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On Stress and Linguistic Rhythm*

0. Prospectus

In this essay a new theory of stress and linguistic rhythm will be elaborated, based on the proposals of Liberman (1975).[1] It will be argued that certain features of prosodic systems like that of English, in particular the phenomenon of "stress subordination", are not to be referred primarily to the properties of individual segments (or syllables), but rather reflect a hierarchical rhythmic structuring that organizes the syllables, words, and syntactic phrases of a sentence. The character of this structuring, properly understood, will give fresh insight into phenomena that have been apprehended in terms of the phonological cycle, the stress-subordination convention, the theory of disjunctive ordering, and the use of crucial variables in phonological rules.

Our theory will employ two basic ideas about the representation of traditional prosodic concepts: first, we represent the notion *relative prominence* in terms of a relation defined on constituent structure; and second, we represent certain aspects of the notion *linguistic rhythm* in terms of the alignment of linguistic material with a "metrical grid".

The perceived "stressing" of an utterance, we think, reflects the combined influence of a constituent-structure pattern and its grid alignment. This pattern-grid combination is reminiscent of the traditional picture of verse scansion, so that the theory as a whole deserves the name "metrical". We will also use the expression "metrical theory" as a convenient term for that portion of the theory which deals with the assignment of relative prominence in terms of a relation defined on constituent structure.

Section 1 will apply the metrical theory of stress-pattern assignment to the system of English phrasal stress, arguing this theory's value in rationalizing otherwise arbitrary characteristics of stress features and stress rules. Section 2 will extend this treatment to the domain of English word stress, adopting a somewhat traditional view of the assignment of the feature [+stress], but explaining the generation of word-level

patterns of stress in terms of the metrical theory developed to treat the phrasal domain. Section 3 will introduce the concept of alignment with a *metrical grid*—fundamentally a formalization of the traditional idea of "stress-timing". We will argue that this concept is central to a satisfactory account of the so-called "rhythm rule", and also gives a realistic picture of relative stress at the syllabic level.

0.1. A Note on the Data

For the most part, this article will advance its case in terms of a reanalysis of old observations, rather than a flourish of new ones. The body of descriptive data we propose to reinterpret has been common (differences of detail aside) to the linguistic tradition that includes the American Structuralists as well as Generative Phonology; it includes the distribution of stressed and unstressed syllables in English words, the location of main word stress, the differential treatment of lexical and supralexical constituents, the preservation of relative prominence under embedding, and so forth.

Over the years, some fundamental characteristics of this description have been called into question on one basis or another. For example, it has been proposed (most notably by Bolinger) that it is incorrect to extend the notion "stress" beyond the word level, "sentence stress" being merely a matter of pitch-accent placement. This same point of view holds that word stress itself is no more than a guide to the word-level location of those (phrasal) pitch-accents that the speaker chooses to impose.

Although it is not our purpose here to argue the point, we feel that the structuralists (and their generative heirs) were closer to the truth. English is a stress language, not a tone or pitch-accent language; English stress patterns, within and among words, have phonetic reality as rhythmic patterns entirely independent of their role in orchestrating the placement of intonation contours.

This much should not be difficult to establish experimentally. One promising line of inquiry relies on the fact that it is possible to mimic an arbitrary English utterance while substituting reiteration of a single syllable (e.g. *ma*) for each syllable of the original. Such "reiterant speech" shows stable durational patterns, which depend on the stress pattern and constituent structure of the utterance,[2] just as durational patterns in natural speech do. It has been shown[3] that listeners are able to extract stress and constituent-structure information from reiterant speech, and that (under the conditions of the cited experiment) duration is the dominant cue in both cases.

In perception experiments, the use of reiterant speech guarantees that stress-pattern perceptions cannot be derived from the hearer's knowledge of the words involved; control of F_0, possible by using analysis–resynthesis techniques, can be used to separate out the role of "pitch accent" (a role that is perhaps less central to stress-pattern perception than is generally believed). In analysis of production data, the

reiterant speech technique permits the study of prosodic influences on duration (as well as amplitude, etc.) in an environment free from segmental influences.

In both production and perception, it is not hard to show the *existence* of stress patterns in English as a descriptive category independent of intonation contour. It remains to be seen whether the particulars of traditional descriptions of stress, or for that matter our reanalysis of them, will provide an adequate framework for phonetic research in this area. We feel, in any case, that both phonologists and phoneticians stand to learn a great deal from the attempt to find out.

1. The Phrasal Stress System of English[4]

It is a commonplace observation that the typical stress pattern of phrasal collocations in English (e.g. *rèd cóws, Sàm léft*) differs systematically from that of lexical compounds (e.g. *kéel-haùl, stréss-shìft, bláckboàrd*). Of course, these typical patterns are often overwhelmed by the chiaroscuro of highlight and background in discourse, but they retain the status of null-hypothesis patterns that emerge when there is no good reason to take some other option.

A second important observation about phrasal stress patterns is that relative prominence tends to be preserved under embedding. Thus the compound *whále-oil* (said in isolation) has its main stress on the word *whale*, with *oil* having some lesser degree of stress, and this inequality is felt to be preserved in the phrase *whàle-oil lámp*, although main stress of the phrase as a whole now falls on the word *lamp*.

1.1. A Familiar Description

These two observations (suitably expanded) lie at the root of the traditional account, within generative phonology, of English phrasal stress. We propose to substitute a theory that embodies the same observations in a rather different way; in order to understand the nature and value of the differences, we begin by describing how English phrasal stress has been treated within a familiar generative theory of phonology.

This theory employs an *n*-ary segmental stress feature, that is, a phonological feature, otherwise like other distinctive features of segments, which is in principle capable of assuming indefinitely many values. Its range is usually limited to five values (four levels of stress, from 1 to 4 in decreasing strength, plus [0 stress]) more or less as a matter of convenience.

The idea of a stress feature with something like three to five values should not be laid, either as credit or debit, to the account of generative phonology. Steele (1775) employed the symbols △, ∴, and : to mark three levels of stress within the barlines of a quasi-musical notation (which also marked pitch contours and seven degrees of length); the use of symbols such as ´, `, ^, ˇ, ˌ, and ˈ to specify three to five levels has long been

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[2] Cf. Liberman and Streeter (1976).
[3] By Nakatani and Schaffer (1976).

[4] By "phrasal" stress we mean stress above the level of the word, including the stressing of lexical compounds as well as that of truly "phrasal" categories.

common; and the numbers 1–4 were used by the American Structuralists whose work formed the foundation on which Chomsky and Halle built.

An essentially novel contribution of generative phonological theory was the idea of cyclic reassignment of [1 stress], coupled with the convention of stress subordination, which follows the reassignment of [1 stress] in a given domain, and demotes all other stresses within that domain by one level. Let us observe these principles in operation in a simple case. In the first line of (1), each word is assumed to have been provided with the feature [1 stress], on the appropriate segment, by the word-level stress rules (to which we will return in section 2). The principle of cyclic application of rules tells us to begin with the innermost set of brackets, which in this case defines the constituent *dew-covered*.

(1) [[[dew] [covered]] [lawn]]

1	1	1	Word Stress
1	2	–	Inner Cycle—CSR
2	3	1	Outer Cycle—NSR

Since *dew-covered* is a lexical category (specifically, a compound adjective) we reassign [1 stress] to the [1 stress] of *dew*, according to the dictates of the Compound Stress Rule (henceforth CSR), and the remaining stress in the current cyclic domain (the [1 stress] of *covered*), is reduced by one level. We then proceed to the next higher cyclic domain, which in this case is the noun phrase *dew-covered lawn*; since this is a phrasal category, we employ the Nuclear Stress Rule (NSR) to reassign [1 stress] to the [1 stress] of *lawn*, and allow the stress subordination convention to do its work, resulting in the desired 2 3 1 pattern.

In this approach, relative prominence is determined within each constituent by the reassignment of [1 stress] at the corresponding cyclic level. If the constituent in question is a lexical category (noun, verb, adjective, etc.) then the "compound stress" pattern of relative prominence will be assigned; if it is a phrasal category (noun phrase, verb phrase, adjective phrase, sentence, etc.) then the "nuclear stress" pattern of relative prominence will be assigned. The subordination principle, applying cyclically, will preserve this relative prominence (as a rank-ordering of stress numbers) as we proceed to assign [1 stress] at higher levels.

A second important innovation of generative phonology has been the development of a formalism for expressing stress-assignment rules such as the NSR and CSR in an explicit and precise fashion. One version of such a formulation is the following:

(2) a. *NSR*

$$\text{V} \rightarrow [1 \text{ stress}] / \underline{\quad\quad} \text{Q }_C]$$
[1 stress]

Conditions: Q contains no [1 stress]
C = NP, VP, AP, S

b. *CSR*

$$\text{V} \rightarrow [1 \text{ stress}] / \underline{\quad\quad} \text{Q } (\#\#\text{P}) _C]$$
[1 stress]

Conditions: Q contains no [1 stress]
P contains no ##
C = N, A, V

Expressed informally, (2a) means "assign [1 stress] to the rightmost vowel bearing the feature [1 stress]." (2b) means "skip over the rightmost word, and then assign [1 stress] to the right-most remaining [1 stress] vowel; if there is no [1 stress] to the left of the rightmost word, then try again without skipping the word."

The application of these rules to our previous example is straightforward. On the inner cycle (represented in (2a)), the CSR will be selected, since we are dealing with a lexical category; the variable P will take the single word that it is permitted, Q will pick up the off-glide at the end of *dew*, and the rule will choose the [1 stress] vowel of *dew* as its locus of application.

(3) a. [#d́ew##ćovered#]

b. [#d́ew##c̀overed##ĺawn#]
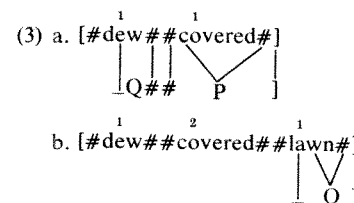
On the noun phrase cycle (represented in (3b)), the NSR will be selected; Q will cover the sequence /n#/, and the rule will reassign [1 stress] to the vowel of *lawn*.

Let us now examine a few more complicated cases. The prediction of the CSR, as formulated in (2b), is that any compound with a uniformly left-branching structure, that is, in which each new cyclic domain is augmented by precisely one word at the right margin, should retain prominence on its leftmost member; however, if at any stage of the compounding process the righthand element is itself a compound form, then this righthand member will assume the primary stress.

For an example of the first sort, consider the compound *law degree requirement changes*.

(4) a. [#ĺaw##d́egree#]

   Analysis (by CSR)

1   2   Output
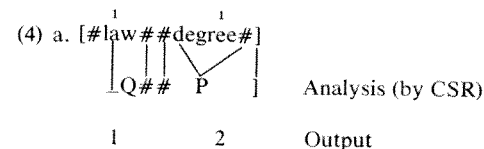
On the first cycle, represented in (4a), the bracket in the rule analyzes the bracket in the target string; the variable P analyzes the single word *degree*, being required to

stop when it comes to the ## boundary; this ## boundary is analyzed by the corresponding term in the rule; Q will be null, since the next available segment is a [1 stress] vowel, which it is forbidden to include; and so the rule's locus of application will be the [1 stress] vowel of *law*, resulting in the pattern *law degree*.

(4) b. [#law##degree##requirement#]

        Q ##   P   Analysis (by CSR)

  1   3   2   Output
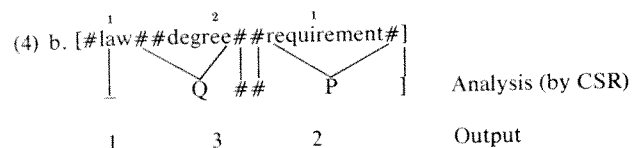
At the next higher cyclic level, represented in (4b), P analyzes the word *requirement*; Q will take the maximal string containing no [1 stress], which is /##degree/; and [1 stress] will again be reassigned to *law*, resulting in the pattern *law degree requirement*.

(4) c. [#law##degree##requirement##changes#]

          Q   ## P   Analysis (by CSR)

  1   4   3   2   Output
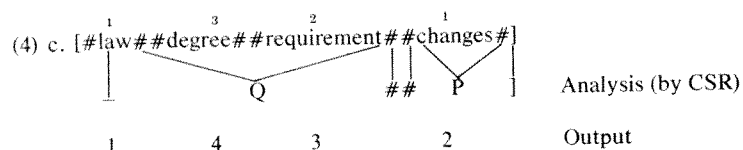
The next application of the rule is represented in (4c): [1 stress] is reassigned once again to *law*, and it should by now be obvious that *law* will continue to receive [1 stress] as long as only one word at a time is added to the domain of the rule.

But now consider the compound *law-degree language requirement*. The two constituent subcompounds, *law degree* and *language requirement*, are cyclically parallel. In each case, [1 stress] will be assigned to the [1 stress] vowel of the word on the left, yielding a 1 2 1 2 pattern as input to the application of the rule at the upper level.

(5) [#law##degree##language##requirement#]

        Q ##   P   Analysis (by CSR)

  2   3   1   3   Output
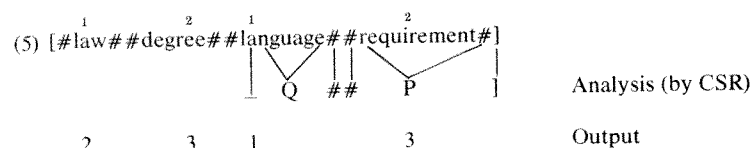
As usual, P will analyze a single word, in this case the word *requirement*. But Q is constrained to contain no [1 stress], and therefore its maximal domain will be the string /ŋgwəĭ/; the rule will reassign [1 stress] to the [1 stress] vowel of *language*. This result is in accord with the facts—compounds of this general type, such as *labor union finance committee, fly-rod trout-fishing*, etc., typically have their main stress on the more prominent word of the righthand member.

It is easy to find cases where adding a word to the righthand constituent does not

seem to change its semantic relation to the lefthand constituent in any significant way, so that no explanation in terms of meaning differences seems readily available. For example, the relation of *Rorschach* to *ink-blot* in *Rorschach ink-blot* seems no different from the relation of *Rorschach* to *blot* in *Rorschach blot*.

1.2. Some Wrinkles: Readjustments and Emendations

In the "traditional" theory we have been discussing, the patterns of stress numbers produced by applying the stress rules to syntactically motivated surface structures have been assumed to be subject to various sorts of correction.

In some cases, the desired result has been obtained by assuming that surface syntactic structures are modified by certain "readjustment rules" before being submitted to the phonological component, which will then produce the correct stress pattern in the normal course of its operation. For example, a left-branching structure such as [[[[John's mother's] brother's] dog's] house], which would produce the output *John's mother's brother's dog's house*, is "flattened out" into a simple concatenative structure, producing in this case the pattern 2 2 2 2 1, which is felt to be more consistent with the perceived stressing of such phrases.

In other cases, the output of the fundamental stress-assignment rules, the CSR and the NSR, has been modified by the subsequent application of various subsidiary rules. Two examples of such emendation will be mentioned here.

Structuralist accounts of English stress (e.g. Trager and Smith (1951)) argued for a distinction between nonprimary stresses within a word, and subordinated main stresses of independent words, a distinction that could be expressed by a one-level downgrading of all nonprimary stresses within the confines of a given word; thus *Tennessee* but *Aral Sea*. In generative treatments, this downgrading has variously been accomplished by a special rule of emendation, and by an otherwise vacuous application of the CSR.

Second, in certain cases a stress pattern that is "rising" when phrase-final, e.g. *thirteen* and *Tennessee*, becomes "falling" when it is followed by a stronger stress in the same phrase, e.g. *thirteen men* or *Tennessee Ernie*. This has been attributed to a "rhythm rule" operating to alleviate clash of stresses and produce a more nearly alternating pattern. Except for the attempt in Kiparsky (1966), this rule has been discussed only informally.[5]

In section 1.3, we will present a different treatment of English phrasal stress assignment. This treatment will employ the first of the concepts we hope to motivate in this article, the idea of representing relative prominence in terms of a binary relation

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[5] Goldsmith (1976) attempts to explain such cases as misinterpretation of certain properties of tone-contour assignment rules. The grounds for our rejection of this view will become clear in section 3.

defined on pairs of nodes in a tree, rather than in terms of a multivalued feature defined on its terminal symbols. This relational theory will mimic the operation of the stress-number theory in a "pure" form, without the readjustments and emendations just mentioned. In our view, many of these "wrinkles" are symptoms of a second aspect of the rhythmic structuring of English, the alignment of linguistic material with a "metrical grid". This phenomenon, and its application to the readjustments and emendations we have just described, will be discussed in section 3.

1.3. A Relational Theory of English Phrasal Stress

We return to this section's beginning, to the observation that relative prominence tends to be assigned one way in lexical compounds, and another way in phrases. Traditional theories represented this relative prominence in terms of some feature of the vowel or syllable where its perceived effect will ultimately lodge. Suppose instead we allow relative prominence to be defined on *constituents*. We may represent this relative prominence graphically, by annotating the nodes of the syntactic tree with the symbols *w* (for "weak") and *s* (for "strong").

(6) a. red cows   b. John left   c. keel haul   d. stress shift
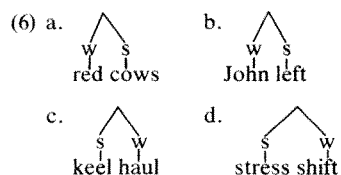
It should be understood that this is simply a notational convenience. Its represents a local property of the tree structure, a relation defined on sister nodes, and the apparent "node labels" *s* and *w* cannot have any existence independent of the definition of such a relation. Therefore an isolated [s], an isolated [w], and the configurations [ss] and [ww] are meaningless.

It is obvious that the relative prominence assigned at a given level of structure will be preserved under embedding, since relations defined on higher levels of structure do not affect lower-level configurations, all definitions being strictly local. Thus in (7) the relative prominence of *dew* in *dew-covered* is not altered in any way by the assignment of greater prominence to *lawn* in *dew-covered lawn*.

(7) R[6] dew-covered lawn
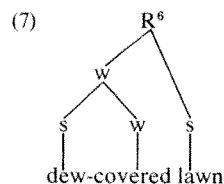
[6] We use the symbol "R" as a convenient label for the root of the tree, which will of course be neither *s* nor *w*, since it is not in a syntagmatic relation with any other node.

In other words, stress subordination is built into the basic nature of this mode of representation, and does not require any special convention.

Another effect of assigning phrasal stress patterns in terms of structural rather than segmental features is that the stress-assignment rules now define strictly local properties of their input. It is not necessary to hunt through a segmental string for "the rightmost [1 stress] vowel," or "the rightmost [1 stress] vowel to the left of the rightmost ## boundary." Rather, we simply define a relation on each pair of sister nodes in the syntactic structure, the output depending on certain local properties of that structure. To be specific, this theory's version of the NSR and CSR can be stated as follows:

(8) In a configuration $[_c A\ B_c]$:
 a. *NSR*: If C is a phrasal category, B is strong.
 b. *CSR*: If C is a lexical category, B is strong iff it branches.

Because of the relational nature of the categories "strong" and "weak", making one element strong necessarily makes its sister weak, and vice-versa. Given that some pattern of relative prominence must be assigned by every application of the rule, the effect of the biconditional in the above statement of the CSR is thus to guarantee that if B is nonbranching it will be weak (and A, correspondingly, strong).

Now, let us reconsider the derivation of *law degree requirement changes*:

(9) a.

law degree requirement changes

b.

law degree requirement changes
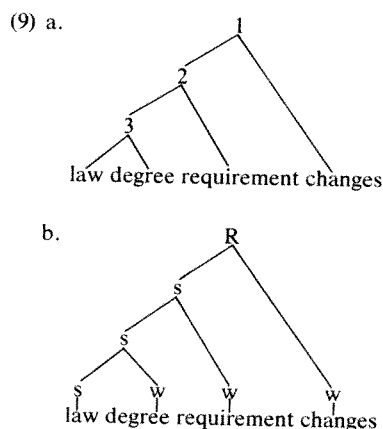
The nodes labelled 1, 2, and 3 in (9a) require the s/w relation to be defined on their daughters. In each case the parent node is the lexical category *noun*, so the CSR will be employed throughout. In every case the right daughter is nonbranching (consists of a single word), so a trochaic pattern will be defined in every case, as shown in (9b).

We now proceed to *law-degree language requirement*:

(10) a.

```
            1
          /   \
         2     3
        /     / \
  law degree language requirement
```

b.

```
              R
           /     \
          w       s
         / \     / \
        s   w   s   w
  law degree language requirement
```
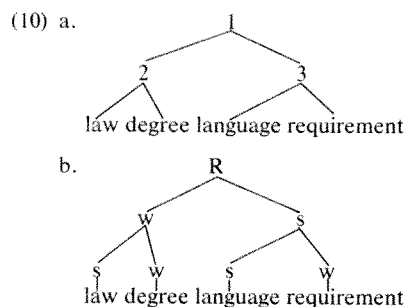
Again, the nodes labelled 1, 2, and 3 require the s/w relation to be defined on their daughters. Again, the CSR is selected throughout. Since the right daughters of nodes 2 and 3 are nonbranching, the daughters of 2 and 3 will be labelled [sw]; since the right daughter of node 1 is branching, the daughters of node 1 will be labelled [ws]. The result is given in (10b).

