A11

Bruce Hayes

The Phonology of Rhythm in English

Much recent research in the phonology of stress has centered on the English Rhythm Rule, which is responsible for stress alternations such as those in (1):

(1) fourtéen – fòurteen wómen
Mississíppi – Mìssissippi législature
seventy-séven – sèventy-seven séals

The rule is of interest as a purely analytic problem, because it is difficult to formalize in a way that does justice to the facts. But it is of even greater interest because of the theoretical problems it raises. For example, the Rhythm Rule has figured heavily in the controversy over the representation of stress. There is a fair consensus in the field that the segmental approach to stress proposed in SPE (Chomsky and Halle (1968)) is inadequate, and that stress requires some kind of suprasegmental representation. But the form of this representation is very much in doubt: various researchers advocate "metrical trees," "metrical grids," and other representations, as well as theories that mix the two. Another question the rule raises is that of defining the role of rhythm in stress. Pretheoretic descriptions of the phenomenon typically invoke rhythmic pressures, attributing it to a need to alleviate "clashing" stresses or achieve "alternating rhythm." If these intuitions are right, one is led to wonder just what rhythm is, what formal model could describe its structure, and through what mechanism it influences the patterning of stress.

This article is an attempt to resolve these questions with a fairly detailed theory of rhythmic phonology. My analysis uses mostly English data, and builds on core ideas presented in Liberman and Prince (1977). It leads to the following specific theoretical conclusions:

(a) Separate representations are required for rhythmic structure and for linguistic stress. These representations should be identified with Liberman and Prince's metrical grids and metrical trees, respectively. The two representations will be shown to play sharply distinct roles in rhythmic phonology.

(b) It is accordingly mistaken to suppose that a theory incorporating both grids and

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trees is redundant. The argument here will be not just conceptual, but also empirical: there exist cases that pose serious problems for theories that propose to eliminate the grid (for example, Kiparsky (1979)), as well as for theories that would eliminate metrical trees (notably Prince (1983), Selkirk (forthcoming)).

(c) The notion of "stress clash" proposed in Liberman and Prince's work plays no role in rhythmic phonology. Instead, the rules of the phonology refer to specific rhythmic targets, encoded in "rules of eurhythmy." Some tentative work suggests that these rules may be universal or subject only to minor variation across languages.

(d) Arboreal rules are subject to a general constraint on how they may analyze tree structure. Like similar constraints in syntax, the constraint I will propose allows idiosyncratic information to be factored out of individual rules, thus avoiding overgeneration and increasing the explanatory adequacy of the theory.

The exposition is organized as follows. I first review the essentials of Liberman and Prince's analysis, showing how it fails in a fair number of cases. I then propose a revised conception of the rhythmic target of the stress rules, showing how it alleviates the earlier difficulties. In the second half of the article, I address the issue of whether a grid-and-tree theory is redundant, developing a fairly elaborate argument in favor of a theory in which trees represent stress; grids rhythmic structure. In the final section, I summarize the results.

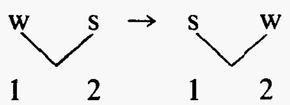
1. Stress and Rhythmic Targets

1.1. Liberman and Prince's Account

Liberman and Prince (1977, hereafter LP) propose a system of rules constructing metrical grids from metrical trees, along with an explicit formulation of the Rhythm Rule. Taken at face value, their system performs two functions: it accounts for native intuitions of syllable prominence more accurately than the *n*-ary [stress] feature of SPE, and it predicts when the Rhythm Rule will apply. LP programmatically suggest additional functions of the grid, but their suggestions are not precise enough for empirical testing. In this section, I will review LP's rules, showing that, as they stand, they cannot account for the full range of facts. I will then propose a more articulated approach to the problem.

LP propose that a metrical derivation begins with the construction and labeling of metrical trees. Later work (e.g. Selkirk (1980), Hayes (1982)) has suggested substantial modifications of these tree construction rules. But for purposes of rhythmic phonology, the various versions are largely equivalent, so that in what follows I will mostly employ the notationally concise LP-style representations. Metrical trees permit a very simple statement of the Rhythm Rule, as shown in (2):

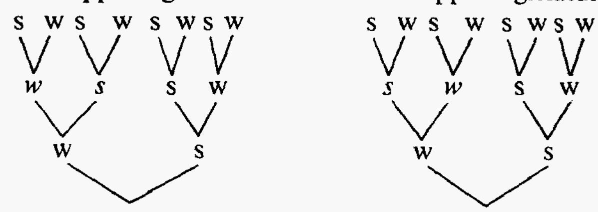
(2) *Rhythm Rule* (LP version)



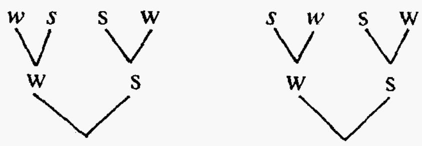
where 2 is not the strongest element of its phrase

The rule applies to forms like *Mississippi legislature* and *Cornell hockey* as follows:

(3) a. Mississìppi législature → Mìssissippi législature



b. Cornèll hóckey → Còrnell hóckey



However, the simple arboreal formulation of (2) fails to do justice to the complexity of the facts. Although applying the rule would be the norm in examples like (3), cases like *Mississìppi legislátion, Cornèll athlétics* would usually not undergo it, even though they contain the appropriate trees. It is to capture distinctions of this sort that the metrical grid comes in. Grids are derived from tree structure by a set of rules that may be stated explicitly as follows:

(4) *Grid Construction* (from LP, 315–316, 322)

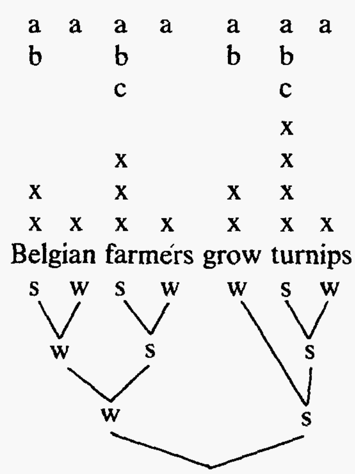
a. As a place marker, assign every syllable a mark on the lowest level of the grid.

b. Assign a mark at level two to the strongest syllable of every phonological word.

c. Assign sufficient additional marks so that the strongest syllable of every constituent labeled S has a higher grid column than the strongest syllable of its weak sister.

