relative independence between the copying rule and the Alternator, as shown in (80).

(80)

		Alternator +	Alternator −
Copy	+	English, Lenakel, Chamorro	Damascene Arabic
	−	Spanish	Vedic, Lithuanian

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