Observe that the pattern that results from our labelling procedure is not dependent on any particular order of application. In (9), for example, we could have operated on the three relevant parent nodes in the cyclically defined order 3 2 1, in the "anticyclical" order 1 2 3, in any randomly selected order, or indeed everywhere at once. In other words, the relational versions of the CSR and NSR can be viewed as well-formedness conditions applying simultaneously to their maximal domains. In the stress-number theory, on the other hand, a cyclic procedure of application is obviously crucial. In *law degree requirement changes,* for example, if we began at the highest level, the main stress of the phrase would be assigned to the [1 stress] vowel of *requirement,* as shown in the analysis below:

```
              1          1         1              1
(11) [#law# #degree# #requirement# # #changes#]
                        \ |/  ||    \  /   |
                         Q    ##     P          ]      Analysis

         2          2         1              2        Output
```
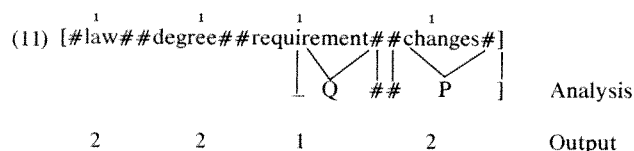
We will have more to say later about the phonological cycle—for now we wish simply to observe that it is a formal necessity in the segmental treatment of stress patterns, given the use of the stress subordination convention as a way to represent the preservation of relative prominence under embedding. The theory we are proposing encodes relative prominence directly, as a local feature of constituent structure, and therefore the formalism itself does not force a cyclic procedure of rule application.

Let us now pause briefly to consider what the labellings we have been imposing really mean, in terms of patterns of relative stress. The "most prominent" terminal

element of a given constituent must surely lie somewhere in its "more prominent" daughter, an argument that can be applied recursively until the most-stressed terminal element is reached. Thus for any given constituent, the location of its main stress (as far down as the lowest level of arborization) can clearly be found by following a path from the root that intersects no nodes labelled *w*. We will call the most prominent terminal element of a given constituent, its "main stress", by the name *designated terminal element*.

It is less clear how such trees should be considered to define relative prominence among their non-main-stressed terminal elements. If we wished to mimic closely the numerology of previous theories, we could make use of the following definition:

(12) If a terminal node *t* is labelled *w*, its stress number is equal to the number of nodes that dominate it, plus one. If a terminal node *t* is labelled *s*, its stress number is equal to the number of nodes that dominate the lowest *w* dominating *t*, plus one.

To illustrate the method of mimicry, we offer the following sufficiently complicated compound:

(13)

```
                      R
                    /   \
                   s     \
                  / \     \
                 w   s     \
                / \  / \    \
               s  w s   w    w
            labor union finance committee president
             3    4    1        4        2
```
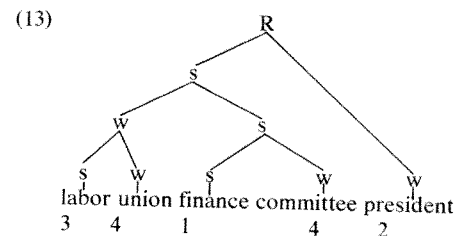
However, the existence of this algorithm for deriving stress numbers of a familiar kind from a relational representation simply expresses the fact that the information that goes into the results of the numerological cycle is also present in the annotated tree of the relational theory. There is nothing inherent in the relational method of representation that would lead one to the particular rank-ordering of terminals implied by (12), as expressing the notion "degree of stress". The relational representation says, simply, that at a given level one subconstituent is stronger than the other. In section 3 we will argue that this simple principle, "strong is stronger than weak," governs a process that implies a partial ordering of terminal stress levels somewhat different from the one imposed by cyclically-assigned stress numbers, one that we think is more in accord with the evidence.

1.4. A Point of Difference

So far, we have examined only cases in which the cyclic reassignment of [1 stress], by the rules in (7), and the definition of the strong/weak relation on sister constituents, by

the rules in (8), are weakly equivalent (i.e. the two approaches establish the same pattern of relative prominence). We will argue, in section 1.5, that the relational theory rationalizes a number of otherwise arbitrary properties of such patterns and of the rules that define them, and is therefore to be preferred on the grounds of greater explanatory adequacy. However, there is at least one class of cases in which the two theories differ descriptively. Unfortunately, the crucial examples cannot normally be constructed in English, but it is worthwhile to note the point at issue, and to examine a case (admittedly rather unusual) where the descriptive difference matters.

This descriptive difference will arise when the CSR applies to a constituent whose righthand member, itself complex, has main stress on its rightmost word. This situation is represented schematically in (14), first as it appears to the relational rule, and then as it appears to the numerological rule.

(14) a.
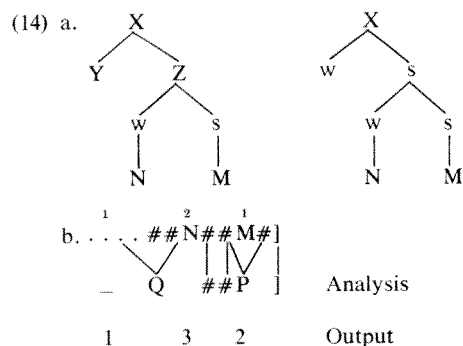
In such a case, the relational CSR will define greatest prominence on the rightmost word (represented as "M"), while the numerological CSR will reassign [1 stress] to the (rightmost) [1 stress] of the lefthand subconstituent (represented as "Y" in (14a) and as the string of dots in (14b)).

To see why this will be the result, compare the formulation of the relational CSR, in (8), with that of the numerological CSR, in (2b).

The relational CSR says that the righthand subconstituent will be strong if and only if it branches, that is, if and only if it consists of more than one word. Its operation is not dependent on the way the strong/weak relation is defined at any other level of constituent structure, and so the node labelled "Z" in (14a) will become the strong member of the pair [YZ], whether Z is internally [ws] or [sw].

The numerological CSR, on the other hand, always analyzes the rightmost word in its domain as the variable term P, and then scans the remaining string for the rightmost occurrence of [1 stress]. If the word analyzed by P contains the [1 stress] vowel of its constituent, then that constituent as a whole has lost its chance to have [1 stress] reassigned within it, regardless of the number of words it contains.

Because of the way English compounds are constructed, real cases meeting the above specifications are rather hard to come by. In the normal course of events, they are impossible, since a collocation of words normally has main stress on its final member only if it is a phrasal constituent, and compounds may be built up only out of lexical constituents. Thus we have *architecture student* as a compound, and *perpetual student* as an adjective + noun NP, but **architecture perpetual student*, though perfectly meaningful, represents an illegitimate attempt to smuggle an NP into a compound form. Similarly, we have *log-rolling contest* and *world-wide contest*, but not **log-rolling world-wide contest*; nor can we get **well-formedness Boolean condition*, **book red cover*, etc.

Our only chance, therefore, is to use as the righthand subconstituent a compound that takes a rising stress pattern, such as *Madison Avenue*, or an adjective + noun grouping that has been lexicalized with its original stressing, while still retaining an internal ## boundary (unlike e.g. *blueprint*, which both takes initial stress and also functions as a single word from the point of view of the rules we have been considering).

We have located an actual occurrence of a fairly clear case of the latter (lexicalized adjective + noun) type, namely the expression *motor unit neural control*, meaning 'the neural control of motor units', and thus parsed as [motor unit] [neural control]. A motor unit consists of a motoneuron together with the muscle fibers it innervates; the word *motor unit* is stressed as a compound. In the milieu in which this example was found, "neural control" is such a central topic that the phrase has apparently been lexicalized. As evidence for this analysis of the situation, we observe that compounds such as *motor unit control*, 'the control of motor units', are common and unexceptionable, while a collocation involving a clearly phrasal righthand member, e.g. **motor unit higher-level control* for 'the higher level control of motor units', seems ill-formed. Thus *motor unit neural control* must be a compound form, and is therefore a plausible example of the kind of case we need. In our opinion, and that of others we have polled, the main stress of this phrase, used for example in the frame *Our lab is interested in the problem of motor unit neural control*, would tend to fall on the word *control*, in contrast to the case of *motor unit control* in the same environment.

This is the result predicted by the relational theory. We do not, however, wish to lean very heavily on this fact, since the case is a somewhat anomalous one; the main advantages of the relational theory's treatment of English lie elsewhere.

1.5. Advantages of the Metrical Theory of Phrasal Stress

In a theory in which patterns of relative stress are represented and assigned in terms of a segmental (or syllabic) features, stress features and stress rules usually have a

number of special properties that distinguish them from other phonological features and rules.

(i) The stress feature is *n*-ary, that is, it may assume a range of values that is limited only arbitrarily; other phonological features may generally be treated as binary, or at least as assuming a strictly limited range of distinct values in any given phonological system.

(ii) Nonprimary values of the stress feature are defined only syntagmatically. In other words, a [2 stress] or [3 stress] segment can exist only in relation to a [1 stress] segment elsewhere in the string, so that the monosyllable *John*,³ for example, could not conceivably stand by itself as a phonological representation. The values of other phonological features are generally defined paradigmatically, that is, strictly in terms of an opposition with a different feature specification that could have occurred in the same segmental position.

(iii) The distinction among various levels of stress has little or no *local* phonetic import—the feature [1 stress] does not imply any specific articulatory or acoustic property of the segment that bears it, any more than the notion "downbeat" necessarily defines any intrinsic property of certain notes in a piece of music, by which they could be sorted without reference to some fairly extensive context. This is not to say that distinctions in degree of stress have no phonetic effect, but simply that their effect must be defined in terms of a pattern (of pitch and time relations) that generally extends over a stretch of utterance much larger than the roughly syllable-sized domains in which the phonetic implementation of other phonological features is to be found.

(iv) The preservation of relative prominence under embedding has provided the clearest evidence for cyclic application of phonological rules. Most of the other evidence for the phonological cycle has come from other characteristics of stress or stress-related phenomena.⁷

(v) As a result of the stress-subordination convention, the effect of stress rules is to cause a widespread pattern of change, rather than simply to change the feature specification of a single segment, as is the case with most nonprosodic phonological rules.

(vi) Stress-assignment rules have typically made use of crucial variables, that is, a variable term in the structural description of the rule that permits its locus of application to be indefinitely far away from some other term necessary to define its environment. Thus the [1 stress] vowel mentioned by the NSR may be any number of segments away from the constituent boundary required in the rule's environment. Other phonological rules generally require either no variables, or variables of a different type (called "segmental variables", e.g. C_0), whose effective range is limited to adjacent syllables.

(vii) Stress rules often make use of the convention of "disjunctive ordering". A term in the environment of the rule is placed in parentheses; this stands for an ordered pair of rules, the first one including the parenthetical term and the second one leaving it out. This sequence of subrules is ordered disjunctively, meaning that if the first subrule applies, then the second subrule is skipped. Many familiar stress rules (e.g. that of Latin) have disjunctively applicable cases, in which the environment of one case is a substring of the environment of another, but such a notation is not motivated for rules assigning other phonological features.⁸

These seven distinctive characteristics of the segmental treatment of stress patterns do not in themselves constitute any argument against that treatment. However, we feel that a relational treatment of stress patterns, along the lines we are presenting here, has the advantage that it rationalizes these special characteristics of stress features and rules, in the sense that they follow directly from the way the phenomenon is represented, rather than being arbitrary typological observations.

(i) In a relational theory, the stress feature is no longer *n*-ary, but (in a sense) binary. It is, however, a relational feature of constituent structure rather than an intrinsic feature of phonological segments; the rest of its special properties follow from this.

(ii) A relation of the kind we are proposing must by its nature be defined syntagmatically, since constituent structure is an essentially syntagmatic notion. Thus a relational theory has no way to represent a secondary or tertiary stress standing alone.

(iii) Since a relational theory defines relative prominence as a feature of constituent structure rather than of phonological segments, it is quite natural that its phonetic implementation should be in terms of larger patterns, rather than in terms of some more localized articulatory gesture or sound quality.

(iv) The way relative prominence is represented in a relational theory guarantees that it will be preserved under embedding, so that cyclic rule application is not required to account for this phenomenon.

(v) In a relational theory, the phonological effect of the rules defining relative prominence is a local one (the definition of the strong/weak relation on sister nodes). No counterpart to the stress-subordination convention is required.

(vi) In a relational theory, the rules defining relative prominence are locally conditioned. In the cases we have considered so far, the domain is a pair of sister constituents, and the conditioning factors are the category of the parent and the terminality (branching or nonbranching) of the righthand sister. No variable is required, since we are annotating the nodes of a tree structure rather than locating segments in order to adjust their feature specification.

(vii) The phenomena we have discussed up to this point do not provide any useful case of disjunctive ordering, so we will postpone discussion of this issue to section 2, where a number of relevant cases will be described.

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⁷ But see Kean (1974), Mascaro (1976).

⁸ See Kiparsky (1973). For a fuller discussion of this matter, see section 2.5.

In the treatment of stress-pattern assignment above the word level, there are thus significant advantages to the representation of relative stress as a structural rather than a segmental feature. However, for this representation to be adequate for the needs of phonological theory, it is necessary to show that it can be extended in a useful way to the treatment of relative stress within words. In the next section, we attempt to show that such an extension is not only possible, but desirable.

2. Words

Hierarchical stress subordination is as characteristic of words as it is of phrases and compounds. The perceived array of prominence in words like *execute* and *cognate* closely resembles that of compounds like *labor union, dog days*; phrases like *red cow, globed peonie* are similar to such words as *pontoon, arrange*; the pattern of *union finance committee* is echoed in words like *execution, polypropylene, etcetera*.

In terms of the theory being explored here, this can only mean that words have an internal metrical structure in which syllables and groups of syllables are weighed against each other. For words, as for phrases, the pattern of subordinations is known to be essentially lawful, and we must expect to find a rule to distribute node labels below the phrasal level, just as we found a metrical version of the NSR and CSR.

However, in dealing with words, as opposed to phrases, we cannot appeal to a syntax of syllables that would design the trees for us, independent of prosodic considerations. We must therefore discover the relevant principles of construction.

2.1. Word-Trees

Consider first the simple situation in which a stressed syllable is weighed against unstressed syllables. It accords quite directly with the intuition behind metrical comparison to regard the stressed syllable as *strong*, its unstressed compeers as *weak*. This, taken with the restriction to binary branching, dictates tree shape and labelling for words like *labor, caprice, Pamela*:

(15)
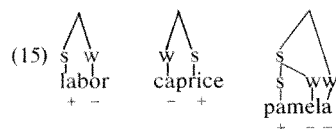
The (+,−) marks indicate the value of the segmental feature [± stress] for the vowels they are written under. Although in the examples cited *s* dominates only (+) and *w* only (−), this perfect correlation cannot be maintained in general, since a [+stress] vowel may well be metrically weak, as words like *gymnast, raccoon* show:

(16) a.
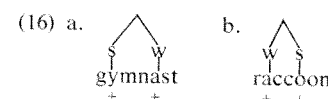
The submetrical distinction in prominence made available by the contrast between *w/+* and *w/−* shows itself when we compare *modest* with *gymnast* or *balloon* with *raccoon*.

(17) a.
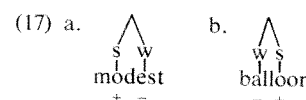
Metrically, *modest* and *gymnast*, *balloon* and *raccoon*, can only be identical, because the members of each pair have identical patterns of *relative* prominence. Examples like these show that the familiar segmental (or syllabic) distinction marked by the feature [± stress] must be maintained within metrical theory.

We hypothesize, then, that the correlation between (s,w) and [(+,−) stress] is given by the following implication:

(18) If a vowel is s, then it is [+stress].

By contraposition, (18) tells us that if a vowel is [−stress], it must be w. Principle (18) will be regarded as a well-formedness condition on metrical structures, functioning to disallow the output configuration (19):

(19)
$$*s \atop | \atop V$$
[−stress]
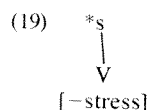
Principle (18) may be paraphrased by saying that only a stressed syllable may be the *strong* element of a metrical foot.

Observe that the condition (18) gives only one parsing for *Pamela*, eliminating the logically possible (20b,c):

(20) a.
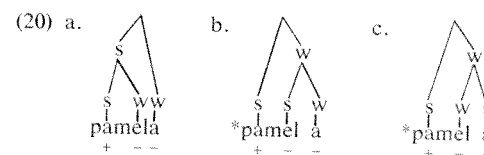
When we turn to words in which a stressed vowel is flanked on both sides by stressless vowels, we find ambiguities of analysis.

(21) a.

```
      s
   w  s  w
   acacia
   -  +  -
```

b.

```
   s
   w  s  w
   acacia
   -  +  -
```
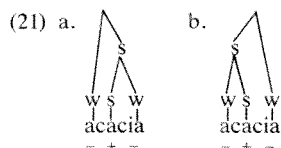
Our principles determine the labels, but allow both rhythmic divisions equally. Although it is possible that such multiplicity could exist and function, we submit that only (21a) is correct, and that English metrical structure is well-defined, in accord with the following description:

(22) a. Every sequence of syllables $+-$, $+--$, $+---$, etc., forms a metrical tree. Because of the condition limiting [−stress] to weak positions, and because of the bivalent (binary-branching) character of metrical trees, the structure and labelling of the sequences is uniquely determined. We have, necessarily, left-branching trees, looking like this:

```
   s  w        s           s
   +  -     s  w  w      s      w
            +  -  -   s  w  w  w . . . .
                      +  -  -  -
```
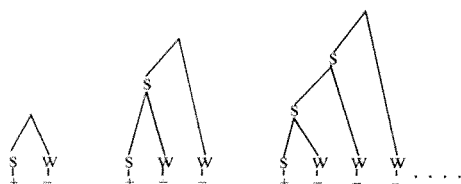
b. The syllable-dominating trees of provision (a) are organized into a right-branching tree whose root is associated with the syntactic node immediately dominating the entire word. The arrangement will look like this:

```
        N
   # △ △ . . . △ △ △ #
```
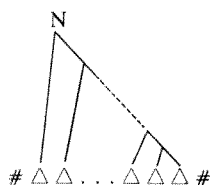
(This description will be modified slightly in 2.4 below, when certain more complex cases are considered.)

Imposing these patterns on *acacia* decides in favor of (21a), [[ᵥₐ][ₛcacia]]; similar results are guaranteed for the parsing of *America*:

(23) a.

```
         s
      s
   w  s  w  w
   america
   -  +  -  -
```

b.

```
         s
      s
   w  s  w  w
   *america
   -  +  -  -
```
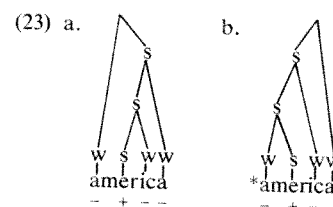
A straightforward method of developing the patterns described in (22a,b) is to start at the end of the word and work leftward, stopping at each [+stress] to build up as much of the tree as possible. In a word like *reconciliation*, for example, the first stop is at *-at-*, and a trochaic foot is erected:

(24)

```
            s  w
   reconcili ation
   +  -  +--+  -
```

The next stop is *-cil-*, and here again a trochee will be called for; but further arborization is also possible, and the two trochees will be joined into a higher-level unit:

(25)

```
         s  ws  w
   reconcili ation
   +  -  +--+  -
```

A final calculation at the first syllable completes the tree:

(26)

```
      s  w  sws  w
   reconcili ation
   +  -  +--+  -
```

Observe that in a word like *execute*, the first stop—at the stressed syllable *-ute*—will not result in the creation of metrical structure; the next stop will arborize the $(+,-)$ sequence *exec-* and join it to the remaining *-ute*, generating the structure (27):

(27)

```
      s  w
   execute
   +  -  +
```

At this point it is appropriate to ask what principle, if any, governs the labelling of "higher-level" nodes. This is equivalent to asking what law or laws of ranking hold among stressed syllables in English words. S. Schane ((1972), reported in Halle (1973)), has found a rule that predicts the location of main stress for a central portion of the vocabulary: primary stress falls on the first stressed syllable from the end of the word, leaving out the final syllable. Schane's insight translates into metrical theory as the following simple rule:

(28) *Word Rule*

In a pair of sister nodes $[N_1 N_2]$, N_2 is *s* iff it branches.

In short, every metrical unit in a word tree falls under one of two descriptions:

(29) a.   (N₂ does not branch)

     b.   (N₂ branches)

Applying the Word Rule to the incompletely labelled examples (26) and (27), we achieve the following representations:

(30) a.   b.

reconcili ation
(2   3   1   )

execute
(1   2   )

(The underscribed numbers, indicating relative prominence, are derived from the trees by applying the algorithm based on the output of the CSR/NSR of earlier theories. Numbers, of course, have no significance in the present theory, and their presence is intended as a heuristic aid to tree-reading.)

The Word Rule gives a direct account of the well-known difference between, for example, *execute* and *execution*; the additional syllable *-ion* creates a branching unit at the end of the word, and provision (29b) will mark it strong:

(31)

ex ec ut ion

There is one respect in which the Word Rule appears to transcend Schane's original goal: the metrical formulation provides the key to labelling every node in the tree, where Schane's rule aims only at specifying the location of main stress. Indeed, in the metrical theory as presently constituted, the rule could hardly function otherwise, since finding the main-stressed syllable involves labelling (as *s*) every metrical constituent it belongs to, and thus will generally mean labelling the entire tree. It might therefore be expected that details of the relationship between nonprimary stresses in long words would shed direct empirical light on the geometry of word trees, in particular on the higher constituent structure, confirming or disconfirming, for example, the choice of right-branching in (22b). However, this relationship is rather unsteady, as noted by Kenyon and Knott (1953, xxv), and is heavily influenced by rhythmic factors. When we turn to consider problems of rhythm and relative prominence in section 3 below, we will argue for an interpretation of the metrical strength relation that does not strictly imitate the effects of the NSR/CSR algorithm. The Relative Prominence Projection Rule (104) will, in itself, flatten out the distinctions between secondary stresses in many configurations—e.g. in words like *Ticonderoga, prognostication, transmogrification*; the factors that distinguish among them will be touched on below in section 3.5. The function of the Word Rule, then, like that of Schane's rule, is to identify primary word stress; it accomplishes this by examining and annotating a hierarchical grouping of syllables that is projected from the location of stressed and stressless elements.