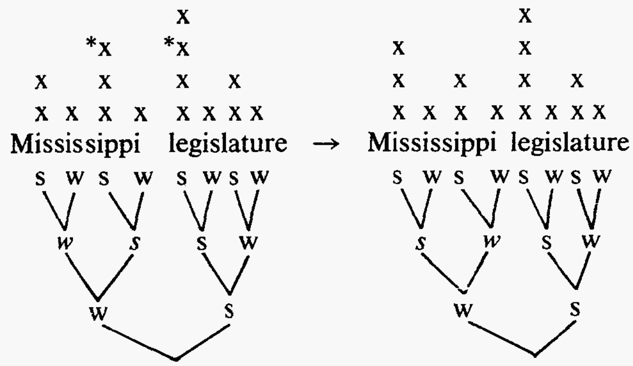
These rules are illustrated in the following sentence, where I have indicated with letters the subrules that have applied in creating each column.

(5)

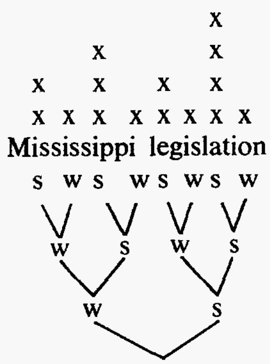


The crucial additional condition on the Rhythm Rule is based on the grid: the rule applies preferentially when it alleviates a *stress clash*, defined as two marks adjacent on their row, with no intervening mark on the immediately lower row. This condition distinguishes the relevant cases. In the examples that follow, stress clashes are marked with asterisks, and relabeled nodes are italicized.

(6) a.

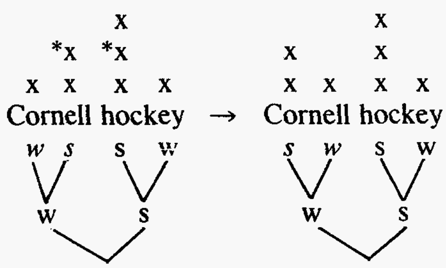


b.

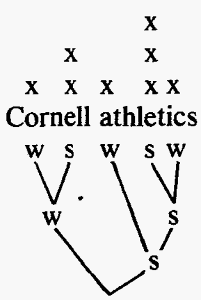


(no clash)

c.



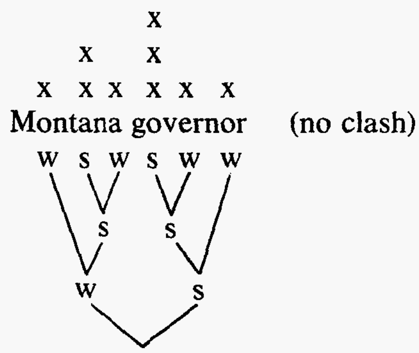
d.



(no clash)

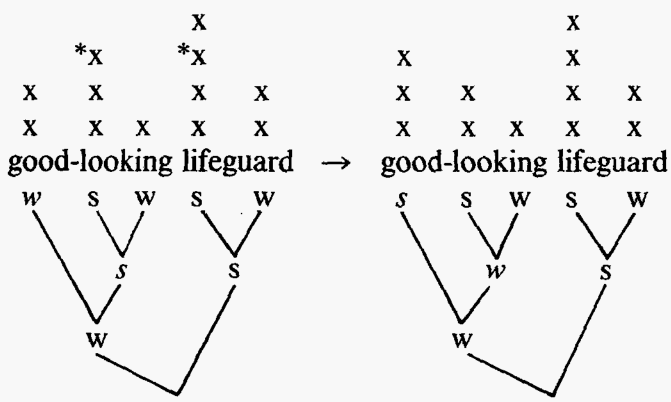
The notion of stress clash also correctly predicts that words with the stress pattern of *Montana* will not ordinarily undergo relabeling:

(7)



In addition, the stress clash theory provides motivation (beyond mere rhythmic intuitions) for rule (4b) of the grid construction algorithm, as shown by examples like *gòod-looking lífeguard.* In (8), the extra mark that rule (4b) places on the syllable *good* causes rule (4c) to promote the column of *look* into a position that clashes with *life*. The Rhythm Rule accordingly applies, even though *good-looking* has the same tree shape as *Montana*, under (7).

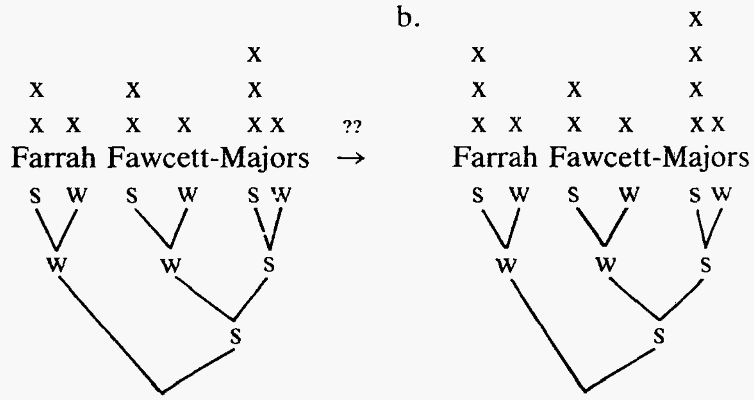
(8)



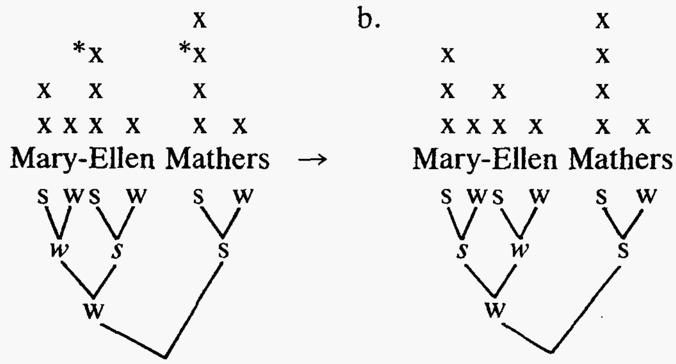
Further arguments for rule (4b) may be found in Hayes (1983).