The astute reader will have noticed that the Word Rule (31) is identical to the Compound Rule (8b). This result seems a sure sign that pursuing the arboreal imperative beyond syntax is a fruitful venture. An interesting problem arises, however, when we try to identify the two parallel processes: word-internal structure, which is absolutely necessary for the correct operation of the Word Rule, does not count as branching in terms of the Compound Rule. If it did, we would find *labor únion (where *union* branches, being bisyllabic) contrasting with *labor dáy* (*day* a monosyllable, therefore nonbranching). Evidently, words have an integrity from the point of view of phrasal stressing. The notion that is relevant to the word/compound rule is "branches at the same prosodic level". The notion of "level" can be marked quite effectively in metrical structure, by stipulating that all words be dominated by a special node *M* (for *mot*, *W* being taken). Under this assumption, *labor union* has the full representation (32):

(32)

lab or union

Let us provisionally accept this method of notating the concept "prosodic level". With this modification of the formalism, the Word Rule (28) and the Compound Rule (8b) are seen to be one. Since compounds are dominated by lexical nodes, arising recursively from rules such as N → N N, we designate this uniform condition on English stress contours the *Lexical Category Prominence Rule* (LCPR):

(33) *LCPR*
    In the configuration [N₁N₂], N₂ is *strong* iff it branches.

2.2. Remark

The LCPR is known to admit of various kinds and classes of exceptions. Bisyllabic verbs like final stress: *torment*ᵥ, *bombard*ᵥ (compare the homophonous nouns); certain prefixes, especially the Greek, like main stress: *monosyllable, television, agriculture, antibody*; words ending in orthographic *-y* reject penultimate main stress: *inhibitory* (**inhibitory*, as predicted), *sedentary, chalcedony, Abernathy*; words ending in phonetically high tense vowels spelled as in *-oon, -ier, -ee, -oo, -oe* display *final* main stress, which is not allowed for in the rule as stated: *pontoon, pantaloon, deportee, engineer, lavalier, bamboo, Tippecanoe*. Some exceptions are merely sporadic: *circumvent* vs. *circumcise*. In collocations, too, we find cases like *fifth avenue* (cf. *fifth street*), (the) *Harvard Bridge*, end-stressing being characteristic of *names: George Washington, SPE, UN*.

These data give valuable evidence about the ways exceptions impinge on otherwise general rules of language, and about how subregularities relate to the wider regularities they depart from. We shall examine these questions in detail when we return to the LCPR in order to broaden its factual coverage of the lexicon.

2.3. Finding [+stress]

So far, we have assumed only that there is a level of phonological representation where segments are marked for values of the feature [±stress]; we have made no assumptions about whether these markings are predictable from other properties of word phonology, and if so, how they are to be predicted. This very issue is perhaps the central descriptive problem addressed in Chomsky and Halle (1968; henceforth SPE); the tradition of research represented by SPE itself and by such important later studies as Ross (1972), Halle and Keyser (1971), and Halle (1973) has made clear the fundamental regularities that govern the location of stressed and unstressed syllables in English

words. That such rules exist raises an immediate question: how (if at all) does the operation of the rules that locate [±stress] in the phonological string relate to the mode of tree construction presupposed by the LCPR? To see the relation, we need an image of the rule system that generates the arrangement of stressed and stressless syllables. In this section, therefore, we present a version of the core processes of English stressing, drawing particularly upon the proposals and observations of Ross (1972) and Halle (1973).

We assume an SPE-like taxonomy of the vowel system, distinguishing two classes with the feature [±long]. The class of underlyingly long vowels is exemplified in the following words:

(34) divīne   pounce   Bermūda
     obscēne   moon   point
     vāne   vōte

This is, of course, the class of tense vowels and true diphthongs.

The underlying short vowels are found in words like these:

(35) pit   put   imp*u*dent
     pet   putt   pong
     pat   pot

Note that phonetically long [ā] of *pot*—generally spelled *o*—is underlyingly short. The *u*-vowel of *Bermuda*, reduced in *impudent*, may be either long or short underlyingly. (For extensive justification of this type of analysis, see SPE.)

With this distinction in mind, consider the placement of stress in the following words (which we offer as a characteristic sample):

(36) a.	b.	c.
América	aróma	deféctive
canónical	Cardóna	referéndum
Éverest	hormónal	amálgam
aspáragus	horízon	eréctor
polýgamous	desírous	anárthrous
élephant	adjácent	Charýbdis

The words in columns (36b) and (36c) are stressed penultimately, those in column (36a) antepenultimately. The distribution of stresses correlates with the shape of the penultimate syllable. If it is "light"—i.e. if the penultimate vowel is short, and followed by (at most) one consonant—stress falls on the preceding syllable, as in column (36a). If the penultimate syllable is "heavy"—i.e. if the penultimate vowel is long (column (36b)), or followed by two (or more) consonants (column (36c))—then it must bear stress itself.

In all the examples so far considered, the final vowel is short. When long, it must

be [+stress], as the following examples illustrate:

(37)

negate	anecdote	divine
repute	execrate	devote
erode	ballyhoo	mahout
balloon	complete	exploit

The position of stress can evidently be projected from a representation of words as sequences of vowels and consonants, with a length distinction among the vowels. Assuming, then, that vowels are in general [−stress] underlyingly, we can register our initial observations in the following rule:[9]

(38) *English Stress Rule* (ESR), Preliminary Version

$$V \rightarrow [+stress] / \underline{\qquad} C_0 \, (\breve{V}(C))(\breve{V} \, C_0) \, \#$$

The rule is intended to apply in accord with the principle of disjunction, so that to any given word only the longest applicable subrule may apply. The sense of this is that one must "skip over" the last two syllables if the end of the word can be analyzed by the formula—$C_0 \, \breve{V} \, C \, \breve{V} \, C_0\#$; that one must skip over the last syllable if it has the shape —$C_0 \, \breve{V} \, C_0\#$ (i.e. contains a short vowel); that in the other cases stress must be final.

Notice that the penultimate term in the stress rule—$(\breve{V}(C))$—has been generalized beyond the data of table (36) to allow for sequences of vowels. Such do indeed occur in words like *alien, simultaneous, radium, labia,* but with a wrinkle: the first vowel of the sequence, lying in the word's penult, is phonetically *tense,* and would thus seem to controvert the $\breve{V}$ requirement of our rule. As it happens, however, phonetically lax vowels are barred from prevocalic position in English; there can be no words such as *[dIən], *[lɛən]. We assume, then, that the surface [iy] of words like *alien* is underlyingly short, and that it is lengthened (or perhaps merely tensed) by a rule that expresses an exceptionless generalization about English sound structure:

(39) *Vowel before Vowel*

$$V \rightarrow [+long] / \underline{\qquad} V$$

Similar to *alien,* etc., are cases like *potáto, albédo, spumóni, Máry* (cf. *Maríe*), where an evidently tense final vowel receives no stress. Here again there is a gap in the phonetic surface (of most dialects): no nonlow vowels appear lax finally. Reserving the low (front) vowel as the source for final schwa in such words as *algebra* (cf. *algebraic*),

---

[9] It appears likely that the stress and stress-related phenomena we will discuss ought actually to be analyzed in terms of syllable structure. When a sequence $\breve{V} \, C \, C \, \breve{V} \, C_0\#$ is divided $\breve{V}$-C-C $\breve{V}C_0\#$ by the rules of syllabification, it is usually skipped over, even though it cannot be analyzed by the formula we have written, $(\breve{V} \, (C)) \, (\breve{V} \, C_0)\#$. Thus: *al-ge-bra, pe-de-stal, re-gi-strant, in-te-gral.* However, we will retain the familiar segment-concatenating notation of SPE, because the details of syllabic representation are not directly germane to the issues we are exploring in this article. The reader is invited to give a liberal interpretation to the recurrent formula -V (C)- and indulgently read it as "light syllable", just as we shall indulgently refer to it by that name. An important discussion of syllable structure and its role in English phonology is found in Kahn (1976).

---

we shall assume that the following rule lengthens the underlyingly short vowels at the end of *potato,* etc.

(40) *Word Final Lengthening*

$$V \rightarrow [+long] / \underline{\qquad} \#$$
$$[-low]$$

The two rules can be combined, using the ordinary resources of generative phonology, into the following expression:

(41) *Exceptionless Vowel Lengthening*

$$V \rightarrow [+long] / \underline{\qquad} \langle V \, X \rangle_b \, \#$$
$$[\langle +low \rangle_a]$$
Condition: a ⊃ b

Rule (41) predicts that ceteris paribus we should find evidence of an underlying vowel-length contrast that affects stress and its concomitants, but that is not directly mirrored in phonetic vowel tenseness. And indeed we do find *Ohio* contrasting with *rádio,* and *vétò* (with its aspirate [tʰ]) contrasting with *móttö* (where the flap [D] indicates a stressless final syllable, as Kahn (1976) demonstrates).

Rule (41) is ordered after the stress rule, of course, so that the underlying distinction it masks may nonetheless have its effect.

At this point it is worth noting that a number of words show some degree of final stress even though they terminate in the sequence -$C_0 \breve{V} \, C_0\#$: for example, *Aztec, insect, Arbib, pyramid, electron, Vermont, Berlin, chaos.* Ross (1972) achieves a fair measure of generality in relating the possibility of such stressing to the character of the final consonant(s). Following the proposal of Halle (1973), we regard these cases as exceptional to the longer subrules of the ESR. The subregularities discovered by Ross will be expressed, we shall assume, in lexical redundancy rules that govern distribution of exception features.

A rather similar kind of unpredicted behavior is seen in words like *bacíllus, Odéssa, vanílla, Agríppa, Kentúcky,* where a light penult receives stress, contrary to the provisions of our rule. Interestingly, the spelling is unequivocal, assimilating such cases to the general principle by positing, as it were, an abstract geminate as a diacritic for stress placement. We, however, can use an abstract diacritic, and mark such forms as exceptional to the longest expansion of the rule.

The essential generalization rendered by the ESR is that location of stress is calculated from the end of the word, and hinges on certain features of the syllables counted. The exceptionality is of the simplest kind: we do not find words like *pódēctăl* [pówdəctəl] or *pónĭtŏde* [pánəDowd], in which a heavy syllable or long vowel is "skipped over" and left unstressed.[10] Instead, we find words that are exceptional to

---

[10] Words like *désignăte*$_A$, *ádjĕctíve*$_N$, which look like *pódĕctăl* on the surface, evidently derive from underlying forms with a long vowel in the final syllable, via a morphologically conditioned rule of affix reduction: cf. *desígnăte*$_V$, *adjectĭval*$_A$.

one or another subrule, with the effect that the full count authorized by the ESR is not always permitted.

As we turn to examine the location of stressed syllables in regions beyond the domain of rule (38), we find that, if we measure from the stress laid down by the ESR, there are three modes of determining the next stress, with choice of mode governed generally by morphology, occasionally by lexical item. For reasons that will become apparent, we will designate these modes by the mnemonic labels the *weak*, the *strong*, and the *long*.

2.3.1. The Weak Mode A number of affixes that bear stress behave like *-oid* with respect to placement of stress. The diphthong [ɔy] patterns with the other diphthongs, so we shall assume it has a long nucleus underlyingly; it will therefore receive stress by the ordinary operation of the ESR. Placement of stress elsewhere in the word is controlled, apparently, by a kind of reprise of the light-penult condition, as these words illustrate:

(42) a. pyrámidoid   b. hóminoid   c. ellípsoid   d. líthoid
     encéphaloid   crýstalloid   mollúscoid   óvoid
     tentáculoid   aánthropoid   cylíndroid   théroid
     cartiláginoid   sólenoid   salamándroid   céntroid

Notice that the marked stresses occur exactly one syllable away from *-oid* in columns (42a) and (42b), where the syllable skipped over is light (*hóminoid*); in column (42c) where the relevant syllable is *heavy*, it receives the stress (*ellípsoid*); in column (42d), we see that a solitary syllable preceding *-oid* will also be stressed, light or heavy (*líthoid*).

These observations motivate the following rule:

(43) *Weak Retraction*

$$V \rightarrow [+\text{stress}] / \underline{\quad\quad} C_0 (\breve{V} (C)) \quad V$$
$$[+\text{stress}]$$

Like *-oid* are affixes such as the following:

(44) *Weak Retracting Affixes*

-ite	molybdenite	stalagmite	samite
	selenite	stalactite	
	cellulite	archimandrite	
	dynamite	gelignite	
-on	positron	electron	lepton
	baryon		hadron
-ode	palinode	electrode	cathode
			epode
-ide	cyanide	peroxide	nitride
	telluride		

-i	Gemini	alumni	foci
		delicti	
-ology	phenomenology	arachnology	
		odontology	
		egyptology	

Also in the same category are monomorphemic words like *Adiróndàcks, Massapéquòd, Agamémnòn* (cf. Ross (1972, 285)), whose final syllables bear stress somewhat idiosyncratically, but bear it nonetheless; and *Oréstès, Laértès, Diógënès,* (with a weak penult); and similarly *Ulysses, Achilles,* with an exceptionality exactly parallel to that of *bacillus, Agrippa.*

2.3.2. The Strong Mode The bulk of verbs that end in *-ate* follow a somewhat different pattern. Although they usually have a stress at most a single syllable away from the *ate*, (e.g. *oríginate, *óriginate*), there is no requirement that the skipped syllable be light (e.g. *designate, concentrate*). Such facts suggest the following rule, which we will call *Strong Retraction*, because it muscles past any type of intervening syllable:

(45) *Strong Retraction*

$$V \rightarrow [+\text{stress}] / \underline{\quad\quad} C_0 (V C_0) \quad V$$
$$[+\text{stress}]$$

The following table provides a characteristic sample of the forms that fall in the domain of the rule:

(46) *Strong Retracting Forms*

-ate	manipulate	salivate	rotate
	articulate	defecate	orate
	originate	confiscate	
	hydrogenate	designate	
	syllabicate	exacerbate	
	humiliate		
	officiate		
	assassinate		
misc.	anecdote	adversary	infantile
	palindrome	sedentary	mercantile
	cavalcade	voluntary	byzantine
	Arkansas	momentary	argentine
	nightingale	salivary	
	caterwaul		
	recognize		
	recognition		
	surreptitious		

distinguished, in both form and function. They all serve to place a stress to the left of the one laid down by the ESR; two of them, the Weak and the Long, depend crucially on the notion "light syllable"; and the Strong Rule, though independent of syllable weight in its operation, retracts stress to a maximal distance of one syllable, just like the Weak Rule.

We take it as significant, then, that the Weak Rule and the Strong Rule are actually *subcases* of the Long Rule. We can therefore state what is basically the Long Rule as our one rule of retraction, indexing the parentheses for ease of reference to the subcases:

(49) *Stress Retraction Rule* (SRR)

$$V \rightarrow [+\text{stress}] / \underline{\quad} C_0 \, (\check{V} \, (C))_a \, (V \, C_0)_b \quad V$$
$$[+\text{stress}]$$

The expansion (~a), i.e. term (a) null, is rule (41), Strong Retraction; the expansion (~b), term (b) null, is just rule (39), Weak Retraction. We shall assume that words are marked in the lexicon for which of the three cases—(~a), (~b), unrestricted—provides their stress, and further that these marks are distributed, whenever possible, according to morphological and phonological subregularities of the type we have been surveying.

The Stress Retraction Rule is strikingly similar to the ESR, which is repeated for convenience of comparison.

(50) *ESR* (= (38))

$$V \rightarrow [+\text{stress}] / \underline{\quad} C_0 \, (\check{V} \, (C)) \, (\check{V} \, C_0) \, \#$$

Both rules measure leftward from a fixed point of reference, the ESR from a word boundary, the SRR from a stressed syllable; and the standard of measure is in both cases virtually the same. This parallelism strongly suggests that we are witnessing a single unified process of stress assignment, repeating itself across the word, feeding on its own output. We therefore represent the entire class of processes as one basic iterative rule:[11]

(51) *English Stress Rule,* Iterative Version

$$V \rightarrow [+\text{stress}] / \underline{\quad} C_0 \, (V(C))_a \, (\quad V \quad C_0)_b \, (\quad V \quad X)_c \, \#$$
$$\langle -\text{long} \rangle_d \qquad [+\text{stress}]$$

Conditions:[12] ~c ⊃ d; ~a, ~b under certain morphological and lexical circumstances.

[11] It may well be that the correct formalization of the notion "iterative rule" is actually in terms of simultaneous application. We will use iterative language throughout, however, because of its familiarity, since nothing in our analysis decides between sophisticated versions of iterativity and simultaneity. A simultaneous-application theory of great conceptual and empirical interest, which provides a simple formulation for the ESR, is developed in Vergnaud (1974; 1976).

[12] The expression "~c" holds when the factor labelled c is absent from the expansion of the rule; that is, on the first iteration. The condition relating c and d merely says that a word-final syllable must contain a short vowel in order to be analyzed by factor b and "skipped over" by the rule. This brings the present rule into complete accord with the preliminary, noniterative version of the ESR, (38). Of course, no such restriction on factor b obtains during further iterations, as the phenomena of long and strong retraction demonstrate.

Observe that this rule is rather more general in its applicability than has been implied in our discussion of particular examples; it will mark not just the two stresses discussed above, but will proceed on its inexorable leftward course so long as there remains a syllabic region to traverse. And indeed, the stress pattern of longer words affirms the iterative expectation. Examples like *Pópocátepétl, Ágamémnón, Mássapéquód, árticulatóry,* show that there is no restriction to having only two stressed syllables per word, and show also that the *third* application of the rule, giving initial stress in the cases cited, follows the same principle of syllable-skipping as the earlier applications, at least as far as the data can indicate.

There is one phenomenon, however, that appears to challenge the assertion; namely, the failure in certain cases of initial light syllables to show up with the predicted stress: we find, typically, *pŏlíce, păráde, Mŏnŏ́ngahéla* with a reduced and stressless first syllable. Heavy initials, on the other hand, show the expected stress: *Móntána, fańdángo, pánjándrum, árticuláte, tótálity.*

Taking account of this phenomenon, Halle (1973) proposes that the stress rules be allowed to operate freely and that their excess be trimmed back by a simple rule of *de*stressing:

(52) *Initial Destressing* (≈Halle's (22))

$$\begin{array}{l} V \\ [-\text{long}] \end{array} \rightarrow [-\text{stress}] / \, \#C_0 \underline{\quad} (C) \quad V$$
$$[+\text{stress}]$$

Although we shall find reason to modify the rule later, we accept it provisionally here, since the insight it expresses will stay with us.

2.4. Relation to Tree Theory

Although much detail remains to be resolved, particularly in the realm of vowel reduction, the basic outline of the stress system has emerged quite clearly. It is appropriate at this point, therefore, to ascertain what relation the iterative process of stress assignment bears to the construction of metrical trees.

Recall that the description of lexical tree *structure* given in 2.1 suggested a method of tree-*building,* mentioned then as a kind of rule-of-thumb: start at the end of the word, work leftward, stopping at [+stress] marks to organize ungathered syllables and earlier trees in accord with condition (22). This procedure, we see now, simply imitates the leftward sweep of the stress rule itself.

It should be noted that the characteristics of tree form and of stress assignment were arrived at by pursuing independent lines of inquiry: tree form, by extending the calculus of prominence from phrases to words; stress assignment, by analyzing the circumstances surrounding the appearance of stressed syllables. The observed parallelism between tree-building and stress placement is consequently rather striking, and suggests that the two should be firmly linked in phonological theory.

We will hypothesize, therefore, that *trees* are an immediate concomitant of

stressing: that each time a rule applies [+stress], the syllables in the domain of that application are organized metrically, in the only way they can be. Thus in a word like *teleological*, the first iteration will, by this account, give as output the following:

(53)


```
       s
      /\
     /  \
    s    w w
teleological
 -  --  +  - -
```

The second iteration would produce (54):

(54)

```
    /\    /\
   s      s
  /\     /\
 s w w s  w w
tel eolog ical      (preliminary version)
 +  --  +  - -
```

For these cases, stipulation (18), to the effect that stressless material may not be *s*, determines completely the structure and labelling of the trees.

In order to realize the more global aspects of tree geometry by iterative construction, we need to add two further basic clauses. First, any (branching) tree erected by the stress rule must be joined to the arboreal result of earlier applications. At this joining, the Lexical Category Prominence Rule is to be invoked. The second iteration on *teleological* would therefore actually produce the entire tree for the word:

(55)　　　M

```
        M
       /\
      w   s
     /\   /\
teleological
 +  --  +  - -
```

Further (leftward) iteration develops a right-branching structure, as in *reconciliation*:

(56)　　　M

```
        M
       /\
      /   s
     /   /\
    w   w  s
   /\  /\ /\
reconciliation
```

So far we have simply followed the description of tree shape sketched in 2.1. We need to depart from it somewhat, however, to give an adequate account of the bracketing of sequences of stressed syllables. In terms of applying the ESR, we must consider the "degenerate" case in which the immediately preceding iteration fails to erect a (branching) tree.

An example is provided by the word *odontology*. The first iteration stresses the antepenult, successfully arborizing the sequence *-tology*. The second iteration, an instance of weak retraction, stresses the syllable *-don-*; but no metrical structure is erected. The relevant domain of the rule is but one syllable in extent; and since metrical structure subsists on relation, none is created. Since no tree arises from the stress rule, there is no joining with the result of previous application, i.e. the tree above *-tology*. After the second iteration, then, *-don-* stands alone. On the third and final iteration, however, for reasons that will become clear when we look at vowel reduction, we want *-don-* to be grouped with *o*. We will therefore stipulate that at each iteration any stray structureless material from the previous application is to be picked up; here again the Lexical Category Prominence Rule provides labelling.

The thrust of this is to establish binary grouping as a kind of baseline for prosodic organization. If the stress rule results in a sequence of contiguous stressed syllables, ... + + + + + + +, this provision will ensure, at the lowest level, a structuring ...+ (+ +) (+ +) (+ +). Notice, too, that by the LCPR each of these units will be trochaic, (sw), so that the result is alternation of prominence.

A final, rather trivial injunction: attach, at the end of iteration, whatever is unaccounted for by the above: i.e. the first syllable of such words as *bandana*, *Monongahela*.

The bracketing procedure we are advocating reduces to the following set of instructions:

(57)　　*Metrical Bracketing*

　　　a. *Domain Provision.* Assign metrical structure to all syllables in domain of application.

　　　b. *Alternation Provision.* Adjoin any unstructured material from previous iteration.

　　　c. *Linkage Provision.* Adjoin any metrical structure provided by (a), (b) to structure created by previous iteration. Adjoin result of final iteration.

To illustrate the operation of the ESR, as interpreted by principle (57), we derive the word *odontology*:

(58) /odontology/

ESR, Domain Provision

ESR, Weak Retraction Subrule

ESR

Alternation Provision, LCPR

Linkage Provision, LCPR

If this approach is correct, it would appear that a principal function of stress rules is to confer metrical constituent structure upon a row of syllables. Having *structure* as a corollary to their application distinguishes stress rules from all other known kinds of phonological operation, and provides the basis for insight into the property of disjunction. Although stress rules typically conflate a battery of subrules (e.g. antepenultimate, penultimate, final), these apply disjunctively with respect to each other, so that in any given case, only one rule applies—the longest. From the point of view of life in the segmental string, this property is unmotivated. Why should changing one segment affect the capacity of a rule to change another segment lying elsewhere in the string? Although disjunction is classically associated with the formalism of parentheses (Chomsky (1951), Chomsky and Halle (1968)), and although parentheses show up in many kinds of rules, there is, to our knowledge, no case of a segmental process that displays the property of disjunction in the way that stress rules commonly do. As an approximate example, consider a subpart of the rule that is responsible for uniform tenseness of final and prevocalic vowels in English.

(59) $V \rightarrow [+long] / \underline{\hspace{1cm}} (V) \#$

This rule, a truncated version of (41), produces $\check{V}$ V# from the long expansion, and $\check{V}$# from the short one. Because the two subrules are collapsed by parentheses, we expect disjunctive application, even though the two rules are in no sense contradictory. But when we look to the crucial cases, words ending $\check{V}\check{V}$# underlyingly, we find that both subrules apply: as in *rodeo, radio*.

With stress rules, construed metrically, the logic of the situation is quite different. Rule application not only marks a segment but also concomitantly imparts structure to the environs of that segment. Each subrule corresponds to an alternative structuring of the string; and each of the alternatives is intrinsically incompatible with the others, under the minimal assumption that a given stretch of string can have only one set of metrical relations defined on it. Conjunctive application of a set of subrules would, in general, breed a chaos of conflicting interpretations; consequently, something like the theory of disjunction is specifically required to regulate the operation of stress rules.

2.5. Vowel Reduction[13]

It has long been known that the distribution of reduced vowels in English words depends heavily on aspects of stress pattern and syllable structure. A major achievement of SPE was to successfully project the surface occurrence of schwa from representations generated by the battery of stress-placement rules.

Within any theory that observes a distinction between hierarchical prominence relations and the simple presence–absence of stress, it is possible to pose an interesting question: can vowel reduction be keyed to just one of these two facets of representation, and if so, which one? In Halle (1973), where this distinction is upheld, the central process of reduction (Halle's (25), the Destressing Rule) applies when only [±stress] has been marked; and crucially so, for in his system patterns of relative prominence are shaped in essential respects by the effects of this destressing. In SPE, on the other hand, there was no choice but to base the rule on a (numerical) stress-level configuration, i.e. relations of prominence. We will argue in this section that the SPE approach is the correct one, and we will show that the generalizations gathered in SPE can be stated in a particularly simple form within the present theory; indeed, we will find that the destressing rule itself makes reference to neither stress nor prominence.

There are three basic and unmistakable environments in which vowels characteristically lose their grip on fullness. First, initial syllables lose stress when they are light and immediately precede a more strongly stressed syllable. The following table,

[13] We are indebted to Debbie L. Nanni for many valuable suggestions and comments that have improved the analysis presented in this section. The reader is referred to Nanni (1976) for an interpretation of these phenomena from a rigorously syllabic point of view.

contrasting light and heavy initial syllables, illustrates the phenomenon:

(60) *Initial Stressing*

a. *Light*	b. *Heavy* (long V)	c. *Heavy* (closed)
police	psychology	bandana
Monongahela	totality	lactation
balloon	Daytona	pontoon
asparagus	neutrality	sectarian
mosquito	tisane	Cartesian
astronomy	maintain	technique

There are some exceptions to the generalization, going both ways. A few words like *raccoon, tattoo, settee, esprit* have nonreduced short vowels in initial, open syllables. Words like *phŏnology, schĕmatic, bănality, lĕgality* are transparently related to other words that imply a long vowel initially: *phōnate, schēma, bānal, lēgal*. These sporadic weakenings we shall regard as the result of a nongeneral minor rule of shortening that applies to selected morphemes. Words with closed initial syllables provide some apparent counterexamples to our claim: e.g. *Kentucky, Vermont, Berlin*. Of these, *Kentucky* is perhaps truly an exception, but *Vermont, Berlin* are phonetically quite regular: notice that *[vɛrmánt], *[bɛrlÍn] are impossible. The vowels [I], [ɛ], [ʌ], [ə] have in certain environments coalesced with [r] in standard American to produce the "r-colored" mid-central vowel; when this vowel is metrically *weak* and nonfinal, it uniformly destresses. It is quite plausible to assume one of these vowels for the first syllable of, say, *Berlin*; then the phonetics of the word will follow regularly once the prominence contour is fixed. (See Kahn (1976) for an interesting discussion of related issues.)

Leaving aside these cases, which are either sporadic or explicable phonetically, we find ourselves beset by hundreds of apparent exceptions to this law of initial syllables when we look into the behavior of Latinate and Celtic derivational prefixes. The following table suggests the regularities of the situation:

(61) *Prefix Stressing*

a. *Full*	b. *Reduced*	c. *Full*
condensation	condense	contemplate
advantageous	advance	adulate
abnormality	absurd	abnegation
adept$_N$	adept$_A$	
adaptation	adjacent	adjuration
conformation	conform	confirmation
prolongation	prolong	product
relay$_N$	relay$_V$	relative
relaxation	relax	replicate
pretense	pretend	predicate

MacDonald	MacIntyre
MacTavish	MacIntosh
MacDonough	MacIlwain
MacBride	MacAnulty

Far from being erratic, these cases conform to a generalization of their own that, in fact, closely resembles the one we have just seen. Prefix syllables, light or heavy, typically reduce when followed by a more strongly stressed syllable. The examples of column (61a) are chosen to demonstrate that mere presence of a following [+stress] is not sufficient to trigger reduction, i.e. that the structure of prominence is the relevant conditioning factor.

Here again there is a certain amount of irregularity to contend with. The prefix *trans-* never reduces, although phonologically similar items do, for example *prō-, prē-, ex-*. In the words *concave, convex*, the prefix retains stress; curiously, in the derivatives *concavity, convexity* it seems easily destressable. A more general and interesting phenomenon is the widespread failure of reduction-to-schwa in vowel-initial prefixes like *in-, ex-, ab-, ad-*, etc. We have [Inténs] not *[ənténs]; [Igzǽkt], not *[əgzǽkt]; but both [əbstrǽkt] and [æbstrǽkt] seem possible (and are given by Kenyon and Knott (1953)).

The rhythmic behavior of these prefixes gives us an angle on the phenomenon of nonreduction. We will see below in section 3.4.2 that, in the clear cases, prominence never shifts under rhythmical influence onto a stressless syllable: *maroón swéater* thus contrasts with *thírteen mén*. Similarly, words like *inténse, exáct* never undergo the "rhythm rule": *íntense líght, *éxact ánswer. We conclude that these prefixes are indeed stressless, but that their initial vowels are immune to reduction-to-schwa, or perhaps merely subject to special assimilations. Words like *abstráct* do participate in the rhythmic alternation, e.g. *ábstract phonólogy*, and thus are destressed only optionally. Notice that a word like *advanced* is a nonparticipant, e.g. **advanced cálculus*, and is therefore always subject to destressing. The picture that emerges is this: while in general the prefixes are obligatorily destressed in the appropriate environment, a certain amount of word-and-morpheme-governed *optionality* (e.g. *abstract*) has managed to hold out in the lexicon.

The third major weakening affects vowels, long or short, that lie in medial open syllables; in closed syllables, stressed vowels are preserved, as the following table illustrates:

(62) *Medial Phenomena*

a.	b. *Medial, reduced*	c. *Medial, closed*
explain	explănation	odontology
rotāte	rotătory	evangelical
compōnent	compōnential	adventitious
parasīte	parasĭtology	Halicarnassus
defīne	defĭnition	relaxation

Notice that this process involves not only shortening but also destressing, whether cyclic derivation is assumed or not. The suffix *-ology* induces weak retraction, as we discovered above in 2.3; consequently, the last syllable of the string *parasīt-* will be stressed when the ESR iterates across *parasitology*.

Can this rule of shortening–destressing be stated in terms of the array of segmental [±stress] marks? Not if it is to have full generality. Consider words like *advisory*, *persuasory*, *supervisory*. The suffix *-ory* catches stress, and retains it, in words like *persuasory*, *admonitory*, *articulatory*. The reduced allomorph /əri/ occurs predictably after a surface-stressed vowel. We shall assume, then, with SPE, an underlying /ō/, which will always be stressed by the ESR, and which will be reduced in a way that we shall discuss below, when we turn to the interesting complexities of *ory/atory* derivatives. For present purposes, it is sufficient to note that the ESR generates *-óry*. If the rule of medial destressing–shortening were to occur in the environment ____ CV́, contingent only on [±stress], it would falsely predict *ádvisóry, pérsuasóry, súpervisóry*. Therefore, this process, like prefix reduction, must indubitably appeal to prominence relations.

Medial destressing–shortening is remarkably free from exceptions, there being notably a certain amount of option in applying the rule to the ending *-ization*, and the reluctance, which can inhibit any reduction process in English, to obscure the shape of unfamiliar words, e.g. *emōtivity*.

At this point, then, we can profitably ask how to give formal recognition to the empirical regularities we have surveyed. An excellent place to begin our inquiry is with the SPE rule, which captures all the essentials of the phenomenon. We cite it here, slightly modified:

(63) *Destressing Rule*, SPE Version (= SPE rule (118a,b), Auxiliary Reduction Rule I)

$$\begin{bmatrix} V \\ m\ stress \\ \langle +long \rangle_a \end{bmatrix} \rightarrow \begin{bmatrix} -stress \\ -long \end{bmatrix} / \#\langle X\ V \rangle_b\ C_0 \underline{\hspace{1cm}} \langle C_0 = \rangle_c\ (C)\ \underset{[n\ stress]}{V}$$

Conditions: (1) *m* weaker than *n*, i.e. *n* < *m*
            (2) a ⊃ (b ∨ c)

Condition (1) expresses, anfractuously, the requirement that the reducing vowel be immediately followed by a stronger stress. Condition (2) says that long vowels only undergo the rule medially and when they are in "equals-boundary"—latinate, hibernian prefixes. The Boolean sense of condition (2) can most easily be seen if we trace through the rule's three basic expansions.

First, let terms *b* and *c* be null, i.e. take the expansion describable as "~b and

~c", which is just the rule of initial destressing. By Contraposition and De Morgan's Law, condition (2) is transformed to read "(~b & ~c) ⊃ ~a". Therefore, in this subrule, ~a obtains; the affected vowel must be [−long]. The rule we have derived looks like this:

(64) *Initial Destressing* (= (63), assuming ~b & ~c)

$$\begin{bmatrix} V \\ m\ stress \\ -long \end{bmatrix} \rightarrow \begin{bmatrix} -stress \\ -long \end{bmatrix} / \#\ C_0 \underline{\hspace{1cm}} (C)\ \underset{[n\ stress]}{V}$$

Condition: *m* > *n*

This rule is intended to apply to words like those cited under (60a): *pŏlíce, Mŏnóngahela, bállóon, ăspáragus, mŏsquíto, ăstrónomy*. The last three words clearly indicate, as noticed in Kahn (1976) and Nanni (1976), that the rule ought to be stated in terms of syllable structure, referring rather to a syllable-final short vowel. However, the issue of syllabic representation, if not orthogonal to present concerns, is at least at a steep angle to them, and, as with the stress rule, we will ask the reader to exercise a certain discreet liberty in interpreting our notations.

The medial rule is obtained when *b* is not null, i.e. by assuming *b*. The (material) implication "a ⊃ (b ∨ c)" will be satisfied, no matter what value *a* assumes, the consequent of the conditional being true; therefore, the rule will apply to any vowel, long or short. The resultant rule takes the following form (we assume also ~c, since prefix facts are irrelevant):

(65) *Medial Destressing* (= (64), assuming *b* & ~c)

$$\underset{[m\ stress]}{V} \rightarrow \begin{bmatrix} -stress \\ -long \end{bmatrix} / \#\ X\ V\ C_0 \underline{\hspace{1cm}} (C)\ \underset{[n\ stress]}{V}$$

Condition: *m* > *n*

This rule will apply in such words as those cited under (62b): *explănation, rotătory, compŏnential, parasītology, defĭnition*.

The prefix rule is arrived at by assuming *c* (and suppressing term *b*, since the relevant prefixes occur initially). For reasons symmetrical to those just discussed in the medial case, this choice will ratify condition (2) regardless of the value of *a*; the rule will therefore have in its domain both the short vowels of *in=, ex=, ab=, ad=, mac=*, and the long vowels of *prō=, prē=, dē=, rē=*, etc.

(66) *Prefix Rule* (= (63), c & ~b)

$$V \rightarrow \begin{bmatrix} -\text{stress} \\ -\text{long} \end{bmatrix} / \# C_0 \underline{\quad} C_0 = (C) \quad V$$
[m stress]　　　　　　　　　　　　　　　　　　[n stress]

Condition: $m > n$

This rule applies to such words as *intense, exude, absurd, advance, MacDonald, pretend, profound, desire, revenge.*

The rule we have been exploring assumes a numerical representation of relative prominence and is specifically keyed to the working of SPE's rules and conventions. The transition to a metrical view of the conditioning environment is quite smooth, however, and is accompanied by an immediate simplification of the rule. Given the tree structures of (57), we need only ensure that the reducing vowel is immediately dominated by *w*, i.e. is *weak* with respect to some other metrical constituent within the word; no other aspects of stress pattern will be relevant. The rule becomes:

(67) *Destressing Rule*, Metrical Version (preliminary)

$$V \rightarrow \begin{bmatrix} -\text{stress} \\ -\text{long} \end{bmatrix} / \#\langle X\ V\rangle_b\ C_0 \underset{w}{\underline{\quad}} \langle C_0 = \rangle_c (C)\ V$$
$[\langle +\text{long}\rangle_a]$

Condition: $a \supset (b \vee c)$

The rule will apply to representations such as the following:

(68)

a. monóngahéla
b. cóntráctuàl
c. expláanàtion

This contextual simplification is made possible by the fundamental hypothesis of the present theory: that relative prominence is correctly represented as a *relation between constituents*. In the SPE system, where the representation is in terms of absolute quantities—integral values of the stress feature—the crucial relation that determines the destressing process must appear as an unsightly, and indeed arbitrary side-condition on the basic rule. In a metrical theory, the only prominence context available is the relational one, and because only *w* may dominate [−stress] by principle (18), the metrical restriction on the rule is, in our terms, a necessary one.

This point is well worth pursuing, but before we do so, we should dispel a certain empirical cloud that hangs over the system as presently constituted. The problem is this: bisyllabic words do not behave as we predict they should. On our account, the ESR will always stress the first syllable; and the Lexical Category Prominence Rule will always assign initial main stress, since a bisyllable evokes a simple two-branch tree, the right node of which is perforce unitary. But many bisyllables are end-stressed: *police, patrol, maintain, advance, absurd,* etc.

A goodly portion of our problem is caused by an insufficiently discriminating statement of the LCPR. Among verbs, the iambic pattern exhibited by *maintain, accuse, re-fill* is entirely regular; many adjectives fit into the same mold, e.g. *august, rotund, profound.* In section 2.8 below, we will make the requisite refinements in our technology of prominence.

Even after such category-based subregularities are noted, our theory will still predict that bisyllabic *nouns* ought in general to have initial main stress. Here again we must winnow out a large set of merely apparent counterexamples of the type *balloon, pontoon, frontier, antique,* for these end in syllables or morphemes that always attract prominence, even in polysyllables, cf. *pantaloon, cavalier, Mozambique.* This done, however, there does remain a residue of true counterexamples, like *manure, police, lament,* which are unexplained by anything we have seen so far.

Surveying the factors that influence the stressing of bisyllables, R. T. Oehrle (1971) suggests that words of the form light syllable–heavy syllable are regularly endstressed, and that they contrast in this with other phonological types, e.g. *árgyle, mícrobe, tópaz, gárgoyle, prótein,* all with a heavy initial syllable.

Halle (1973) takes account of this proposed generalization in a striking and attractive way. His stress system, like ours, supplies stress to all initial syllables, and removes it in certain cases by an analogue of the Destressing Rule (67). However, he orders the rule *before* relative prominence is determined, stating its environment in terms of (what amounts to) a binary stress feature. Consequently, the first syllable of a word like *manure* will be destressed, whereas that of *microbe* will be untouched by the rule; prominence assignment (his Detail Rule), which is essentially congruent to our LCPR, will then correctly produce *mícrobe* and, of course, *manúre,* the only possible outcome, the first syllable *ma-* having suffered prior demotion from the ranks of potential stress-bearers.

Halle's system thus elegantly explains a whole class of apparent counterexamples to the LCPR in terms of an independently needed process of vowel reduction. However, we have already encountered the data that belie the basic assumption of his theory: that destressing precedes, and thereby determines, prominence assignment. As we learned from examples like *advisory, persuasory,* medial destressing responds to the weak–strong distinction; prefix destressing likewise, as is shown by the contrast between words like *cóndensation, rélaxation* and words like *cómpensatory, rèlax,*

where the relevant environment is identical, [±stress]-wise. (This important fact, and its consequences for Halle's analysis, was brought to public attention in Zonneveld (1976).)

For initial light-syllable destressing the indications are not as clear, simply because illuminating morphophonemic alternations are scarce, or even absent. Notice that once the *-oon, -ier, -ique,* etc. class and the words of latinate prefixal derivation are abstracted from the bisyllables, not many true cases remain, and there are perhaps as many exceptions as examples: against *police, lament, manure* stand *rabbi, satire, Danube, essay.* Prefix vowels, even in open syllables, go by the law of prominence, and can withstand the presence of a following stress: cf. *adept*$_N$, *adaptation* (*ádáptation*). We shall conclude, then, in the spirit of Zonneveld (1976), that the LCPR must be amended to supply words like *manure* with an iambic rhythm, and that the processes of reduction in English are based on the organization of prominence.

In order to express the appropriate conditioning environment of the Destressing Rule (67), we must, it seems, be able to refer to aspects of tree form in phonological rules, rules that make adjustments at the segmental level, based largely on features of segmental or syllabic structure. The general question posed by our empirical result is this: how much of the complex information encoded in metrical trees is accessible to segmental rules? In the particular case at hand, the information required is essentially trivial, from our point of view. Since, by principle (18), metrical *s* must dominate [+stress], the rule could hardly function to reduce metrically *strong* vowels, thereby producing ill-formed representations. There is no reason, then, that a specific rule such as (67) should have to refer to a metrical property that follows from general principles. We need to bridge the gap between well-formedness conditions like (18) and the theory of rule application, which interprets the meaning of structural descriptions. To do this, we suggest the following rather minimal condition:

(69) No rule may apply so as to produce an ill-formed representation.

(Notice that this is not tautological: the notion of well-formedness could be relevant only at the underlying level; or we could permit rules to deform structure arbitrarily, so long as all damage was repaired before the surface.)

With principle (69) constraining applicability, the redundant elements can be removed from the statement of the destressing rule, yielding the following formulation:

(70) *English Destressing Rule* (Final Version)

$$V \atop [\langle +\text{long}\rangle_a] \rightarrow \begin{bmatrix} -\text{stress} \\ -\text{long} \end{bmatrix} / \# \langle X V \rangle_b C_0 \text{------} \langle C_0 = \rangle_c (C) V$$

Condition: $a \supset (b \vee c)$

Success in eliminating descriptive reference to metrical properties from the EDR, (70), suggests that it may be possible to ban all such reference from segmental rules. This would provide a clear answer to the question of translevel accessibility. However, it would be premature to confidently assert such a strong claim, in the absence of a fuller understanding of the relevant class of rules; in Prince (1975), for example, certain complex segmental alternations in Hebrew are analyzed under somewhat richer descriptive assumptions. At any rate, the applicability condition (69), which will have effects throughout the present theory, establishes a baseline of simplicity that the English Destressing Rule does not depart from.

2.6. *Words in* -ory/-atory *and Related Issues*[14]

The metrical version of English Destressing is not only notationally simpler than the SPE rule; it is also somewhat more general in its applicability. Consider a structure like the following:

(71)
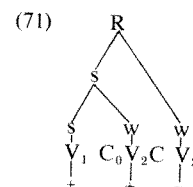
According to our formulation of the rule, V_2 ought to suffer reduction, even though it is not followed by a stronger stress, simply because it is metrically weak, in an open syllable, and medial. And indeed, SPE proposes a rule that reduces vowels in an environment quite similar to the one indicated in diagram (71).

(72) *Poststress Reduction* ($\cong$ rule (118a), SPE)

$$V \rightarrow \begin{bmatrix} -\text{stress} \\ -\text{long} \end{bmatrix} / [1 \text{ stress}] C_0 \text{------} C V$$

Poststress Reduction, though ordered next to SPE's version of English Destressing (cited above as (63)), cannot be combined with it in any interesting way, because the environments of the two rules are so disparate. This, however, may well be an artifact of the segmental representation of prominence patterns. If we can show that diagram

[14] Words like *classificatory, significatory, respiratory* (as opposed to *divinatory*) will not be treated as central data here.