LP's work contains a second rule of rhythmic adjustment, although they do not state it explicitly. This rule is based on the fact that in right-branching structures that are labeled *wws*, an alternating prominence pattern usually develops that cannot be derived by relabeling the tree. For example, the stress pattern of *Farrah Fawcett-Majors*, under (9), displays the same sort of rhythmic alternation found in the left-branching form *Mary-Ellen Mathers*, under (10). But it is only in the left-branching case that alternation can be achieved by the Rhythm Rule. The rules stated so far provide no way of converting the predicted form (9a) into the correct output, (9b).

(9) a. b.



(10) a. b.



In fact, this problem is quite general. As (11) shows, it is easy to construct pairs of examples that differ in labeling and direction of branching just like (9) and (10), yet are homophonous:[1]

```
           2     3     1                2     3     1
(11) a.  [sea-green] soup          = see [green soup]
            2      3      1              2      3     1
     b.  [twenty-eight] steaks     = twenty [ate steaks]
            2        3       1           2       3        1
     c.  [twenty women's] jackets  = twenty [women's jackets]
```

An additional rule is thus needed to induce rhythmic alternation in the right-branching cases. LP do not formalize this rule, but their article implies something like (12), which I will call *Beat Addition*, adapting a term from Selkirk (forthcoming).

(12) *Beat Addition*

Freely add additional marks to the grid columns, provided the relative prominence relations specified in the tree are preserved.

By virtue of this rule, grid (9a) may be amplified to produce (9b), since the additional marks that (9b) contains do not violate any of the tree labelings. Notice that the rule achieves "prosodic homophony" with *Mary-Ellen Mathers*. Similar results hold for the examples of (11).

The Beat Addition rule (12) seems precise enough as far as its structural *change*

[1] No theoretical status should be attributed to the numbers in the examples; they are only a shorthand notation for prominence rank.

goes, but it includes no structural *description;* that is, it does not say which syllables should be amplified. LP's remarks on this matter (p. 327) are interesting but programmatic. I will try to provide an explicit account below.

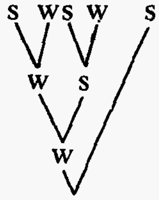
1.2. Some Arguments against LP's Rules

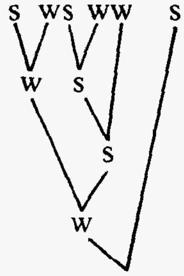
LP's system predicts that phrases eligible for the Rhythm Rule will fall into two classes: those containing stress clashes, in which relabeling is preferred; and those lacking them, in which the basic stress contour is normally retained. This dichotomy is appealingly simple, and it would be a significant result if true. But a fair range of examples suggests that stress clash is neither a necessary nor a sufficient basis for predicting when the Rhythm Rule will apply. A simple case of this sort involves comparing utterances having originally disyllabic interstress intervals with examples having originally trisyllabic intervals:

```
             2   3      1                 2   3        1
(13) a.  Mississippi Mabel          b.  ?Minneapolis Mike
          2    3       1                  2    3        1
         Punxatawny Pete                ?Passaconaway Pete
         2  3       1                    2  3         1
         analytic thought               ?analytical thought
          2  3      1                     2  3        1
         diacritic markings             ?diacritical markings
              2        3      1                2   3      1
         the Passamaquoddy verb         ?the Potawatomi verb
         2  3       1                    2   3         1
         Alabama relatives              ?Alabama connections
         2    3    1                     2    3         1
         European history               ?European historian
         2   3      1                    2    3         1
         Oklahoma congressman           ?Oklahoma congressional district
           2   3       1                   2   3           1
         two thousand one               ?two thousand and one
```

It seems clear that the trisyllabic cases are more resistant to relabeling. By LP's theory, there should be no difference between the two cases, since both involve a stress clash as their rules define it:

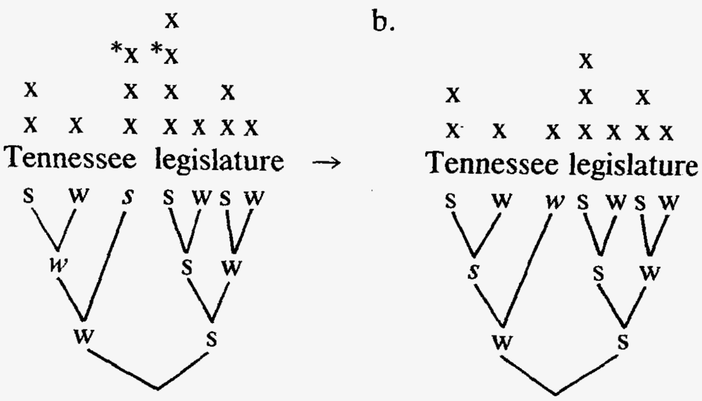
```
(14) a.            x              b.             x
             *x   *x                       *x     *x
          x   x    x                  x  x        x
          x x x x  x                  x x x x x   x
          analytic thought            analytical thought
          s ws w   s                  s ws ww     s
```





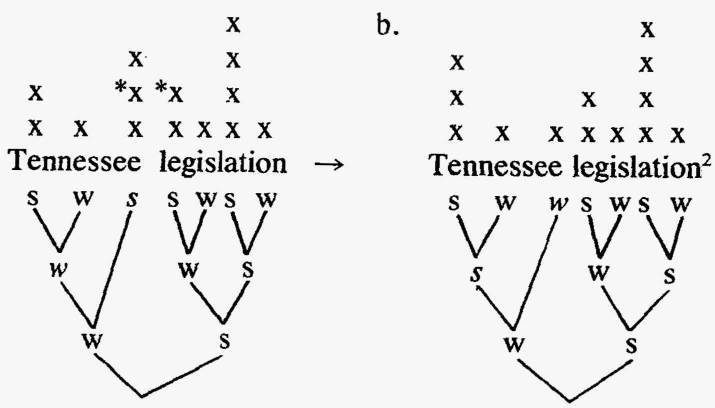
There are other forms that contain a clash in LP's sense, yet are resistant to relabeling. Consider the contrast between *Tènnessee législature*, where rhythm is the norm, and *Tennessèe legislátion*, where the original stressing is usually retained. The first example is a straightforward case of clash resolution through tree relabeling:

(15) a. b.



However, under LP's theory there is no reason why the same adjustment should not take place in *Tennessee legislation*, which also suffers from a stress clash:

(16) a. b.