(71) is appropriate to those cases where the rule of Poststress Reduction is called on, then our metricized version of English Destressing, (70), will cover these new data without further ado. This would be a real result for metrical theory; a *w* is a *w*, whether it lies to the left or to the right of its strong sister, and it is difficult to see how this kind of equivalence between pre- and poststress positions could be captured in a theory that does not make use of constituent structure in the way we are proposing. Notice, too, that it is not a question of collapsing a new rule with the old one by means of a notational convention. The old rule, in its very simplest form, predicts destressing in the new environment; it would have to be complicated if it were not to apply.

The primary motivation for Poststress Reduction comes from the behavior of the suffixes *-ory, -ary*. As noted above, these suffixes receive stress by the ESR: e.g. *promissory, laudatory, sedentary, preliminary*. We will therefore assume, with SPE, an underlying long vowel, giving *-ōry, -āry*; the lax quality of the surface vowels is a normal phonetic consequence of the following /r/.

Beyond this, these suffixes share two peculiarities. First, although they receive stress always, they are not always gracious enough to keep it. Indeed, they regularly lose it in the environment specified by the rule of Poststress Reduction: right after a [1 stress], as in such words as *contradictory, olfactory, cursory, advisory, elementary, rotary, dispensary*. Now, if we took any of these words and constructed a metrical tree based on the surface pattern of stresses, we would obtain a structure perfectly congruent to that of diagram (71).

(73)   M
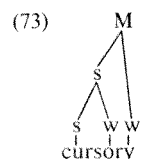
However, if we start out from the expected base form, *curs+ōry*, applying the ESR and the LCPR will confer the following incorrect tree upon the word:

(74)   M
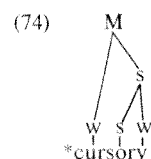
Figure (74) highlights the second peculiarity of the suffixes, alluded to briefly above in section 2.2: when they end a word, they never bear main stress, even though the LCPR predicts that they should. We might consider them simply exceptional to the LCPR, or somehow lexically marked for weakness, so that the interpretation of *cursory* would be like this:

(75)   M
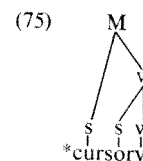
Though more accurate in terms of relative prominence, this representation runs afoul of the principle that metrical *s* cannot immediately dominate [−stress], which we found to be well motivated for the essentially straightforward mode of reduction dealt with in 2.5.

How are we then to model these morphologically complex cases while maintaining the features of metrical theory that illuminate the simple cases? In particular, how do we express the janus-faced combination of a reluctance to bear main stress with precipitous eagerness to reduce?

In SPE, it is argued (p. 130 ff.) that the affix *-y* of *-ory, -ary* (and elsewhere) is underlyingly the nonsyllabic glide /y/. We submit that this is, in essence, the correct solution to the problem. From our point of view, *-y* functions as a kind of "extrametrical" syllable; it simply does not take part in the metrical calculation induced by the ESR. It is not material to our concerns whether this be represented segmentally, in the manner of SPE, or as an abstract property of the morpheme; we shall merely assume that this *-y* is effectually *hors de combat* in the basic determination of metrical structure. Under this hypothesis, derivation proceeds as follows:

(76) /curs + ōry/
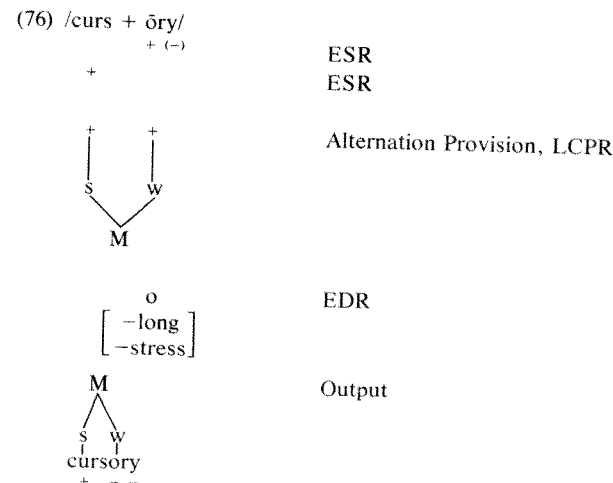
(Of course, further rules will apply, e.g. the one reducing all stressless lax vowels to schwa, the one assimilating vowels to /r/, etc.)

Because *-ory* is metrically unitary rather than branching, it is assigned the label *weak* by the ordinary action of the LCPR; because the first vowel of the suffix is *weak*, and because it is followed by the sequence -CV, it will reduce by the English Destressing Rule. Thus both peculiarities follow from the extrametricality of the ending *-y*.

If the sense of the present theory is that stress provokes the organization of syllables into constituent groupings, it is reasonable to assume that every syllable is to be accounted for metrically. We need, therefore, a rule (or general convention) that will join the wandering syllable *-y* to the tree of the word it belongs to. We know of little evidence that bears on the details of this adjunction, but we will propose to accomplish it in a "structure-preserving" fashion, that is, so that the output resembles a tree that would have been generated under more normal circumstances.

To this end, let us define a notion *left foot*.

(77) *Definition: Left Foot*
     Any uniformly left-branching tree that has *s* as its leftmost node is a *left foot*.
     (All trees whose terminals read *s w w* . . .)

We can now frame the convention for adjunction in terms of this notion.

(78) *Stray Syllable Adjunction* (SSA)
     Any syllable unaccounted for by the ESR and its concomitant tree-building is to be adjoined as a weak sister to the nearest maximal left foot, respecting word boundaries. Informally,

Condition (78) will give the following arborizations:

(79) a.

b.

c.
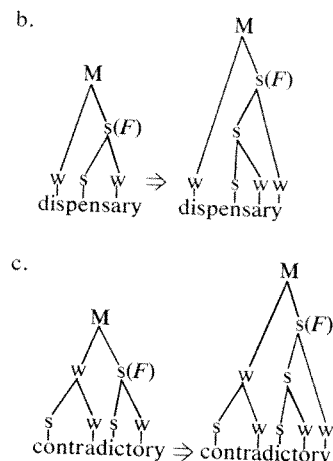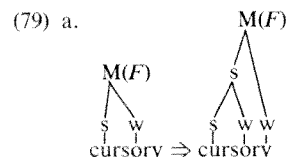
The nodes that play the role of "nearest maximal left foot" have been marked with (F) to clarify the procedure.

Stray Syllable Adjunction is evidently active in the derivation of words other than those of the *-ory/-ary* class. There are in English a few words like *ancestor, carbuncle, autopsy, necropsy, ancestry,* which on the surface appear to contravene the LCPR. It is striking that words of this class tend to end in sonorants or orthographic *-y*. If these are underlyingly nonsyllabic, the general functioning of our rules, with some Rossian concern for stressing final syllables *-cestr, -uncl,* etc., will give the correct prominence pattern. Syllabification of sonorants in the environment C _____ # will produce fodder for Stray Syllable Adjunction. Words like *curmudgeon, Carmichael, Hoboken* should also be treated this way; note the characteristic final sonorant. These words are exceptions to the Destressing Rule, which should apply to reduce the penultimate vowel; however, they are exceptional in any theory that regularly reduces *-ory* in such words as *cursory*—perhaps the rule syllabifying sonorants *m, n, l, r* is ordered after the EDR. (Notice, though, that there are analogous exceptions among trisyllables of the *-ary* class: *primary, rosary, binary, library, contrary.* These contrast with the regular *plenary, granary, rosary, rotary, pessary, peccary,* etc.).

Words in *-atory*—and their underived analogues like *alligator, caterpillar*—present an additional problem of analysis. Consider how the present theory would treat *articulatory*: the ESR applies three times, stressing *-ŏr-*, then (by long retraction, typical of *-atory*) *-tic-*, and finally, of course, the first syllable. This will result in the tree represented in (80a) below, which is adjusted by Stray Syllable Adjunction to that of (80b).

(80) a.

b.

The problem is that *articulatory* is perfectly parallel to *contradictory* in the metrical structure attributed to the suffix *-ory*. If nothing further were to be said, we would find reduction by the EDR, giving **articulătŏry*.

We propose to correct the representation of *-atory* words by means of another "structure-preserving" readjustment. The curious thing about (80b) is the long left foot (s w w w w) comprehending a stress sequence ($+ - - + -$), which looks as if it ought to support *two* simpler feet. The offending configuration is the final sequence (. . . w w w), where there is a decline in intrinsic prominence, from [+stress] to [−stress], in the last two *w*s. To remedy this defect, let the following rule, which we state graphically rather than formally, make the requisite adjustment:

(81) *Foot Formation* (FF)

Observe that $\triangle_2$ will have to be [+stress] for the rule to apply, by general convention, and we do not need to stipulate this restriction in the rule itself.

Foot Formation will have the following effect on a word like *articulatory*:

(82)

Notice that Foot Formation does not provoke a revaluation of prominence by the LCPR.

Once Foot Formation has made its emendations, the English Destressing Rule can freely apply to reduce all medial weak vowels that lie in open syllables, the /ŏ/ of *contradictŏry* as well as the /æ/ of *explănation*.

These two rules of readjustment will combine to ensure correct derivations for a large number of words from the learnèd vocabulary, latinate and greek, in which the phenomenon of extrametricality skews the expected pattern of relative prominence. So: from *-ory*, we have *promissory, category, allegory*, etc.; from *-ary, sanguinary, sedentary, emissary, dignitary*, and many others; miscellaneously from the *-y* class, *sanctimony, parsimony, narcolepsy, chalcedony*. Outside of these, there are quite a few words ending in syllabic liquids that display the same prominence (and reduction) properties: *caterpillar, pumpernickel, alligator, alabaster, paradiddle, salamander, participle, Aristotle, axolotl*. If words like these end lexically in nonsyllabic /r,l/, then a simple and exceptionless rule syllabifying sonorants in the environment C ____ #, ordered anywhere after the ESR, will, given the readjustments necessary to model the *-ory/-atory* contrast, produce exactly the observed surface forms.

Our decision to maintain the simplicity of the EDR and the LCPR by treating certain final syllables as "extrametrical" (or underlyingly nonsyllabic) has a certain apparent cost attached to it: the rules of readjustment that we called Stray Syllable Adjunction and Foot Formation must be spelled out. Of these, the first, or something like it, is clearly necessary in any grammar that has syllables created in the course of derivation, and is thus a prime candidate for the status of general convention, rather than grammatical rule. The second is perhaps more specifically motivated, but its effects, too, are quite natural, and it could easily be regarded as a general law rather than a feature of English. If this is correct, then what we have presented as rules of readjustment ought rather to be seen as consequences of the definition of tree form in

prosodic theory. At any rate, they allow us a straightforward account of a considerable body of English data, drawn from diverse parts of the vocabulary, resolving apparently unrelated peculiarities of prominence and reduction in a principled way. We conclude, therefore, that the EDR is *the* rule of morphophonemic vowel reduction in English, and that the simplification and generalization of it made possible by the theory of metrical constituent structure are legitimate and illuminating.

2.7. Remark on the Cycle

There is a striking difference in kind between the evidence for the phonological cycle within words and the evidence for the cyclicity of phrasal stress rules. The motive and the cue for the phrasal cycle has been the fact that, in languages like English, patterns of relative prominence are largely determined by syntactic constituent structure and are quite generally preserved under embedding. Within words, however, such motivation from the character of prominence phenomena is entirely lacking. Morphology, the analogue of syntax, falls far short of providing a constituent structure of syllables that is adequate to metrical labelling. On the one hand, many polysyllables are monomorphemic, (e.g. *Tatamagouchi*), so that morphology has nothing to say about their internal organization; on the other hand, when morphology does provide structure, it is typically irrelevant to metrical grouping. Consider, for example, the word *compensation*: morphology will analyze it as [[compensat] ion], while phonology must see the principal significant division as [[compen][sation]]; the two parsings are grossly incompatible.

In addition, morphological embedding freely disrupts the pattern of relative prominence. In *compensate*, the first syllable predominates over the third; in *compensation*, the relationship is reversed; in *compensatory*, these two prominences are utterly reduced, and the weakest syllable of the inner constituent (*-pen-*) becomes the strongest syllable of the entire word. The prosodic constituent structure varies correspondingly, changing from word to word, regardless of the constants of morphological relatedness.

(83)

a. [compensate_V]   b. [[compensat_V]ion_N]   c. [[compensat_V]ory_A]
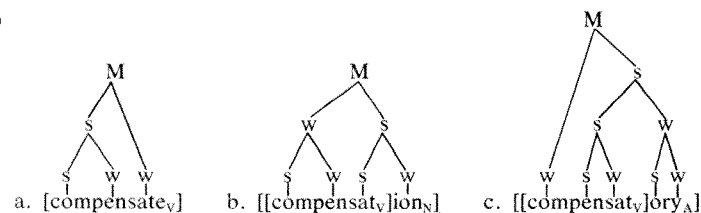
The primary evidence for the subword cycle comes from the persistence of the segmental mark [+stress], unmoored from any syntagmatic relations it may enter into. Consider the following array of facts:

(84) a. *Base Type I*	b. *Embedded*	c. *Type II*	d. *Embedded*
advantage	advantageous	compensate	compensation
impregnate	impregnation	designate	designation
infest	infestation	orchestrate	orchestration
subjective	subjectivity	anecdote	anecdotal
abnormal	abnormality	demonstrate	demonstration
indent	indentation	concentrate	concentration
report	reportorial	recognize	recognition

The interesting action takes place in the second syllable. In column (84b), the second-syllable vowels are all nonreduced [æ, ɛ, ɔ]; in column (84d), which contains words of similar make-up, in terms of segments and prominence, the analogous vowels are uniformly reduced; they are schwa (with perhaps some environmental coloration). Whether the vowel reduces or not in the complex word correlates perfectly with its status in the base forms listed in columns (84a) and (84c). If it is unstressed in the base, as in column (84c), it is unstressed when embedded; if stressed as in (84a), it shows stress when embedded, and does not, therefore, admit of reduction to schwa. (Notice, too, a clearly perceptible rhythmic difference between the words of columns (84b) and (84d), a consequence, presumably, of their different (±) stress patterns.)

This kind of phonological dependency between complex words and the simpler words they contain is widespread in the lexicon of English and generally quite regular. Exceptionality involving Type II words is, we believe, unknown; there are apparently no alternations of the hypothetical form *concntrate ~concɛntration*. Among Type I words, a certain amount of unexpected reduction is found, but it appears to lie within a phonetically circumscribed domain: metrically weak nonlow vowels occasionally collapse with following tautosyllabic sonorants, even when they should bear a protecting stress. We find such examples as *commntary (commɛnt), consltation (consʌlt), transfrmation (transfɔrm)*, and, optionally, *sentimntality (sentimɛntal)*. Note that there are nonreduced instances of all these: as in *indɛntation, confɔrmation, exʌltation*. Perfectly regular, though unstressed, is the second syllable of *confirmation*; as noted above, the vowel [r] of *confirm* is always stressless when metrically weak in medial position. In fact, *all* syllabic liquids and nasals (*m n̩ l r*) are stressless when medially weak, and we can conclude that what is unusual about words like *transformation* is the coalescence of the vowel with the sonorant /r/; after that, the reduction of the resulting *r*-colored vowel (or syllabic *r*) is completely normal.

A second, very similar type of translexical redundancy involves the location of

(secondary) stresses in long, morphologically complex words. Consider the following examples:

(85) a. recíprocal　　b. recíprŏcality　　c. Tátămăgóuchi
　　　 corpóreal　　　　 corpórĕálity　　　　Pássămăquóddy
　　　 artifícial　　　　 artifícīálity　　　　 cátămărán
　　　 oríginal　　　　　 orígĭnálity　　　　　hétĕrŏdýne
　　　 munícipal　　　　 muníctpálity　　　　 Wínnĕpĕsáukee
　　　 relígious　　　　　relígiósity　　　　　Kálămăzóo
　　　 volúminous　　　　volúmĭnósity　　　　ánthrŏpŏmórphic

The marked vowels of column (85a) are all short underlyingly (for the last, cf. *volŭme*), and they are stressed by the ordinary operation of the ESR. The interesting contrast is between (85b) and (85c): words in (85c) have a second stress as far back from their endmost stress as is possible; the words in (85b), which have a syllable structure identical in the relevant respects to that of the words in (85c), show a second stress that falls one syllable short of its greatest possibilities (e.g. **óriginálity*). This shortfall means that the derived word will have a stress just where its base has one. As with the reduction cases, we regularly find a stressed syllable where we could as easily find a stressless one if the rules operated freely or randomly.

Paradigms like these show conclusively that the (±) stress pattern of a complex word depends on the (±) stress pattern that its morphological constituents assume in isolation. The most elegant and restrictive device proposed to represent this kind of pervasive "transderivational" relationship, and the one we shall accept, is the phonological cycle. By means of it, aspects of the derivation of subconstituents become, literally, part of the derivation of the whole. In SPE and Halle and Keyser (1971), the marked stresses on such words as *reláxation, originality* necessitated cyclic application in a direct, "observational" way; for without it, no stress would be placed on those syllables by the posited rule system, which differs from ours in not having an iterative stress rule. Theories of this sort depend on derivations of the following form:

(86) *Noniterative Derivation Type*

	[[[origin$_N$]al$_A$]ity$_N$]
First Cycle, Stress	+
Second Cycle, Stress	+
Third Cycle, Stress	+
Other Rules	--
Output	oríginálity

Under the present analysis, of course, no such straightforward argument for the cycle, based on the mere presence of [+stress], is available. The iterative rule we have

postulated—and we have been careful to illustrate its operation at every step with noncomplex words—has the capacity to place stress appropriately in *relaxation, originality,* etc. We need simply mark such words for weak retraction. To do so, however, would be to abandon the generalization that such stress positioning correlates with morphological composition. Even if it could be argued that weak retraction is the "unmarked" mode for complex words, and therefore need only be stipulated once for the entire class, the argument from lost generalization still has force; with a cycle to transmit to the whole word the features that its parts earn on their own, the fact that suffixes like *-al, -ous, -ive, -age,* etc. induce weak retraction when stressed follows directly from the fact that the ESR treats them quite normally when they end a constituent; no lexical stipulation is required, general or specific, to guide the stressing of such suffixes and the words they belong to.

To accommodate this generalization within our analysis, we must slightly modify the ESR and our conception of its effects. The ESR takes on the following shape:

(87) *ESR* (Cyclic Version)

$$V \rightarrow [+stress] / \underline{\quad} C_0 \left(\begin{bmatrix} V \\ -long \\ -stress \end{bmatrix} (C) \right)_a \left(\begin{bmatrix} V \\ [\langle -long \rangle_d] \end{bmatrix} C_0 \right)_b (\acute{V}\ X)_{c\ d}]$$

Conditions: $\sim c \supset d,\ \alpha = N, A, V$

The rule has been changed to measure from the end of a constituent rather than from the end of a word; and the term *a* has been further restricted so that it can only correspond to stressless syllables. This will prevent it from skipping over the cyclically assigned stress of *originality, religiosity,* etc. Term *b* must, however, on our account, be able to analyze a stressed syllable, in order to correctly derive words like *compensatory.*

What of the metrical constituent structure entailed by the ESR? The first thing we determined about morphological embedding was that it fails to preserve relative prominence relations and (hence) the prosodic structures that represent those relations. Any trees erected by the ESR on a cycle below the word level simply do not influence further processing. They do not, apparently, survive the passage to the next cycle. We need, therefore, to amend our theory of tree-building with a clause that ensures what might be called "deforestation" at the beginning of each cycle.

(88) *Deforestation*
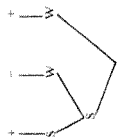Before applying any rules on a cycle, erase all prosodic structure in the domain of that cycle.

This will leave the ESR with a slate that is clean except for the residue of [+stress] marks deposited by applications on earlier cycles.
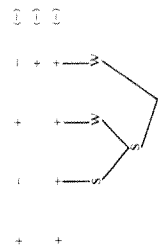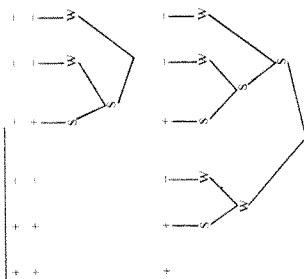
Derivations like this will result:

(89)

ESR

Deforestation
ESR

ESR

Deforestation
ESR

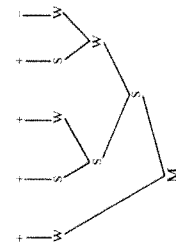ESR

ESR

Deforestation
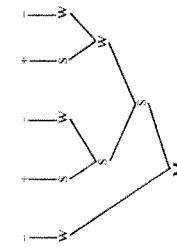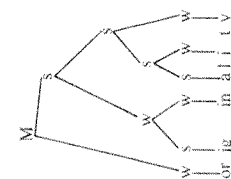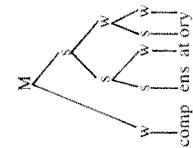ESR
ESR (*long retraction*)

ESR

SSA

ESR

EDR

FF
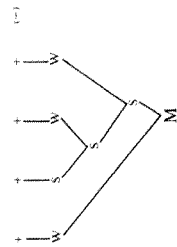
EDR

Output:

Metrical stress theory is thus brought into consistency with cyclic application of rules like the ESR. (Note that the Destressing Rule (70) remains word-level.) Because the subword cycle is not defined on metrically relevant bracketing the way the phrasal cycle is, the present theory does not illuminate the structure-dependence of (±)-stress rules. As in former theories, this is a special property that does not follow from independent assumptions about the nature of the grammar.

Given cyclicity, then, and our understanding of the arboreal consequences of applying stress, a principle is required to adjudicate among the conflicting structural claims of various cyclic applications of the ESR; we offer (88), Deforestation, which rules in favor of the last cycle on which the rule operates, the one that encompasses the whole word. Further evidence is of course needed to establish (88) as the correct interpretation of the phenomenon, in the face of the many imaginable technical and conceptual alternatives. It is interesting to note that the other well-known mode of phonological organization, grouping of segments into syllables, also changes under morphological embedding: compare the second syllable of *ex-plain* with that of *ex-pla-na-tion*; if stress rules are sensitive to syllable structure per se, as suggested above, then there must be de- (and re-) syllabification at each cycle, just as there is de- and re-forestation. Principle (88), then, which may be the metrical reflection of a more embracing theory of cyclic reorganization, allows us to present a version of the ESR, (87), that can play a key role in representing the system of "translexical" regularities typified by the data discussed in this section.

2.8. The LCPR Reconsidered

The LCPR says: in a metrical configuration $[N_1 \; N_2]$, N_2 is *strong* if and only if it branches. The "if and only if" gives the rule two ways to fail, and both are easily illustrated. Branching right nodes that are *weak*, not *strong*, we have seen in such words as *category, laudatory, antimony, Aristotle, salamander*. For these cases, it seems quite plausible to appeal, as we did in section 2.6, to a notion of extrametricality (of certain surface syllables) that is independently useful in maintaining a straightforward, general account of vowel reduction. Conversely, nonbranching right nodes that are *strong* instead of *weak* are seen in words like *pontoon, marquis, serenade, lament, police, manure, contradict, advance, maintain, overt, august.* Casting one's eye over the list—and it can be made much longer—one might wish to conclude that Schane's generalization about main stress, which the LCPR takes over, is overblown or perhaps entirely spurious, a mere artifact of unscrupulously preselected data. Such scepticism (though it has, presumably, its uses) is quite unjustified, for an actual consideration of the facts shows that a few subregularities cover the bulk of apparent exceptions, and provide a basis for understanding the rest.

Words like *pontoon, marquis, serenade* belong to a sizable class of words, identifiable by the shape of the last syllable, that have kept their end-stressing in the passage from one side of the English Channel to the other. The following list gives

many of the relevant endings, with examples to show how they attract main stress:

(90) -ier, -eer   engineer, frontier, veneer, lavalier, chandelier
    -oon   pantaloon, octaroon, tycoon, baboon, poltroon
    -ique   unique, antique, bezique, Mozambique
    -oo   tattoo, kazoo, shampoo, bamboo, canoe
    -ise   chemise, valise, expertise
    -ade   serenade, cascade, grenade, stockade, blockade
    -ette   novelette, cigarette, vignette, corvette
    -ee   deportee, addressee, trustee, absentee, Tennessee
    -elle   bagatelle, moselle, villanelle
    -air   affair, corsair, debonair
    -che   cartouche, pastiche, brioche, panache
    -esce   acquiesce, recrudesce, incandesce, effervesce
    -ane   mundane, transpadane, ultramontane, chicane
    -ār   guitar, bizarre, cigar, (bazaar)
    -eau   flambeau, tableau, chateau, portmanteau
    -esque   picturesque, grotesque, statuesque, romanesque

(A useful discussion of words of this type is found in Oehrle (1971).)

Assuming that the members of this class are designated [+F], we can restate the LCPR to take their existence into account:

(91) *LCPR*
In the configuration $[N_1 \; N_2]$, within a lexical category, N_2 is *strong* iff:
A. It branches, or
B. It immediately dominates [+F]

Although this formulation is marked by a clear incursion of lexical–morphological information into the LCPR, the disturbance is narrowly restricted, and the rule retains its essentially local character.

A similar modification will be necessary if we wish to give direct recognition in the rule to the kind of weakening of initial light syllables that motivated Halle's (1973) treatment of destressing. Not many convincing examples survive when the [+F] items and the verbs (to which we turn next) are removed from the domain of consideration; however, one might offer such words as *July, manure, attire, patrol, lament, arachnology, electricity, electronic, depártmental* (as opposed to *départmental,* with a long initial vowel). This process, as noted above in 2.5, is subject to a fair amount of lexical idiosyncrasy: *rabbi, satire, essay, áristocracy* (*ărístocracy*) should all be iambic in the relevant metrical group. (Note that the shortness of the first vowel of *aristocracy* is shown by its reduction in *aristocrat.*) A more interesting general restriction is seen in data brought to our attention by P. Kiparsky: words like *lithoid, ovoid, cathode, anode, epode, hadron, Semite, samite, Hittite* are not subject to the

rule, even though they would appear to be prime candidates for it. Apparently such affixes repel prominence, with the effect that the ESR stress on the first syllable is allowed to surface. We can record these observations in the following clause:

(92) *LCPR* (cont'd)

    C. $N_1 = \# \, C_0 \quad V \quad$ and N_2 does not immediately dominate an affix
                [−long]

Note that this rule, like all rules that interact with metrical structure, may not function to create a *strong* stressless syllable; it cannot apply to words such as *atom, gallop,* etc.

Verbs have their own pattern of prominence, determined partly by metrical geometry, partly by morphology. Before we can investigate it, we shall need to make clear two aspects of the ESR, unmentioned in our original discussion, that set the stage for the prominence rule by assigning [+stress] in places where we might otherwise not expect it.

(1) The first iteration of the ESR may not skip over the entire stem of a word: we find, for example, *consider, infer, repel, emit, equip, discover, comment, permit*$_N$, *insect, MacDonald, MacCord,* where in each case a syllable that could have been ignored is supplied with stress. This restriction does not in general limit further iterations, cf. *concentrate* (stem *centr*), *recognize* (stem *cogn*), *MacIntyre* (stem *Intyre*). The notion *stem* here should probably be further limited to the latinate (and goidelic) segment of the vocabulary, for the accentuation of greek words does not turn on quite the same distinction: with them, the stem, so long as it meets the purely phonological requirements, may be skipped over (*anaLYSis, photoGRAPHy, synTHESis*) when it is not absolutely word-final (*photograph, orthodox, monolith*). These conditions we will regard as lexical redundancies governing the choice of subrule; they could, of course, be written directly into the ESR in the form of Boolean conditions relating the parenthesized terms (a), (b), (c) to a feature [+stem] on the vowel to be stressed.

(2) Verbs (and frequently, adjectives) strongly tend to require stress on any *heavy* final syllable, even if it does not contain a long vowel: e.g. *bombard, ferment, cavort, molest, document*$_V$, *ribald, jocund, august.* Since very few verbs have antepenultimate stress (*minister, jettison, garrison, monitor, discipline, reverence, interest,* perhaps some others), we can regard the essential verb rule as being the following, maximally penultimate subrule of the ESR:

(93) *ESR* for non-nominal items, first iteration

    $V \rightarrow [+\text{stress}] / \underline{\quad\quad} C_0 \, (V \, (C))_a]$

Notice that this is simply a somewhat attenuated version of the normal rule; we can say that non-nominal items are usually (~b) on the first iteration. Exceptions to this subregularity, like *challenge, govern, bollix, modest,* will go by the full ESR. Observe, too, that as with the full ESR, we find that cases of pseudogemination—*caress, harass*—can be treated as being lexically marked (~a), like *Agrippa, bacillus.*

Having placed the stresses correctly, we can inquire as to their customary ranking. There are basically three points to notice. (We are indebted to Debbie L. Nanni for many essentials of this remark.) First, verbs (and, generally, adjectives) have the iambic pattern not only when N_2 branches (*impregnate, proposition*$_V$, *commission*$_V$), but also when N_1 is *non*branching: for example, *maintain, caress, harass, advance, bombard, lament, torment*$_V$, *discourse*$_V$, *infer, rotund, overt, august, robust.* This provision has very few exceptions (e.g. *comment, ribald*) and is responsible for the widespread alternation of prominence between verbs and homophonous nouns, which go by the LCPR as originally presented. A sample of typical participants in the alternation:

(94)

survey	address	protest	abstract
detail	transfer	insert	combine
suspect	permit	progress	record
contact	export	convict	relay

The liveliness of this kind of category differentiation is attested by its regular effect on productively derived verb–noun pairs: as in *re-fill*$_{V,N}$, *re-match*$_{V,N}$, *over-flow*$_{V,N}$, *re-make*$_{V,N}$, *over-dose*$_{V,N}$, etc. The serious exceptionality has to do not with the verbs and adjectives, but with the (nearly) homophonous nouns, many of which retain the iambic pattern in the face of the imperative of the category they actually belong to; for example, *advance, abuse, constraint, delay, lament, excuse, suspense, descent, offense, pursuit, design, accord.* We shall regard these as illicitly undergoing the verb rule.

The second point is that affixes such as *-ate* (in American English) and *-ize* fail to receive main stress, even when they are coupled metrically to a single syllable: *rotate, frustrate, orate, locate, cognize, Texize, baptize, capsize.* This rejection of prominence, reminiscent of the situation in such nouns as *lithoid, hadron,* might be definable generally on the class of affixes per se, but for a few nonproductive exceptions (e.g. *bombard*).

The third factor that influences verbal prominence patterns is the location of the stem: N_2 is *strong* if it immediately dominates the stem, regardless of the shape of N_1. Typical examples are *intervene, intersect, intersperse, interpose, intercept, superpose, comprehend.* Occasional exceptions are found: *súpervise, círcumcise* contrast with the normal *supervéne, circumvént.* The rule does not seem to pertain to adjectives, cf. *circumspect, derelict.*

These observations can be brought together in a two-part clause that fits easily into the LCPR.

(95) *LCPR* (cont'd)

    D. (Non-nominal constituents)

        (i) N_1 does not branch, N_2 does not directly dominate *-ate, -ize*.

        (ii) (verbs) N_2 immediately dominates the stem.

We can now assemble a fairly complete picture of the prominence regularities that

obtain within English words. For concision, let us use the notation A/B to mean 'A immediately dominates B'. The LCPR will take the following form:

(96) *Lexical Category Prominence Rule*
   In the configuration $[N_1 \ N_{2 \ \alpha}]$
   I. N_2 is *strong* if any one of the following conditions is met:
      A. N_2 branches
      B. $N_2/[+F]$
      C. $N_1/\#C_0$ V and not (N_2/affix)
         [$-$long]
      D. α = non-nominal or [$+R$],
         (i) N_1 does not branch, and not (N_2/-*ate*, -*ize*)
         (ii) α = verb and N_2/stem.
   II. Otherwise, N_2 is *weak*

The "if and only if" of earlier statements has been dismembered for ease of interpretation. Exceptionality has a clear meaning in terms of the format of rule (96); words like *Ládeföged* can be marked as [$-$I], sending them straight to Rule II, the elsewhere case, which assigns a trochaic pattern; words like *advance*$_N$, *delay*$_N$, *accord*$_N$, which cling to the verbal pattern, are to be marked [$+R$], entitling them to undergo case (D), as their homophonous verbs more regularly do.

Compounds turn out to follow the predictions of the revised LCPR rather well, once certain masking subregularities are recognized. Adjectival compounds, a productive category, ought to go by case (D), and indeed many types do:

(97) *Adjectival Compounds*

a. grass-green	b. Anglo-French	c. high-born	d. well-meaning
stone-deaf	politico-economic	ill-tempered	easy-going
crystal-clear	socio-political	clean-cut	far-reaching
skin-deep	anarcho-syndicalist	hot-headed	sweet-smelling

(We are assuming that such units as *politico* is column (97b) count as *words*, and are therefore single units in the calculation of compound prominence, being dominated by the node *M*. For a thorough and insightful survey of compounding, the reader is referred to Marchand (1969), from which the above list was compiled.)

The compounds that do not follow this pattern—that, in fact, behave as the original LCPR predicts—seem to uniformly have a noun as their first element: e.g. *color-blind, class-conscious, crest-fallen, ocean-going, frost-bitten, moth-eaten*. Except for "comparative" compounds like those listed under (97a), and a few cases like *hand-picked, home-made*, it appears that we can regard adjectival compounds as being marked [$-$case D] when they incorporate nouns.

For verbs, the only truly productive derivational process that resembles compounding is prefixation with word-like elements such as *re-, de-, pre-, under, over, out*, as in *re-do, de-pants, pre-date, under-cook, over-cook, out-cook*. As expected, these

collocations are uniformly iambic, since N_1 dominates a single word and is thus nonbranching in the relevant sense. Items like *horse-whip*$_V$, *stage-manage, air-condition* are verbal by zero-derivation, always applicable to make a noun into a verb, or by backformation (*stage-manager, air-conditioner*). Presumably, a more developed understanding of morphology might tell us why such words slavishly follow the prominence pattern of their sources, as in e.g. *cold-shoúlder*$_{N,V}$, *mass-prodúce*$_V$ (*mass-production*$_N$), vs. *hórse-whip*$_{N,V}$. The cases of verbs like *pistol-whip, keel-haul, spoon-feed*, which stand on their own without a nominal back-up, seem to imply that for verbs, as for adjectives, incorporation of a noun renders a form [$-$case D], i.e. subject to the usual compound rule.

At this point, although details could be pursued farther, it appears safe to conclude that compounds behave in essential respects like other members of the lexical categories they belong to, and that the basic branching–nonbranching distinction pertains to the prosodic level where words are grouped, as well as to the subword level where syllables are hierarchically organized into constituents.

In order to improve the LCPR to the level of adequacy represented by the formulation in (96), we had to let it refer to morphological and lexical information of a kind that is not represented in the structure of trees. However, this information enters into the rule in remarkably limited ways: it is apparently necessary to know only what a given node in the formula $[N_1, N_{2 \ \alpha}]$ *is*, as it were, to correct the errors of purely geometric calculation. Thus, the syntactic category of α is relevant, as is, apparently, that of N_1 in verb and adjective compounds. Material *immediately* dominated by the N_1, N_2 of the formula is also pertinent under certain circumstances, but we found no call to look further up or down the tree. This suggests a narrowly local theory of prominence assignment, in which labelling is based only on structural properties of a node (branching–nonbranching), syntactic or morphological properties of a node or of the node immediately dominating it (α), or on morphological properties of immediately dominated material. Of course, only detailed work on a range of languages can validate such restrictions; encouragingly, J. Bing (1976) examines Dari (Afghan Persian) stress from a metrical point of view, presenting a thorough and persuasive analysis that operates well within the limits we are suggesting.

We conclude, then, that the first promise of metrical theory, to unify the rule for prominence assignment in words and compounds, is borne out by close investigation. Metrical theory provides the means for a simple account not only of the broad features of the lexicon but also of the characteristic complexities and subregularities that are so much a part of the English stress system.

3. The Metrical Grid

3.1. The "Rhythm Rule": Description

The preservation of relative prominence under embedding has been a central theme of work on English stress rules, this article included. However, there is a significant class

of cases in which relative prominence is *not* preserved under embedding. For example, we have *thirteen*, but (usually) *thirteen men*; *achromatic*, but *achromatic lens*; *Tennessee*, but *Tennessee air*. [15]

Such cases are commonly mentioned in discussions of English stress patterns, often with some reference to the concept of "rhythm" and the desire to maintain an alternating pattern. Thus Gimson (1962, 265) says

> The accentual (rhythmic) pattern of a word generally remains constant whatever the environment, retaining its rhythmic identity in the total rhythmic grouping of the longer utterance . . . Although a word may lose, in connected speech, the nuclear pitch change which it has in isolation, the relation of primary and secondary accents is not changed. . . But it happens that when a word (simple or compound) pattern consists in isolation of a primary accent preceded by a secondary accent . . . , the primary accent may be thrown back to the syllable carrying secondary stress in isolation, if, in connected speech, a strong accent follows closely . . .

Bresnan (1972) points out that some special provision for such examples is necessary, in order to maintain the generality of the contrary case:

> There is a well-known case where internal stress relations are altered: compare the word *thirteen* in isolation with the same word in prenominal position, *thirteen men*. If this were the general case, the cyclic principle would be unjustified; however, since it is exceptional, it is taken to be the result of some sort of special rhythm rule.

This "rhythm rule" can also readjust the pattern of secondary stresses in compounds or phrasal collocations, as well as within a word—thus *he's good-looking* but *good-looking lifeguard; empty bed* but *empty bed blues*, etc.

Kiparsky (1973) attempted to formalize such rule for German, where a somewhat similar phenomenon exists. [16] He cites examples such as *halbtot*, but *der halbtote Mann; fing an,* but *er fing an zu reden*. He also observes that a corresponding phenomenon, a shift of secondary stress away from primary stress, may occur when the secondary stress follows the primary one, e.g. *sichtbar* but *unsichtbar; Grossvater* but *Urgrossvater; anziehen* but *den Rock anziehen*. To account for these cases, he proposes a mirror-image rule, stating that the second subordinate stress before and after a primary stress has [2 stress] reassigned to it, with a generalization of the stress subordination convention to downgrade by one level all nonprimary stresses in the cyclic domain in question.

[15] These examples (translated into numerical representation) are taken from Kenyon and Knott's (1953) *Pronouncing Dictionary of American English*, which generally follows the practice of giving both stressings of such words, along with an example to indicate the environment of the retracted case.

[16] An interesting discussion of these and related phenomena of German is found in Austin (1976).

Note that unlike German, English does not show a symmetrical pattern of rhythmic stress adjustment. Thus *sports contest* never becomes **sports contest; verb paradigm* will not emerge as *verb paradigm; etc .

Stress in Masoretic Hebrew, as discussed in Prince (1975), exhibits a similar retraction under the influence of a following context. The Hebrew case, like the English one, is asymmetrical, occurring only to the left of its environment, but is sharply restricted by features of syllable structure.

The existence of examples in other languages suggests that the "rhythm rule" is a reasonably natural phenomenon, not a strange quirk of English. However, the striking differences between its domains of application in English, Hebrew, and German rule out the possibility that it is some sort of phonetic universal. Therefore, one would like to have a description of this phenomenon that would account for its naturalness (hopefully in terms of the intuition that points to a rhythmically-motivated alleviation of "clashing" stresses) while allowing for language-specific differences in its implementation.

Such a description would have two parts. First, we need an account of linguistic rhythm in terms of which the appropriate stress configurations are marked as "clashing", thus producing a *pressure* for change. Second, we need a specification of the circumstances in which a given language grants *permission* for such a change to occur.

3.2. Metrical Hierarchies

Let us consider first how to represent the notion of "stress clash". It is not enough, obviously, to speak of "adjacent stresses" as clashing. It is possible, indeed common, for stressed syllables to stand adjacent to one another in English—in *thirteen men*, for example, the syllable *-teen* retains some stress even though the main word stress is retracted, producing an "alternating" pattern.

Nor is it enough to speak of "adjacent main word stress". In *achromatic lens*, before the Rhythm Rule has applied, a syllable intervenes between the main word stresses of the adjective and the noun. Nevertheless, we must speak of these stresses as "clashing" in a way that is alleviated by the Rhythm Rule's stress retraction.

The stress-retraction which the Rhythm Rule accomplishes can be stated, rather simply and naturally, in terms of the hierarchies of relative prominence relations developed and discussed in sections 1 and 2. However, the notion of "stress clash," which would generate pressure for retraction to occur in certain stress configurations rather than in others, is not much easier to define on relative prominence patterns than on strings of stress numbers.

Still, there seems to be some truth in the intuition that the purpose of the Rhythm

Rule is to create a (more nearly) alternating pattern, by eliminating perniciously close, or "clashing", stresses. But in order for this intuition to be expressed effectively, the terms "adjacent" and "alternating" must be defined in terms of positions in a novel representation of stress patterns, a representation whose basis is neither the traditional n-ary stress feature, nor our *strong/weak* constituent-structure relation.

To illustrate what we mean, consider three simple cases—*thirteen men,*
Tennessee air, and *achromatic lens.* Suppose that the succession of syllables in these examples is represented as a sequence of numbers, for ease in reference. Then in the case of *thirteen men* there is another "level" of stress on which *-teen* and *men* are represented—we symbolize this by placing a second level of marks above the first (continuing to use consecutive integers as place-holders). The fact that *men* is the main stress of the phrase can be indicated on a third level, if desired:

(98) a.
			6	level 3
		4	5	level 2
	1 2		3	level 1

thirteen men

b.
		6	level 3
	4	5	level 2
1 2		3	level 1

thirteen men

We observe that (98a) has two adjacent placeholders on level 2 (labelled *4* and *5*) with no intervening elements on level 1. This configuration can be taken to represent a "clash" of stresses; and of course it is not present in (98b), where the "secondary stress" has been retracted to the first syllable of *thirteen.*

In terms of the grid-like structures we have erected above these two stressings of our first example, the "degree of stress" of a given syllable is represented by the height of the column of marks that stands over it. Notice that all of the inequalities of stress implicit in the pattern *thirteen men* (*-teen>thir-, men>-teen*) are captured by the grid in (98a).

We now turn our attention to the second case mentioned above, *Tennessee air.* A similar attempt to capture inequalities of stress would yield the grid pattern shown below:

(99)
			10	level 4
		8	9	level 3
	5	6	7	level 2
1	2	3	4	level 1

Tennessee air

Observe that the grid pattern in (99) contains a pair of "clashing" elements", those labelled *8* and *9* on level 3. In fact, levels 2, 3, and 4 in this case have exactly the same configuration as levels 1, 2, and 3 did in the case of *thirteen men.*

Applying the same method to our third case, *achromatic lens,* yields a grid like that in (100):

(100)
			11	level 4
		9	10	level 3
	6		7 8	level 2
1	2	3 4	5	level 1

achromatic lens

Again, we see a pair of adjacent elements, this time those labelled *9* and *10*, which are not separated by an intervening element in the next level down. There is, of course, a *syllable* intervening between the two syllables that correspond to elements *9* and *10*; but in terms of the metrical hierarchy, on levels 2, 3, and 4 this case is exactly the same as the two cases considered previously.

In what follows, we will suggest a more precise formalism for such metrical hierarchies or "grids", and explore their relationship to the patterns of relative prominence discussed in preceding sections. Once we have done this, we will be in a better position to motivate the use, in describing English stress patterns, of this additional formal device.