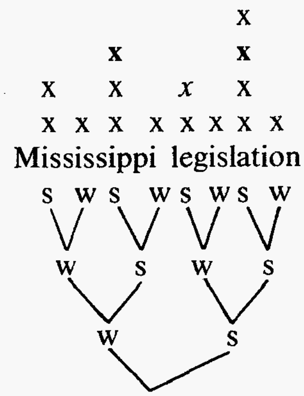
One remedy would be to restrict the definition of stress clash to cases in which the second column involved is higher than the first. As we shall see, this proposal is untenable.

Another class of cases in which stress clash fails to induce relabeling can be con-

[2] The additional grid mark on *Tennessee* would be derived by Beat Addition.

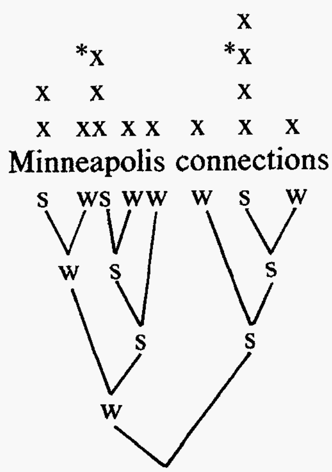
structed as follows. Consider first the grid of *Mississippi legislation:*

(17)



By LP's account, what keeps the boldface grid marks in (17) from clashing is the italicized "intervener" stress on the immediately lower level. By a judicious shift of word boundary, we can remove this intervener while keeping all else constant, as in (18):

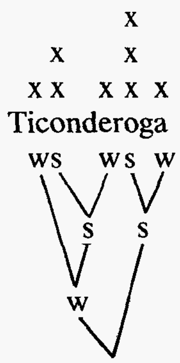
(18)



This introduces clash, but surely no greater propensity to undergo the Rhythm Rule. Other pairs of examples behave the same way: cf. *Punxatàwny celebrátions* vs. *Passacònaway convéntions, achromàtic aberrátion* vs. *mathemàtical invéntions, sympathètic Presbytérians* vs. *evangèlical Repúblicans.*

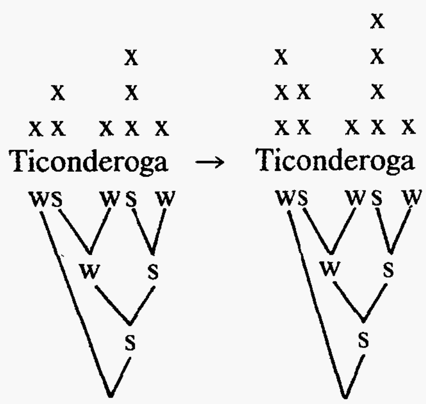
Words like *Ticonderoga* (also *Ompompanoosuc, Dodecanesus*) pose yet another problem for the theory of stress clashes. These words have two possible stress contours, 32010 and 23010. I follow Kiparsky (1979) in assuming that this results from a property of English tree construction: above the foot level, the direction of branching is free when not dictated by morphological structure. This derives the 3–2–1 version straightforwardly, given the rules for English word tree labeling (for details, see Hayes (1982)):

(19)



The difficulty lies in how the right-branching tree is to be interpreted as a 2–3–1 pattern. Kiparsky assumes that this is to follow from LP's algorithm for translating trees into SPE stress numbers, in which the less deeply embedded of two weak constituents is taken to be more prominent (see LP, 259). However, this algorithm has been shown to be wrong both by LP and by Selkirk (forthcoming). More plausibly, the 2–3–1 contour derives from Beat Addition, as in (20):

(20)

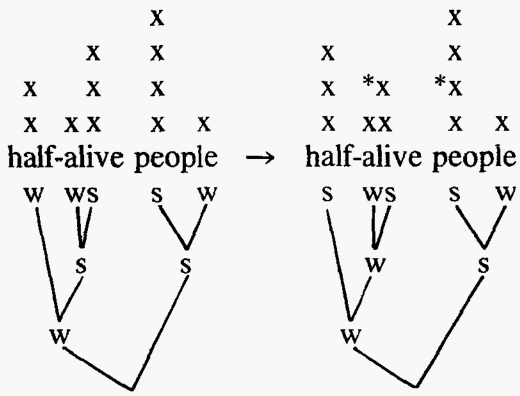


The crucial question is why the shift of (20) should count in any way as a rhythmic improvement. Under LP's theory, it clearly does not, since it only adds a stress clash.

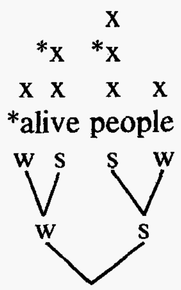
Further evidence can be found in the work of Bolinger (1965b). Bolinger's argument is based on the well-known inability of adjectives beginning in stressless *a-* to occur prenominally, as in **alìve péople*, **aslèep stúdents*. The restriction is due historically to the origin of these adjectives as prepositional phrases, but can be shown to be synchronically productive by its extension to *a-* adjectives not descended from PPs, as in *afraid, aghast, averse*. The interesting point is that in adjectival compounds, such as *hàlf-awake péople, sòund-asleep stúdents*, the restriction is abandoned. Bolinger argues that the historical pressure to retain the restriction is prosodic. His assumption is that rhythmic pressures act as a shaping force in linguistic change, disfavoring innovations that would systematically create dysrhythmy. Under this account, the *a-* adjectives are predicted to acquire prenominal subcategorization only reluctantly, since they would normally produce a clash in that position. In contrast, the compound forms are always able to avert dysrhythmy by undergoing the Rhythm Rule. This option is not available to bare *a-* adjectives, because the rule is unable to retract stress onto an entirely stressless syllable (see LP, 265, 290; Prince (1980, 523)).

Bolinger's prosodic explanation seems intuitively plausible. Note, however, that LP's theory will not accommodate it. According to LP's definition, the degree of stress clash in the output grid of *hàlf-alive péople* is the same as that of the unacceptable **alìve péople:*[3]

(21) a.



b.



The collective weight of this evidence, then, is that the notion of stress clash is not doing the job it was intended for. It is too strong, in that it incorrectly marks certain examples as needing adjustment; and it is too weak, in that it will not in all cases distinguish between varying propensities to relabel.

1.3. An Alternative to Stress Clashes

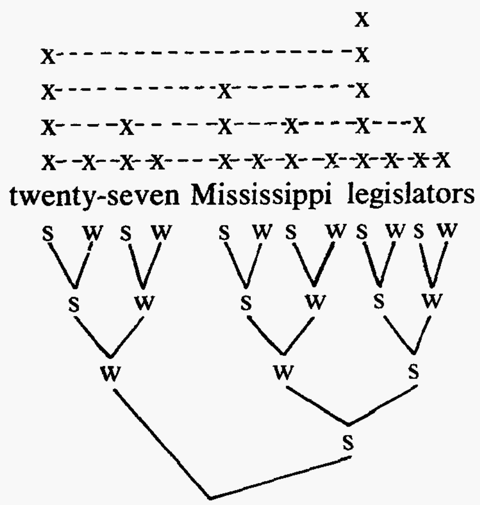
The clue to an improved account, I believe, lies in interpreting the grid in the way suggested at the beginning of this article: as a representation purely of rhythmic structure,

[3] The fact that the main stress column of (21a) has four marks, while that of (21b) has only three, makes no difference. (21b) is not improved if we substitute for *people* a contrived expression (for example, *swámp alligators*) having a main stress column of height four.

rather than of linguistic stress. I propose that certain rhythmic structures are designated as highly valued, or "eurhythmic," and that the propensity of the Rhythm Rule to apply is determined by how much it increases the eurhythmy of the text.

There is good reason to suppose that grids embody rhythmic structure, beyond its strictly linguistic manifestation. For example, Jackendoff and Lerdahl (1980) argue that a formal theory of music should include grids as the representation of rhythmic structure. In Hayes (1983) I propose that the rhythmic structure of poetic meters should be represented with grids as well. Grids also neatly capture our intuitive notions of rhythm. The most basic feature of rhythm is repetition of beats at roughly equal intervals. For example, in *twenty-seven Mississippi legislators*, the most basic beat is set by a rapid sequence of twelve evenly spaced syllables. What makes rhythm interesting, however, is that several interbeat intervals may occur simultaneously. In the example just cited, the hearer may perceive disyllabic intervals separating the beats *twen . . . sev . . . Mis . . . sip . . . leg . . . lat*. Quadrisyllabic intervals also occur, separating the beats *twen . . . Mis . . .*, and *leg;* and many hearers will perceive an octosyllabic level encompassing the beats *twen . . . leg*. The intervals obey the law that any beat taking part in longer intervals necessarily participates in all shorter intervals—to use LP's apt phrase, rhythm involves a "hierarchy of intersecting periodicities." Observe now that all of these intuitions are reflected quite clearly in the grid derived for this text by LP's rules:

(22)

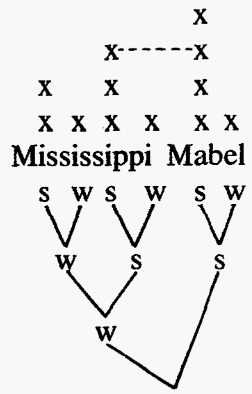


The rows of the grid correspond to the interbeat intervals described above, and the height of each column reflects stress prominence, as a result of the grid construction rules. Under grid theory, the law that stronger beats participate in longer intervals is reflected in the formalism.

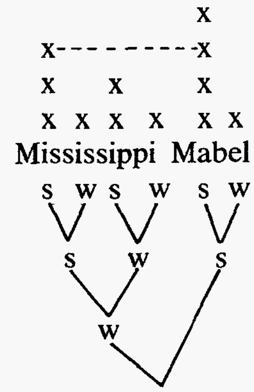
The strategy pursued here, then, is as follows: I am assuming that grids represent rhythmic structures, and that they are projected from arboreal stress representations by rules (4a–c). The Rhythm Rule applies more readily when as a result the text receives a more highly valued rhythmic structure. The value of a rhythmic structure is computed from its grid by a set of rules I will call *rules of eurhythmy*. From this perspective, the problem of predicting the likelihood that the Rhythm Rule will apply consists in defining the eurhythmy rules, and it is to this task that I now turn.

From the preceding discussion, a reasonable hypothesis would be that the eurhythmy rules require equal spacing of grid marks at all levels. This comes close to the truth, I believe, but other factors enter in as well. In particular, eurhythmy requires a *particular spacing of marks* to be found at some level of the grid. This interval appears to center around four syllables, with greater dysrhythmy at greater divergence. We can see this by comparing a number of cases. In *Mississippi Mabel*, relabeling is clearly the norm—a quadrisyllabic interval is preferred to a disyllabic one, as (23) shows.

(23) a.

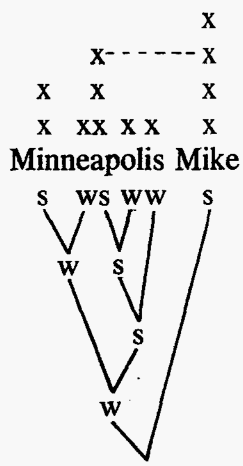


b.

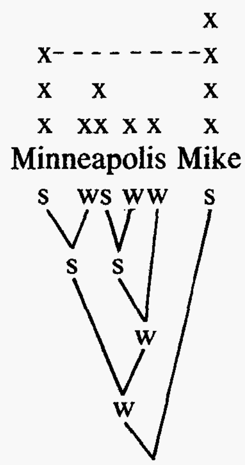


But in *Minneapolis Mike*, shown with its grid in (24), there is little pressure to relabel—a pentasyllabic interval is no improvement over a trisyllabic one if four syllables is the target distance.

(24) a.



b.



These cases in fact form part of a larger continuum: as the interstress interval of the input form is decreased from the ideal of four syllables, the propensity to apply the Rhythm Rule correspondingly increases. This can be perceived by reading the chains of examples below consecutively.

(25) a. Tennessèe abbreviátions — Tènnessee abbreviátions
Tennessèe legislátion — Tènnessee legislátion
Tennessèe connéctions — Tènnessee connéctions
Tennessèe rélatives — Tènnessee rélatives

b. Mississìppi legislátion — Mìssissippi legislátion
Mississìppi connéctions — Mìssissippi connéctions
Mississìppi rélatives — Mìssissippi rélatives

Further, when the interstress interval of the input is kept constant, the propensity to relabel decreases as the interval of the output is increased beyond four syllables:

(26) Àlabama rélatives — Alabàma rélatives
Àlamogordo rélatives — Alamogòrdo rélatives
Àpalachicola rélatives — Apalachicòla rélatives[4]

These examples motivate the following rule of eurhythmy:

(27) *Quadrisyllabic Rule*
A grid is eurhythmic when it contains a row whose marks are spaced close to four syllables apart.