3.3. Formalism

Although a metrical hierarchy is, as its name implies, hierarchical, a formalization in terms of tree structures would not serve our purposes very well. We wish the rows (or "levels") and columns of the grid-like graphical representation to be perspicuous in the formalization. Representing such grids as trees, although possible, requires us to define rows and columns derivatively, and also requires the imposition of constituent-structure relations that will have no relevance to our present purposes. Therefore, we choose to formalize such grids as, in a sense, hierarchies of intersecting periodicities.

We define a metrical hierarchy (in the general sense) as an ordered set of levels L1 through Ln, each level being itself an ordered set of elements E1 through Em; and a function F that maps each (member of some subset[17]) of the elements of a given level onto some member of the immediately preceding level, in a way that preserves ordering relations.

Graphically, we represent metrical levels as the rows of a grid, with the elements of each row ordered left-to-right, and the function F represented by columnar alignment.

Two simple (and by now familiar) examples of such metrical grids are given below. Again, integers are used as place-holders for ease of reference.

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[17] Inclusion or omission of the parenthesized words will define two different types of metrical hierarchies, as we indicate later on. For the kind of grids we choose to employ in this article the parenthesized words should be omitted.

(101) a.

		11		level 4
	9	10		level 3
6	7	8		level 2
1 2 3 4 5				level 1

b.

		11		level 4
9		10		level 3
6	7	8		level 2
1 2 3 4 5				level 1

Terms like *adjacent, alternating, clashing,* etc. can now be defined in a way that makes sense of intuitions about the role of the Rhythm Rule. Elements are metrically adjacent if they are on the same level and no other elements of that level intervene between them; adjacent elements are metrically alternating if, in the next lower level, the elements corresponding to them (if any) are not adjacent; adjacent elements are metrically clashing if their counterparts one level down are adjacent. Thus the elements labelled *9* and *10* are metrically adjacent in both of the examples given above. However, in (101b) elements 9 and 10 are alternating, since 6 and 8 are not adjacent, while in (101a) elements 9 and 10 are clashing, since 7 and 8 are adjacent.

We could, of course, project the objects represented in (101) onto a single row of symbols, by allowing the symbols in that row to define column height. However, any definition of *alternating* and *clashing* in terms of such a linear projection of the grid would in essence depend on some more-or-less overt process of inverting the projection.

Before returning to the linguistic relevance of metrical hierarchies, it will be convenient to define some additional terms with which to describe their structure. In a given metrical grid, the number of levels is finite, and therefore the "column" in which any given element stands has both a bottom and a top. Let us define a function B that maps every element of a metrical grid onto the element at the bottom of its column, B(A) being called the "terminal counterpart" of A; and a function T that maps every element of a metrical grid onto the element at the top of its column, T(A) being called the "highest counterpart" of A. We now define the "terminal set" of a given metrical grid as the range of the function B defined on its elements. If we define a function L that maps every element of a metrical grid onto the level of which it is a member, then for any pair of elements E1 and E2, E1 is "metrically stronger" than E2 iff L(T(E1)) > L(T(E2)).

Notice, incidentally, that as we have formalized the concept of a metrical grid, the elements of a grid's terminal set need not all be members of the same level—for example, a configuration such as this is possible:

(102) a. 5   6   7   b. 5   6 7
      1 2 3 4   1 2 3   4

In this case, the terminal set is {1,2,3,4,7}. Since we have defined left–right order

only within a given level, no ordering is defined on the elements labelled *4* and *7,* and the two graphical representations given in (102) are equivalent. But the usefulness of a metrical hierarchy depends on the possibility of mapping its terminal set onto the elements of a temporally-ordered string; and once this mapping has been accomplished, the terminal set is of course well-ordered.

Formally, this amounts to saying that for every metrical hierarchy G there is an ordered set S and a function C that maps every element of the terminal set of G onto some element of S, in a way that preserves ordering relations. Given this addition, ordering ambiguities like those of the terminal set in (102) are not pernicious to our enterprise, and indeed there may be some value in allowing grids of this sort. However, the empirical differences are rather small, and it will be expositionally more straightforward to insist for now that the terminal set of a grid be simply its lowest level. This stipulation is most easily accomplished by eliminating the parenthesized material in the definition given previously of the translevel counterpart function F, so that the domain of F includes every element of all levels above the first one, rather than a subset of the elements of these levels.

3.4. The "Scansion" of Speech

3.4.1. The Relative Prominence Projection Rule

The notion "stress clash" has been defined on metrical hierarchies or "grids". For this effort to be of interest to us in explaining the Rhythm Rule's pattern of occurrence, we need to specify how to construct a metrical grid that "scans" any given piece of linguistic material. We have already seen what kind of result we want, in a general sense—thus, the sample grids given in (101) are appropriate to the case of *achromatic lens*:

(103) a.

		11		
	9	10		
6	7	8		
1	2	3 4	5	

achromatic lens

b.

		11		
9		10		
6	7	8		
1	2	3 4	5	

achromatic lens

We are assuming that the elements of a grid's terminal set correspond one-to-one to syllables; and we have previously defined "relative metrical strength" with respect to elements of a metrical hierarchy. It follows naturally, therefore, that the "relative strength" of the elements of a grid's terminal set ought to be congruent to the "relative strength" of the syllables they correspond to.

This simple principle, which we will call the Relative Prominence Projection Rule, is almost all that is needed to ensure the correct "scansion" of linguistic material. A

more precise statement is given below, phrased in terms of the representation of relative prominence developed in sections 1 and 2.

(104) *Relative Prominence Projection Rule*

In any constituent on which the strong–weak relation is defined, the designated terminal element of its strong subconstituent is metrically stronger than the designated terminal element of its weak subconstituent.

A metrical grid is "aligned" with a linguistic phrase by the previously-mentioned function C, which maps the grid's terminal set one-to-one onto the syllables of the phrase, preserving order. The Relative Prominence Projection Rule (henceforth RPPR) is to be interpreted as a wellformedness condition on such alignments.

We referred to this principle briefly in section 1.3, as the method by which the relation of relative prominence, defined on constituent-structure nodes, was to be projected onto "a partial ordering of terminal stress levels somewhat different from that imposed by cyclically-assigned stress numbers, one that we think is more in accord with the evidence." We will return shortly to this role of grid alignment, after completing the discussion of the rhythm rule.

3.4.2. The Rhythm Rule: A Formal Treatment For many of the cases in which the Rhythm Rule operates, the grid alignments (or "scansions") that the RPPR admits as well-formed on the basis of the input relative prominence pattern contain stress clashes that disappear in the scansions appropriate to the output stress pattern. For example:

(105) a. input scansion:
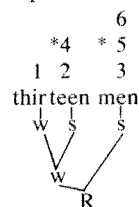
b. output scansion:
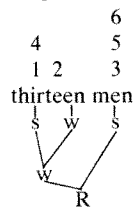
(106) a. input scansion:
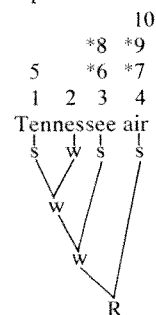
b. output scansion:
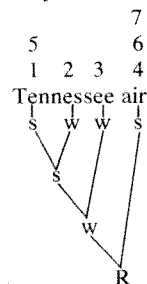
(107) a. input scansion:
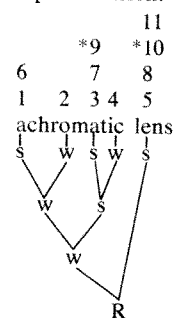
b. output scansion:
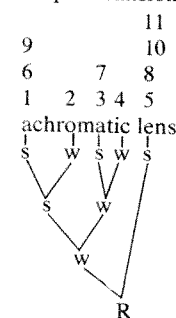
(108)
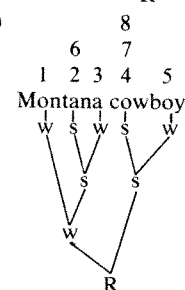
In each case, the clashing elements are marked with asterisks. It is interesting to note that a case like *Montana cowboy*, which fits the structural description of the Rhythm Rule as given by Kiparsky, does not require a "clashing" scansion, according to our principles. In general, such forms[18] are much less likely to undergo stress retraction than the other cases we have discussed. Indeed, many speakers (including ourselves, when we first considered the matter) feel that retraction is impossible in such cases. However, we have noticed a few instances of retraction in examples of this form, in our own speech as well as that of others. D. Jones (1956) cites *Salvation*

---

[18] I.e. words of the form S1 S2 S3. When a word boundary, single or double, intervenes between S1 and S2, the situation is quite different, and retraction is preferred. We have already cited *good-looking lifeguard.* Among single word boundary cases, compare productive uses of affixes (where # remains) with more "frozen" forms: *pretonic lengthening* but not **prevailing winds; invalid sample* but not **insipid coffee.* Retraction is also common in cases where the stem is a bound morpheme, but the prefix is "alive" in the sense that its root meaning is an important part of the meaning of the word: *preceding message, interior decorator.* Note, too, the behavior of *already,* which is transparently a fusion of two words, even though semantically noncomposite: *he already left, he left already.*

Army, a form that strikes us as possible, but not nearly as likely as the other kinds of retraction we have discussed. After examining the nature of the retraction process itself, we will reconsider some of the details of its distribution in speech.

The nature of the rule that, in our system, accomplishes the stress retractions we have been studying is indicated by the output scansions we have given in (105)–(107). For example, in (107b), clashes have been eliminated on two levels simultaneously, with concomitant loss of one grid element. We are assuming that the Rhythm Rule does not function simply to shift an element over in a metrical grid, which would have produced the pattern in (109) below:

(109)   10
            8   9
            5   *6 *7
            1 2   3   4
            Tennessee air
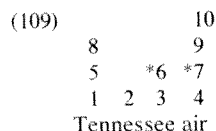
Instead, *Tennessee* (in this position) has been given the scansion appropriate to a word like *institute*. Although the last syllable of *institute* is stressed, it is assigned the relative prominence pattern given in (110a) below, so that the RPPR suggests the grid alignment given in (110b):

(110) a.   M

            s

            s   w w
            institute

b. 4
    1   23
    institute
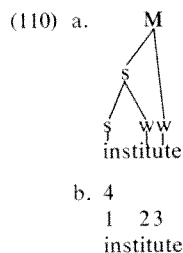
In other words, the stress clashes that motivate the Rhythm Rule's application are to be found in the metrical grid, but the rule itself operates on the relative prominence pattern, reversing the strong–weak relation within one of its constituents. Of course, this reversal compels a new scansion, in accord with the provisions of the Relative Prominence Projection Rule, which, being a well-formedness condition, is constantly applicable.

Note that this realizes the goal we described at the beginning of this section: "First, we need an account of linguistic rhythm in terms of which the appropriate

stress configurations are marked as 'clashing', thus producing a *pressure* for change in stress-pattern. And second, we need a specification of the circumstances in which a given language grants *permission* for such a change to occur." As promised, the *pressure* is apt to arise in any language that has a counterpart to the Relative Prominence Projection Rule, that is, in any stress-timed language. The *permission*, specific to English, can be stated as follows:

(111) *Iambic Reversal* (optional)

      w s   →   s w
      1 2   1 2

Conditions: 1. Constituent 2 does not contain the designated terminal
                element of an intonational phrase.
             2. Constituent 1 is not an unstressed syllable.

Condition 2 does not really need to be stated here, since rules are not allowed to create the configuration s/[−stress] as a matter of general principle. Condition 1 presents the rule from shifting the "nuclear syllable" of an intonational phrase; without this limitation, it is interesting to note, the unbridled pursuit of trochaic fluency would drastically change the meaning of many utterances. However, even if the shift would take place within a single word, the nuclear syllable is generally exempt from being affected by this rule, so that an expert on the Chinese language is a *Chinése-expert*, not a *Chinese-expert*, even though a stress clash remains, in our terms. Likewise someone who rides a kangaroo is a *kangaróo-rider*, not a *kángaroo-rider*. However, if the main phrase stress is removed from the word *kangaroo* in this last case, as in the phrase *a kangaroo-rider's saddle*, "iambic reversal" becomes possible. Thus, both of the versions given in (112) below are allowed:

(112) a.   13
              11   12
              8   9   10
              1   2 3 4 5   6   7
              kangaroo rider's saddle
              s   w w s w   s   w

                   s   w   s

                        s

                              w

                              R

b.

```
                    14
         12        13
    8   9  10      11
    1   2  3   4 5  6   7
    kangaroo rider's saddle
    |    | | | | |  |   |
    s    w s s w    s   w
     \  /   \ /      \ /
      w      w        s
       \      \      /
        s      \    /
         \      \  /
          \      \/
           w
            \
             \
              R
```

3.4.3. The Optionality of Retraction   Depending on circumstances, the Rhythm Rule appears to be more or less optional, in degrees ranging from "strongly preferred" to "quite unlikely." For example, *Marcel Proust* (²⁴ ¹) is very strongly preferred to the unretracted case, but *Marcel's book* (²⁴ ¹) and *Marcel's book* (⁴² ¹) seem almost equally likely, and *Marcel's finished* (⁴² ¹) seems (in many conditions of usage) preferable to the retracted form.

Why these differences? Given the system we have proposed, many of them are quite reasonable. Recall that Iambic Reversal is an optional rule, which nowhere mentions the notion "stress clash", but simply generates an optional relative prominence pattern in a wide variety of cases. In some of these, one option requires a scansion that contains a stress clash, while the other does not. Nevertheless, in all such cases both pronunciations remain possible—one can always say e.g. *thirteen men* (⁴² ¹), at the expense of lengthening the syllable *-teen* to compensate for the lack of an intervening syllable. Since this lengthening seems awkward and unfluent in such a tightly bound constituent, the alternative will naturally be preferred. If, however, the lefthand element in the clash falls at the end of a constituent that is somewhat more loosely bound to what follows, a longer "pseudopause" (lengthening of the terminal syllable(s) of the phrase) is likely to employed in any case to mark the constituent boundary. In this situation, the clashing pattern is not such a liability.

Thus the acceptability of a stress clash depends, in part, on the extent to which the interstress interval is prone to be lengthened, independently, by prepausal lengthening. It also seems to depend, in some cases, on other durational properties of the interstress material, although the differences here are perhaps too delicate to be reliably investigated by means of intuitive data.

One of the advantages of our approach is that it does not require considerations of this kind to be treated as formal constraints on the phonological rule that accomplishes the stress retraction. Indeed, our rule of Iambic Reversal could not possibly be subject to such constraints, since it does not refer to the interstress interval, and there is good reason to limit conditions on phonological rules to properties of elements of their structural description. Happily, then, we are forced to say that Iambic Reversal is always an option (subject only to the conditions that the first subconstituent is not an unstressed syllable, and the second does not dominate the nuclear syllable of an intonational phrase), and that the choice of a particular option in real-life situations depends on the independent consideration of such goals as maximization of metrical alternation, equalization or maximization of interstress intervals, etc.

We believe that the theory of metrical grids, as we have laid it out, provides a clear and useful characterization of some of the factors that influence how speakers of English choose to employ the optional stress-retraction process that we have formalized as the rule of Iambic Reversal. However, there remains one significant class of examples (mentioned earlier) that our theory, as it stands, does not treat properly.

In cases like *Montana cowboy* (⁴² ¹), *Salvation Army* (⁴² ¹) our theory predicts no strong pressure for retraction, since the original stressing produces no metrical clash. Iambic Reversal is possible here, as it always is, but the unretracted case is not metrically awkward, according to our analysis, and therefore retraction should be much less likely than it is in examples like *thirteen men* (⁴² ¹), *Tennessee air* (⁴² ¹), *achromatic lens* (⁴² ¹). This prediction is a correct one, we believe. But examples like *pretonic lengthening, good-looking lifeguard* are quite different. Retraction is strongly preferred, and the unretracted cases seem to be subject to the same elongation of interstress interval that afflicts e.g. *achromatic lens* (⁴² ¹). Yet our system presently treats *Montana cowboy* (⁴² ¹) and *good-looking lifeguard* (⁴² ¹) identically:

(113) a.

```
                 8
            6   7
    1   2   3   4   5
    Montana cowboy
    |   |   |   |   |
    w   s   w   s   w
     \ /     \ /
      s       s
       \     /
        \   /
         \ /
          w
           \
            R
```

b.

```
                    8
              6     7
        1     2  3  4     5
        good-looking lifeguard
        w     s  w  s     w
         \   / \  /  \   /
           s      s    s
            \    /
              w  /
               \/
               R
```

The difficulty seems to be that the initial monosyllabic word (or # prefix) in cases like *good-looking* is not being given its proper "weight". It seems wrong to give a lexical entry (albeit monosyllabic) no greater representation in the metrical grid than a pretonic initial syllable would receive.

The difference in applicability of the Rhythm Rule is related to this greater metrical strength of the lexical monosyllable. If the grid column standing over *good*, in (113), is made one level higher, and the scansion is adjusted in conformity with the RPPR, then a stress clash will result, and the pressure for Iambic Reversal to occur will be the same as it is in examples like *thirteen men*:

(114)

```
                    11
              *9     *10
        6     7      8
        1     2  3   4     5
        good-looking lifeguard
        w     s  w   s     w
         \   / \  /   \   /
           s       s    s
            \     /
              w   /
               \ /
                R
```

It is reasonable that lexical entries (aside from unstressed function words) should be guaranteed a certain metrical strength, even if they are monosyllabic, and the addition of such a provision to our system results in an empirically better account of the Rhythm Rule's pattern of occurrence.

There are any number of formal devices one could employ to implement such a provision. We propose to adopt the most straightforward one, an addendum to the Relative Prominence Projection Rule stating that the main stress (if it exists) of any #-level unit must have at least two levels of metrical strength. Like any other rule, this one has effects outside the class of cases that motivate it. Designed to distinguish e.g.
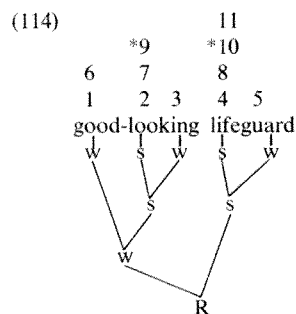
pretonic from *Montana,* it also distinguishes *gym mat* from *gymnast, tentacle tip* from *catamaran.* The value of such distinctions remains to be explored; we are not aware of any adverse empirical consequences, however.

3.5. Grid Alignment as a Picture of Syllabic Stress Levels

Although we have argued that "relative prominence" is best treated as a constituent-structure relation, it is equally clear that syllables (or some other class of terminal elements) differ among themselves in degree of stress. In the present treatment, the inequality among stress numbers (whether assigned by cyclic rules, or determined from relative prominence patterns by an algorithm like (12)) is replaced by the notion of relative metrical strength, defined in terms of the metrical grid with which a relative prominence pattern is aligned. The partial ordering of relative syllable stress thus obtained is different, in certain respects, from that implied by cyclic reassignment of [1 stress] with concomitant stress subordination, or (equivalently) by the output of (12). These differences, for the most part, represent an improvement.

Of course, a metrical grid can certainly be collapsed into a linear stress-number representation, as we observed earlier. Therefore, preference for the metrical theory's picture of syllabic stress relations does not help motivate the hierarchical aspect of the metrical grid. However, a metrical theory, like any other candidate in this area, must provide a reasonable picture of relative syllable stress, and we believe that the grid-alignment system just described, which was devised primarily to account for the Rhythm Rule's pattern of application, passes this test rather well.

We will consider four cases: left-branching structures with main stress on the left; right-branching structures with main stress on the right; left-branching structures with main stress on the right; and three-word structures, either right- or left-branching, with medial main stress.

In a left-branching structure in which each constituent has the relative prominence pattern [sw], the RPPR requires only that the initial element be metrically stronger than each of those that follow:

(115)

```
        1
        2  3  4  5  6 ...
        X  X  X  X  X ...

        s  w  w  w  w ...
         \ /  /  /  /
          s  /  /  /
           \/  /  /
           s  /  /
            \/  /
            s  /
             \/
             s
```
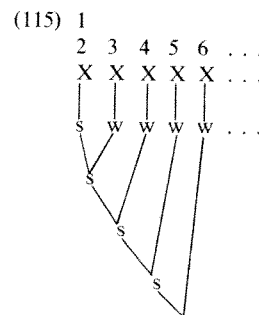
Of course, (115) is merely the simplest grid alignment that meets the RPPR's well-formedness condition. There is nothing to prevent further differentiation among the sequence of "weak" elements, but neither is there anything to require it.

This pattern can occur both within the word and at higher levels:

(116) a. 4
```
    1 2 3
    execute
    s w w
     \ | /
      s
       \
        M
```

b. 5
```
    1  2  3  4
    knowledgeable
    s  w  w  w
     \ /
      s
       \ /
        s
         \
          M
```

c. 13
```
    9      10     11      12
    1  2  3  4  5  6  7  8
    law degree requirement changes
    s  w  s  w  s  w  s  w
     \ /    \ /    \ /    \ /
      w      s      w      w
       \    /        \    /
        s              w
          \          /
            s
              \
                R
```
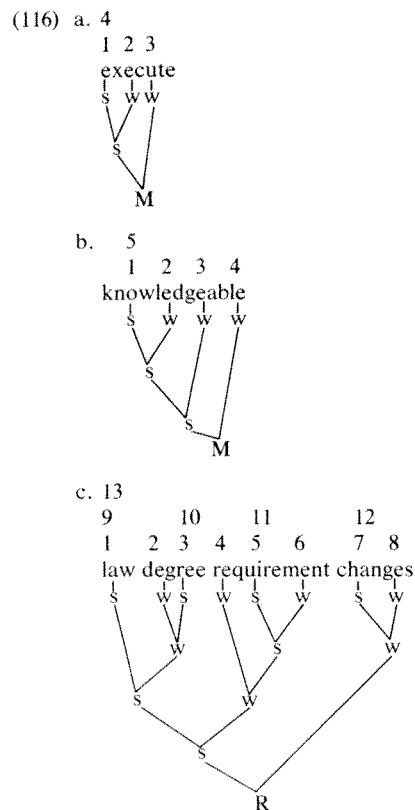
Some people feel that the last element in the sequence may be stronger than the other weak elements, a feeling that often surfaces, for example, in the way that such patterns are set to music. However, the 1 4 3 2 pattern that the traditional cyclic theory assigns to cases like (116c) seems overly differentiated; the non-main stresses are more equal than this pattern implies. In cases like (116b), previous theories of course do not differentiate among the unstressed syllables any more than we propose to do.