The Quadrisyllabic Rule should be taken as a principle of grid scansion: a grid is searched for the row that best fits the rule's description, and eurhythmy is proportional to how close the marks come to the desired four-syllable interval. Although judgments are delicate, my impression is that the scale of dysrhythmy is nonlinear, at least at the lower end: each successive syllable deducted from the quadrisyllabic norm results in a greater loss of eurhythmy.

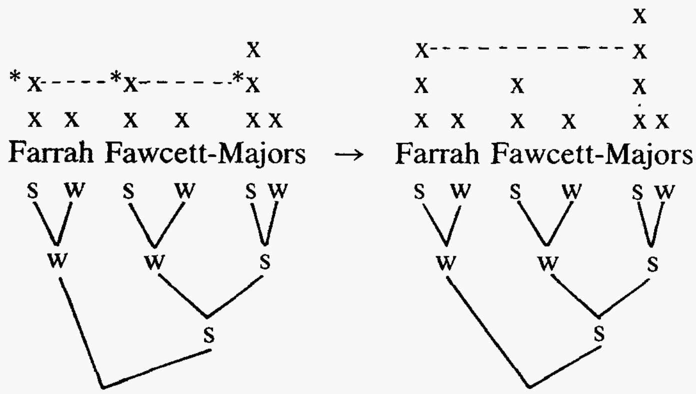
In what follows I will refer to the level selected by the Quadrisyllabic Rule as the *level of scansion.*

Returning to the earlier data, we find that the differences in propensity to relabel attributed by LP to the presence or absence of a clash are equally well explained in terms of greater or lesser gains in eurhythmy, with one exception to be dealt with below. For example, the interval shifts at the level of scansion found in *Mississippi legislature* and *Mississippi legislation* ((6a,b)) are from two to four and from four to six syllables, corresponding respectively to eagerness and reluctance to undergo the Rhythm Rule. Further, all the cases that proved problematic for the stress clash theory are accounted

[4] It is quite difficult to retract stress just two syllables in this example, as in **Apalàchicola rélatives*. This follows from a precedence principle requiring smaller syntactic domains to receive rhythmic adjustment prior to larger ones—note the contrast between [*Alabàma Street*] *bús route* and [*Àlabama Road*] *bús route* (see also Prince (1983)). A full discussion of this phenomenon goes beyond the scope of this article.

eurhythmy as the Quadrisyllabic Rule defines it:

(30)



The application of Beat Addition to *Ticonderoga*, under (20), is similarly motivated by an interval shift from two to three syllables:

(31)

```
                          x
          x          x-----x
   x---x             xx    x
  xx  xxx            xx   xxx
Ticonderoga  →  Ticonderoga
```

That this creates a stress clash in LP's sense again appears not to matter.

The Quadrisyllabic Rule thus accounts for a fair range of data. However, it is not the only principle that dictates rhythmic adjustment. As mentioned above, rhythm involves a whole set of isochronous intervals enacted in a simultaneous hierarchy. It should not be surprising if the rhythmic goals of the phonology should involve more than one level. In particular, I would argue for another principle of eurhythmy, as follows:

(32) *Disyllabic Rule*

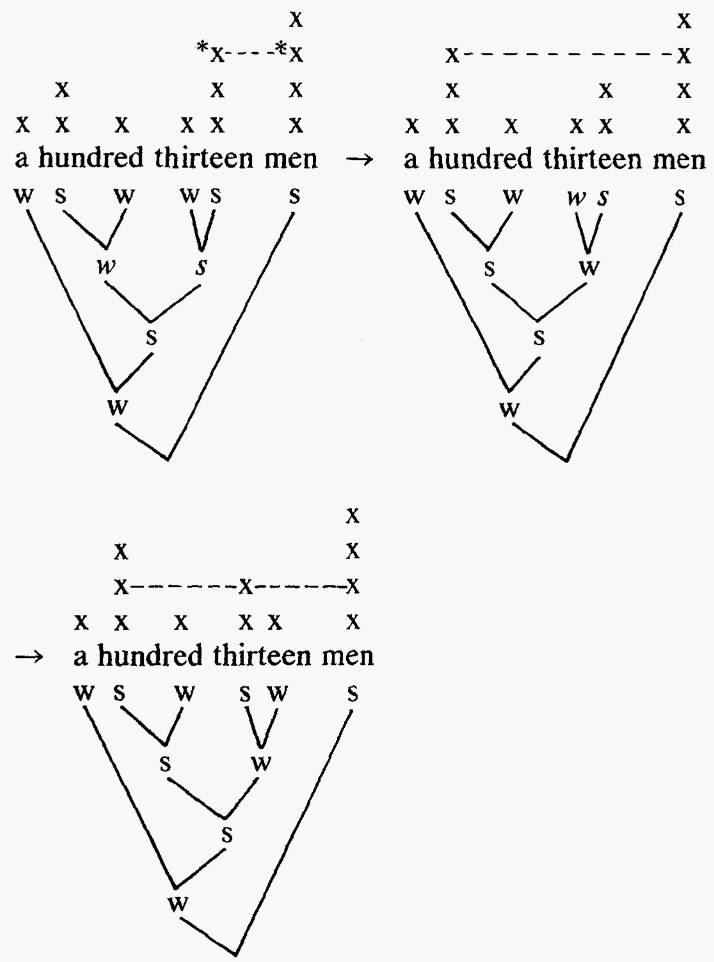
The domains delimited on the level of scansion should be divided evenly by a mark on the next lower grid level.

According to (32), the level of scansion is primary, but the general principle that rhythmic intervals should be equal holds both for the level of scansion and for the level below it as well.