In cases like (116a), it may seem odd not to make the terminal syllable, which is [+stress], metrically stronger than the preceding unstressed syllable. However, Kiparsky (1977) argues that poets have treated such words exactly as our scansion suggests.

A right-branching structure in which each constituent has the relative prominence pattern [ws] is the mirror image of the situation just described, and our system treats it in an analogous manner:

(117)
```
                               1
    ... 6  5  4  3  2
    ... X  X  X  X  X
    ... w  w  w  w  s
                 \ /
                  s
               \ /
                s
             \ /
              s
           \ /
            s
```
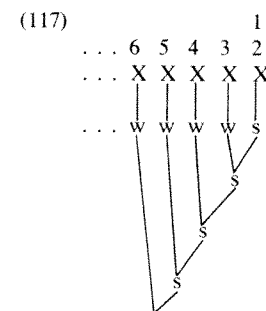
This pattern does not occur within the word, except as the result of successive affixation of #-prefixes (which is a relatively rare occurrence); it is common enough, however, in phrasal collocations:

(118) a.
```
            7      8          10
            1 2   3 4         9
            poly vinyl chloride
            s w   s w         5 6
             \ /   \ /        s w
              w     w          \ /
               \   /            s
                w              /
                 \            /
                  \          /
                   \        /
                    s
                     \
                      R
```

b.
```
            1         2  3   4     5
            John's three red shirts
            w         w  w   s
             \         \ /  /
              \         s  /
               \         \ /
                \         s
                 \       /
                  \     /
                   R
```

c.

```
                       12
       9        10     11
    1 2   3    4   5   6 7 8
    reports of threats of vi olence
     |  | |   |   |   |   ||
     w  s w   s   w   s   ww
        \ /    \ /     \ /
         w      w       s
          \      \     /
           \      \   /
            \      \ /
             \      s
              \    /
               \  /
                s
                 \
                  \
                   \
                    s
                     \
                      \
                       R
```
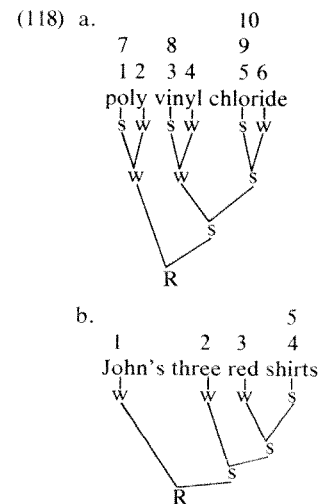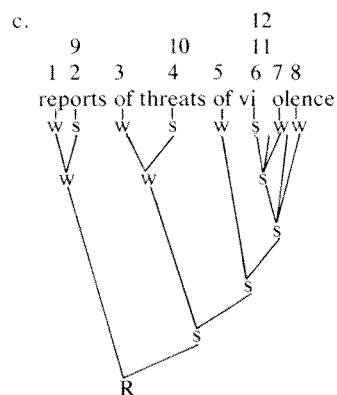
Here again, the RPPR requires only that the strongest stress be metrically superior to all the others. There is, however, a tendency to strengthen one of the otherwise metrically equal positions. Thus most people pronounce *polyvinylchloride* with *vinyl* less stressed than *poly*; it is interesting that they also treat this word as if its constituent structure were [[polyvinyl]chloride], which would produce such a pattern of relative stresses as a matter of course:

(119)

```
                  12
       10         11
    7  8       9
    1 2 3 4    5 6
    poly vinyl chloride
     |  | |  |   |  |
     s  w s  w   s  w
      \ /  \ /    \ /
       s    w      s
        \   |     /
         \  |    /
           \w   /
             \ /
              R
```
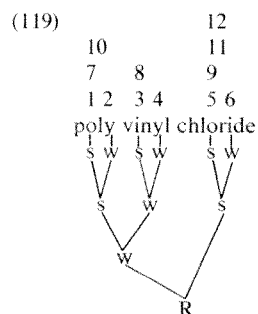
In *John's three red shirts*, one might well strengthen *three*:

(120)

```
                    7
            5       6
        1       2 3     4
        John's three red shirts
          |     |   |    |
          w     w   w    s
                     \  /
                      s
                     /
            \       /
             \     s
              \   /
               \ /
                R
```

The "extra" grid element, labelled 5 in the diagram above, is perfectly consistent with the RPPR, although not required by it. It has the effect of breaking up a sequence of otherwise equal "upbeats". The break-up of equal stresses into some kind of alternating pattern seems very natural in the case of constituent-initial sequences, "upbeats" so to speak, but quite unlikely in the case of posttonic sequences. Our theory contains no left–right asymmetry, and therefore does not predict this distinction. One possible alternative is to define a kind of partial constituent structure on metrical grids, each unit extending from a given element to the next hierarchically equal element. These units would be in a sense analogous to the metrical "feet" 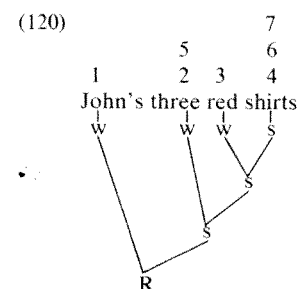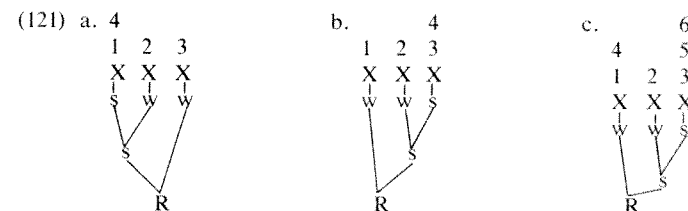of writers like Abercrombie, although the particulars of this proposal are rather different from his. According to this principle, (121a) would consist of only one "foot", while (121b) would consist of three and (121c) of two:

(121) a.

```
        4
     1  2  3
     X  X  X
     |  |  |
     s  w  w
      \  \ /
       \  /
        \/
        S
        |
        R
```

b.

```
        4
     1  2  3
     X  X  X
     |  |  |
     w  w  s
      \  \ /
       \  /
        \/
        S
        |
        R
```

c.

```
            6
     4      5
     1  2  3
     X  X  X
     |  |  |
     w  w  s
        \ /
         \
          S
          |
          R
```

In a case like *John's three red shirts,* making *three* metrically stronger than *John's* and *red* would then cause the new "foot boundary" to fall on the major constituent break, as well as breaking up the sequence of upbeats. If "foot"-like metrical units can be shown to be a phonetically useful concept, then this line of inquiry would become quite appealing.

Note that some of the cases for which so-called "readjustment rules" have been devised have the right-branching [ws] pattern just discussed; e.g. (122):

(122)

```
                                    14
        11              12          13
   1  2    3  4    5  6    7  8    9   10
   the cat that ate the rat that stole the cheese
    w  s   w  w    w  s   w  w    w   w   s
```
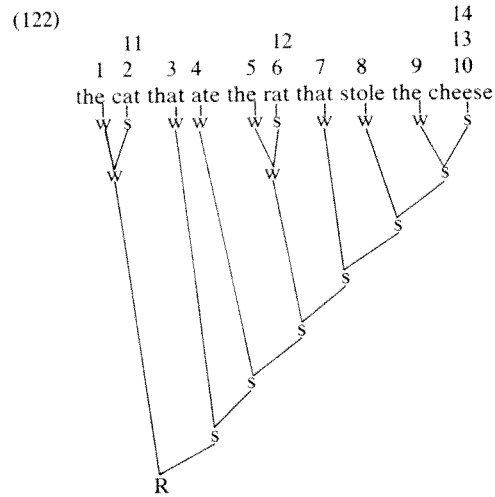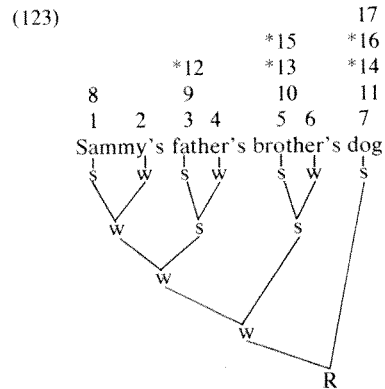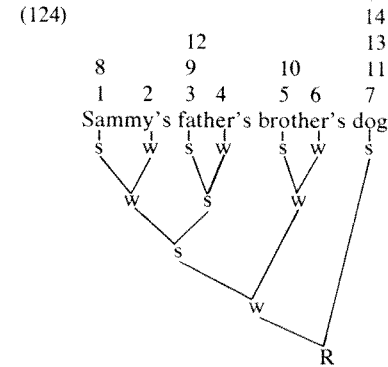
Operating directly on the syntactically-motivated surface structure, our system provides a counterpart to the even prenuclear stress pattern that the readjustment rule is designed to produce.[19]

The case of a left-branching structure in which each constituent has the relative prominence pattern [ws] arises only at the phrasal level. Strings of possessives are a common example:

(123)

```
                                 17
                         *15    *16
                 *12     *13    *14
        8         9       10     11
   1    2     3  4    5   6       7
   Sammy's father's brother's dog
   s    w    s   w   s   w       s
```

Such configurations produce a rather unlovely "triangular" grid, which is the equivalent of the 4 3 2 1 stress pattern that they receive by cyclic reassignment of [1 stress]. Since the grid required in (123) above is so clash-ridden, a judicious application of Iambic Reversal is motivated, producing (say) the pattern in (124) below:

(124)

```
                                 14
                 12              13
        8         9       10     11
   1    2     3  4    5   6       7
   Sammy's father's brother's dog
   s    w    s   w   s   w       s
```

This is another case of cases in which readjustment rules have been employed to "even out" the prenuclear sequence. We are able to obtain a rather plausible picture of syllabic stress levels, in such cases, without the necessity of recourse to constituent-structure modifications.

The last example we will use to explore the metrical grid's picture of syllabic stress levels is the well-known distinction between the two parsings of sequences like *American history teacher*. For the meaning 'teacher of American history', parsed [[American history] teacher], cyclic reassignment of [1 stress] gives the pattern *American history teacher*, while in the meaning 'American teacher of history', parsed [American [history teacher]], the pattern *American history teacher* is produced. It is often observed that these two parsings do not really seem to be stressed differently, but are phonetically distinguished (if at all) only by a (pseudo-) pause at the constituent boundary. Therefore, it is to our theory's credit that these two cases are given identical grid alignments:

---

[19] Note, incidentally, that the normal phrasing *this is the cat/that ate the rat/that stole the cheese* is expected, independent of any constituent-structure readjustment, due to the fact that Š boundaries in general require intonation breaks.

(125) a.

b.

3.6. *Discussion of Previous Work*

This article is based principally on ideas about the representation of stress patterns set out in Liberman (1975), a work that attempted primarily to construct a theory of English intonational patterns, and to predict the effect of stress and constituent structure on the alignment of such tonal sequences with linguistic material. Our debt to other descriptions of English stress should be obvious; in particular, the phonological system of SPE, and subsequent works in the same tradition, forms the background and foundation of our research.

It has been brought to our attention that some aspects of our proposal are prefigured in Rischel (1964; 1972) and Martin (1972).

Rischel (1972) discusses stress assignment in Danish compounds, and sketches a theory that assigns relative prominence as a constituent-structure relation. He notes that stress assignment can be accomplished without cyclic application in such a theory. He also points out the existence of an algorithm, similar to our (12), for deriving stress numbers from a relational representation, although he expresses some dissatisfaction with the result. He observes the existence of some cases analogous to those we have discussed under the heading of the Rhythm Rule, cases comparable to those Kiparsky cites for German, in which secondary stress is shifted rightward away from primary stress. However, he attributes the effect, in the examples he gives, to the operation of various constituent-structure readjustment rules, although his proposals are quite tentative and he abandons the attempt without reaching a real conclusion.

He does not attribute any role (in the assignment or representation of stress) to hierarchical structure within the word. Nor does he postulate anything comparable to our metrical grids—instead, he argues (1972, 224) that

> indications of graded stresses are linguistically significant only indirectly, namely by defining types of constructions. Hence it seems to me superfluous to introduce such representations if the constructions themselves contain sufficient information without being transformed into representations with graded stress . . . the expression "reduction of nth order" should be replaced, e.g., by information referring to pitch jumps and temporal relations.

We disagree, believing that patterns of stress are a phonetically real and linguistically significant aspect of speech. We are all for "information referring to pitch jumps and temporal relations," but we question whether such information can be predicted, in the general case, without postulating the kind of partial ordering of syllabic stress levels that is produced by our Relative Prominence Projection Rule, or for that matter by many previous descriptions.

Rischel refers to a 1964 paper by himself, and a 1948 paper by Fischer-Jørgensen, which he reports to provide a treatment of English, in the first case, and an "outline of the hierarchical concept" in the second. We have been unable to obtain copies of these earlier works. Based on Rischel's description, however, it appears that Fischer-Jørgensen deserves credit for initiating the idea of representing relative prominence in terms of a constituent-structure relation.

Martin (1972) presents a stirring polemic in favor of "rhythmic (hierarchical) versus serial structure in speech and other behavior." He argues (p. 488) that "sequences of sounds, speech or otherwise . . . possess hierarchical organization, that is, a coherent internal structure." He sketches a formalism for representing "rhythmic patterns" as tree structures with the pattern [1 0] assigned to their branches. These everywhere trochaic patterns define "accent level" on their terminal elements by the principle (p. 490): "Read up the tree, convert the binary number to decimal number, and add 1."

In the proposed application to speech, the relationship between the constituent structure of Martin's rhythmic hierarchies[20] and the constituent structure of linguistic material is arbitrary, so that for example *Old MacDonald had a farm* is assigned the structure (126):

(126)

Old MacDonald had a farm ϕ

Martin gives two rules for establishing the accent pattern of a given rhythmic hierarchy: the "accent rule", which assigns the pattern [1 0] to all nodes of the tree, and the "terminal rule", which "applies to nonrepeating or terminal sequences like musical cadences, as well as to a variety of speech units" (1972, 492). Martin defines the "terminal rule" as: "First apply the accent rule to the tree to obtain the sequence of accents, then reverse the position of accent levels one and two" (1972, 492). Note that this does not alter the pervasive trochaic pattern of the tree, but simply metathesizes the two greatest terminal "accents" (= stress numbers).

The method of application of this apparatus to speech is indicated primarily by reference to a small number of simple examples, and depends crucially on "the syllable marked for primary accent" being determined in advance, by some other principle. Martin (p. 493) mentions the NSR as one possible such principle, and also "context, mispronunciation, 'foreign accent,' regional dialects, the use of emphasis or contrast, and so on." The end result, it appears, is to force all phrases into a sort of procrustean bed consisting of two bars of 2/4 time, with the downbeat of the second bar aligned with the "syllable marked for primary accent." The procedure consists of (1) constructing the "minimal tree required;" (2) applying the accent rule; (3) applying the terminal rule; (4) mapping the resulting sequence of accent levels "onto the syllable strings such that accent level one corresponds to the syllable marked for primary accent." As Martin observes, the "result of this manoeuvre . . . places relative accent level" on the non-primary-stressed syllables of the string. But unless the examples are chosen with care, considerable violence will be done to the true pattern of secondary stresses; for

example, upon application of what we take to be his rules, *the big dog* emerges as *the big dog*.[21]

Although we are in sympathy with Martin's aims, his system seems simplistic as a description of rhythmic patterning in general, and of limited empirical value in the description or generation of English stress patterns.

4. Conclusion

We have argued in this article for a substantial revision in the theory of phonological representation. The phonetic–phonological level of linguistic description has been commonly conceived to provide only for simple concatenation of its basic units—segments and boundaries. We believe, however, that many of the essential characteristics of stress systems can only be insightfully described in a theory that recognizes hierarchy as a mode of phonological organization. In particular, we propose that relative prominence is defined *between* phonological constituents, rather than *on* them with a "metrical grid", which can be thought of as a hierarchy of intersecting periodicities (rather than constituents), the structure of which is relevant to phenomena of rhythm and timing.

Construing relative prominence in this way leads to a number of rather unexpected results. In earlier theories, rules of prominence assignment like the NSR, CSR, and Schane's Detail Rule had to be equipped with essential variables, so that they could have the power to search through unlimited stretches of string in order to find a 1-stressed vowel. In the present theory, such rules are rendered as very local conditions on the labelling of nodes that are strictly adjacent in metrical structure. The metrical versions of the CSR and NSR furthermore apply to their entire domains simultaneously, rather than pursuing a cyclic path through them, as the SPE—or "linear"—versions must. A theory that has variables and cyclic application allows for a tremendous range of complex rules and rule interactions, as *syntax* shows us. Phrase phonology does not exhibit this complexity, and the present theory excludes it in principle by allowing rules to be local and simultaneous rather than cyclic and long-distance. The possibility of this restriction is a direct reflex of the mode of representation we have adopted.

Extending the relational idea from the phrase level, where the relevant constituency is independently determined by syntax, to the word and below, we argued that

---

[20] Which is essentially the constituent structure implied by the concept of metrical subdivision in music, as Martin points out.

[21] It may be that Martin intends the alignment process to be guided by the linguistically observed pattern of secondary stresses, as well as by the location of the "syllable marked for primary accent." This interpretation would deny the "rhythmic hierarchies" any role at all in the assignment of stress patterns, however, which does not seem to be Martin's position.

stress rules like the ESR function to confer the prosodically significant structure on rows of syllables. Because of this, disjunction is seen to be a natural and necessary concomitant of the application of stress rules, rather than an arbitrary property of certain notations. Furthermore, from this perspective of function, the iterativity of the ESR becomes quite intelligible, given that every syllable must be put in its metrical place.

The structures induced by the ESR, motivated primarily by considerations of relative prominence assignment, also allow a considerable simplification in the rules of vowel reduction. Because the notion "weak constituent" is equally applicable to pre- and poststress positions, we were able to eliminate the special rule of Poststress Reduction merely by stating the prestress rule in its simplest form. We also found that the metrical conditioning of the English Destressing Rule was of the most elementary sort, easily subsumed under the general restriction that stressless vowels occupy only *weak* positions. This interpretation of the relationship between metrical strength–weakness and [+stress] plays a multifarious role in the present theory, constraining the application of such diverse processes as prominence assignment (tree-building algorithm (57), LCPR (96)), destressing (EDR (70)), and readjustment of prominence (Iambic Reversal (111)).

The phonological constituent structure required to support a simple mode of assigning prominence patterns also proved to be basic to expressing their mutations under rhythmic influence. The rule of Iambic Reversal, local in environment, simultaneous in its application, describes the essential form that rhythmic stress shift assumes in English. The factors that encourage the application of this optional rule are, however, of a rather different kind from those at play in the initial construal of relational patterns. The basic notion of a motivating "stress clash" is not one that is perspicuously definable on constituent structure. To model it, and its desirable opposite "alternation of stress", we formalized a second kind of hierarchy, a stratified grid with a notion of metrical strength intrinsic to it. When material is associated to the grid via the Relative Prominence Projection Rule (104), which is based on the strong–weak relation between constituents, stresses that are intuitively "clashing" appear adjacent at the same grid level. Judicious application of Iambic Reversal eliminates these adjacencies. Other factors that appear to influence Iambic Reversal, such as interstress distance and the status of "upbeats", are directly represented in the grid formalism.

Our proposal entails an enrichment of phonological theory. But it is strengthening, rather than a dissipation of our understanding. By removing from linear representation those aspects of stress and rhythm that are essentially hierarchical in nature, and providing them with a truly appropriate formal characterization, we lay the groundwork for a greatly simplified and narrowly restricted theory of stress phenomena and prosodic processes.

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Remarks
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Replies

On Semantic and Distributional Properties of Sentential Adverbs*

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In this article, I will present some comments on the description of sentential adverbs proposed in the literature and will try to show that it does not satisfactorily take into account either the semantic or the surface distributional properties of adverbs. Let me first discuss the semantic aspects of the existing descriptions.

In recent linguistic literature, mention is often made of some logical forms[1] that are supposed to represent the meanings of sentences, but rarely can we find explicit statements as to what kind of logical language is presupposed. Montague's grammar is evidently one of the exceptions in this respect, but it covers only a small part of English and adverbs are not given much attention.[2] Thomason and Stalnaker (1974) have presented a semantic theory of adverbs, but they have distinguished only two classes of adverbs: sentence adverbs and predicate adverbs. Their semantics is based on intensional logic; hence, propositions are conceived of as intensions of sentences, and singulary propositional functions as intensions of predicates. All sentence adverbs denote functions taking propositions into propositions, and all predicate adverbs denote functions taking singulary propositional functions into singulary propositional functions. No other classes of adverbs have been distinguished. It is not the case, however, that all sentential adverbs can uniformly be described in such a way. I will therefore take as a starting point Jackendoff's classification of adverbs (Jackendoff (1972)), which is correlated with semantic interpretation rules and which is more exhaustive (although not rigorously formalized). It seems to me that Jackendoff's principle of correlating semantic properties of adverbs with their surface distributional classes—if pushed to its

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* This is an extended version of a paper presented at the CLA Meeting, Edmonton, 1975.

[1] Statements to this effect appear in many papers on generative semantics (by Lakoff, McCawley, and others), as well as in recent papers on generative syntax. See, for instance, Dougherty (1975) or Chomsky (1974), where we find the following passage (pp. 5,6; emphasis mine):

> ... it seems possible to give an organized and systematic account of the syntax of the relevant expressions in terms of reasonably well-motivated principles of grammar, and the same may be true of the set of "readings" or correlates in *some logic.*

[2] For the treatment of adverbs, see Montague (1970).