Several arguments support this claim. First, there are cases in which the Rhythm

Rule applies twice within a four-syllable phrase, as in (33):

(33) a.



b. an almost hard-boiled egg (2 3 1)

c. an extremely unkind comment (2 3 1)

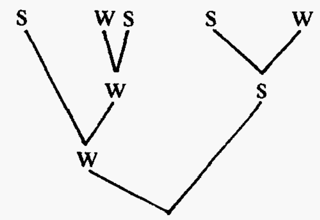
In (33), the "outer" application of the Rhythm Rule (to *hundred thirteen*) is clearly motivated by the Quadrisyllabic Rule. But the rule provides no explanation for the "internal" rhythm found on *thirteen*.[6] This relabeling would follow directly from a pressure for even spacing on the subscansion level, as the Disyllabic Rule requires. If the rule is

[6] Prince (1983) claims that internal rhythm is impossible, even though he presents examples of it (claiming that they are special cases). His examples that purport to show the impossibility of internal rhythm are for the most part ruled out independently, since they do not involve an increase in eurhythmy as defined here. Selkirk (forthcoming) admits internal rhythm, supporting her claim with examples that conform to the eurhythmy rules proposed here. Further examples of internal rhythm appear below.

correct, then the pressure for internal rhythm should disappear when it does not create even intervals. This appears to be true: compare (33a–c) with the corresponding examples (34a–c).

(34) a.

```
                x
x               x
x       x       x      x
x     x x       x      x
one thirteen Main Street
```




```
        2        3     1
b.  a non-hard-boiled egg

        2      3      1
c.  a most unkind comment
```

An example from Prince (1983) points this out quite clearly: in *no-propane blues* (2 3 1) and *no-cocaine blues* (2 3 1), the underlying stress contrast between *própane* and *cocáine* is preserved.

These forms provide compelling counterevidence to the suggestion made above that the definition of "stress clash" should be restricted to cases in which the second column involved is higher than the first. Under the stress clash theory, one would clearly want to claim that internal rhythm is blocked in these cases in order to avoid a "falling" clash.

The Disyllabic Rule can inhibit relabeling as well as induce it: in the form *John took out the book* (2 4 3 0 1), the rule inhibits the relabeling of *take out* that would be the norm in *Take out the book.* (2 3 0 1) Relabeling is virtually guaranteed if *take* is placed in the middle of a quadrisyllabic span, as in *Peter took out Alice.* (2 0 3 4 1 0)

Another argument for the Disyllabic Rule can be made from the stereotyped expressions under (35), in which *rising* stress is idiosyncratically assigned to words whose lexically specified stress contour is falling (the opposite of the ordinary Rhythm Rule):

```
(35) a.  When is a boy not a boy?
                   2     3      1
         When he turns into a store.
                               1
         (compare: What did he turn into?)
```

```
        2       3        1
b.  I think therefore I am.
              1      2       1
    (compare: I think. Therefore, I am.)
```

The pressure for this sporadic phenomenon can be seen to be even division below the level of scansion.

Prince has pointed out (personal communication; see also Bolinger (1981, 34)) that the free variation in the stressing of *Ticonderoga* vanishes in the compound *Fort Ticonderoga*, which must be stressed 203010. The two grids involved are as follows:

```
(36) a.                          b.
                                                 x
                   x                 x           x
     x             x                 x     x     x
     x-----x----x                    x     xx    x
     x     xx   xxx x                x     xx    xxx x
     Fort Ticonderoga               ??Fort Ticonderoga
```

In both cases, the marks on the level of scansion are spaced at the healthy distance of four syllables. The superiority of (36a) to (36b) may be attributed to the Disyllabic Rule.

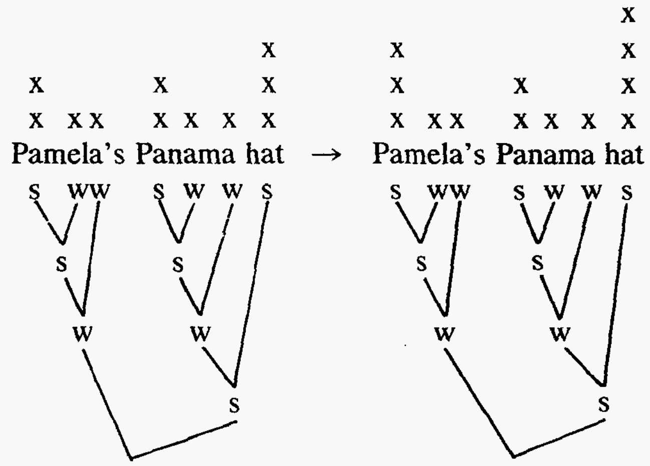
The two rules of eurhythmy motivated so far imply a rapid 4/4 time as the ideal rhythm in English—it is realized perfectly in texts like (22). However, most English texts diverge considerably from the norm, for several reasons. First, the trees of the input form may be shaped in a way that blocks the Rhythm Rule and Beat Addition from achieving the 4/4 pattern. Second, phrasal stress in English can serve ends other than rhythmic ones, notably the marking of focus and contrast. Third, the phonetic means of realizing stress also have divided loyalties: for example, increased duration signals not only stress, but also the ends of syntactic constituents (Klatt (1976)). Thus, the effects of the eurhythmy rules become clear only when other factors are controlled for. The eurhythmy rules can also make themselves apparent in highly rhythmicized speech, when they are given greater control over prosodic resources.

The strict binarity implicit in 4/4 time leads one to seek out binary rhythms at higher levels—is there an "octosyllabic" level of rhythm? Examples (37a–c) are encouraging in this vein: here, the Rhythm Rule has applied to create an alternating pattern among stresses that are already spaced at comfortable three- or four-syllable intervals:

```
             2         3           1            2         1
(37) a.  an amazingly interesting idea        (cf. amazingly interesting)
            2      3       1                       2     1
     b.  the Italy-Germany football match     (cf. Italy-Germany)
              2        3        1                    2        1
     c.  the Saginaw, Michigan Journal        (cf. Saginaw, Michigan)
```

In right-branching configurations, Beat Addition creates the same sort of alternation:

(38) a.



b. an [impressive^{2} [aluminum^{3} structure^{1}]]

c. [twenty-seven^{2} [alligator^{3} briefcases^{1}]]

A look at longer utterances, however, produces a surprising result: the target is not really a doubling of the quadrisyllabic interval. Instead, the second strongest stress is placed as early as possible in the phrase, even at the expense of binary alternation. This was originally pointed out in Bolinger (1965b, 160).

(39) a. Union^{2} of Soviet^{3} Socialist^{3} Republics^{1}

b. Topics^{2} in the Theory^{3} of Generative^{3} Grammar^{1}

c. when we were disagreeing^{2} about^{3} Stacy^{3} and Eric^{1}

d. I^{2} think you're not^{3} being entirely^{3} honest^{1}

(39c) and (39d) are recorded spontaneous utterances.

This evidence necessitates a third, asymmetrical principle of eurhythmy:

(40) *Phrasal Rule*

A grid is more eurhythmic if its second highest level bears two marks, spaced as far apart as possible.

The Phrasal Rule and the Quadrisyllabic Rule sometimes conflict, for example in (6b), *Mississippi legislation*. My impression is that in such examples, the pressure to apply the Rhythm Rule is slight, suggesting that the Quadrisyllabic Rule is accorded more weight in the evaluation of eurhythmy than the Phrasal Rule.

1.4. The Scope of the Eurhythmy Rules

There is evidence, then, for three distinct rhythmic targets in English: (a) a level of grid marks spaced about four syllables apart (the level of scansion); (b) a lower level that divides the level of scansion in half where possible; and (c) a higher level that gives the initial beat of the level of scansion precedence over any other beats at that level. These targets are formalized in the Quadrisyllabic Rule, (27), the Disyllabic Rule, (32), and the Phrasal Rule, (40). In this section I will present further evidence for the validity and generality of these rules.

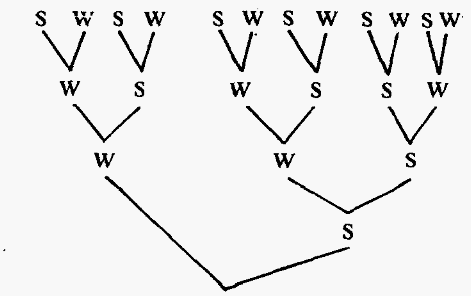
One important point is that no one level of the grid always constitutes the level of scansion. For example, in (41a), (41b), and (41c) the level of scansion is found on the second, third, and fourth levels of the grid, respectively:

```
(41) a.                       b.                    c.           x
                                               x      x---------x
                 x            x-------x      x   x         x
     x--------x               x    x     x      x   x x       x
     x xx  x    x             x x  x  x  x      x   x x   x  x
     Manitowoc Falls        Mississippi mud   ten-cucumber lunch
```

Examples (10) and (54) similarly satisfy the eurhythmy rules at different levels. For this reason, the eurhythmy rules should be interpreted as a "scansion" procedure, which searches the grid for the best available match-up.

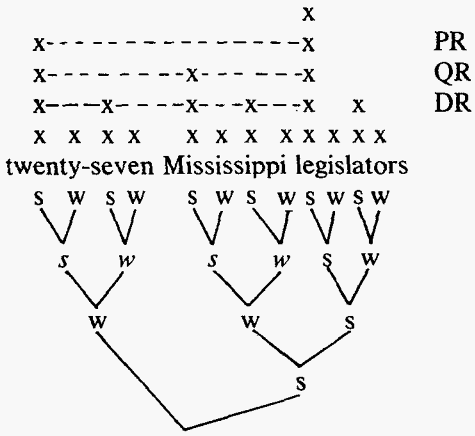
A second point is that the Rhythm Rule and Beat Addition may apply several places in a string when eurhythmy is increased. For example, the phrase *twenty-seven Mississippi legislators* is markedly dysrhythmic before the rhythmic adjustment rules apply to it:

```
(42)                                x
                x--------*x--*x          QR, PR
      x         x----x---x      x   x    DR
      x  x  x x    x  x  x  x    x x x x
     twenty-seven Mississippi  legislators
```



Specifically, the marks with asterisks are spaced too closely to conform to the Quadrisyllabic Rule, the Disyllabic Rule is only halfway satisfied, and the Phrasal Rule is not obeyed at all. Two applications of the Rhythm Rule and one of Beat Addition, however. produce the grid (43), which fulfills all requirements perfectly:

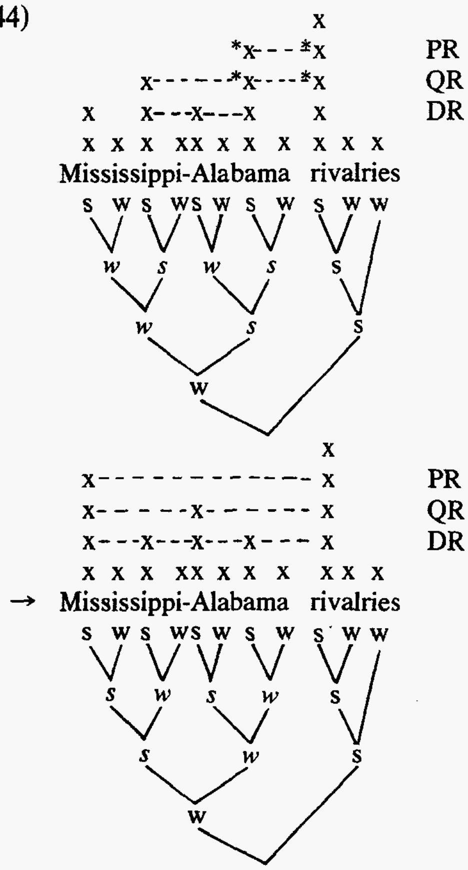
(43)



An example from Thompson (1980), *San Francisco*[2] *Golden Gate*[3] *Bridge*[1] (cf. *Sàn Francísco, Gòlden Gáte*), would undergo essentially the same derivation.

In (44), the text is made eurhythmic by applying the Rhythm Rule three times:

(44)



There appears to be no upper limit in principle to the number of adjustments that can be made. The following example, heard in spontaneous speech, involves three applications of the Rhythm Rule and one of Beat Addition, with excellent rhythmic results:

(45)
```
                                                   x
                x------------x--------*x----*x          PR, QR
     x          x-------x---x------x--x      x          DR
 x x x   x   x    x   x  xx  x  x    x x x  x   x  x x
 I can understand if we disagree on Presidential candidates

                                                   x
     x-----------------------------------------x          PR
     x------------x---------x-------x          QR
     x----x-------x--x------x--x----x          DR
 x x x   x   x    x   x  xx  x  x    x x x  x   x  x x
→ I can understand if we disagree on Presidential candidates
```

The phonological rules of rhythmic adjustment are separate from the rhythmic targets they serve: each of the three rules of eurhythmy can be satisfied both by Beat Addition and by the Rhythm Rule. Examples of all six kinds are shown in the chart below:

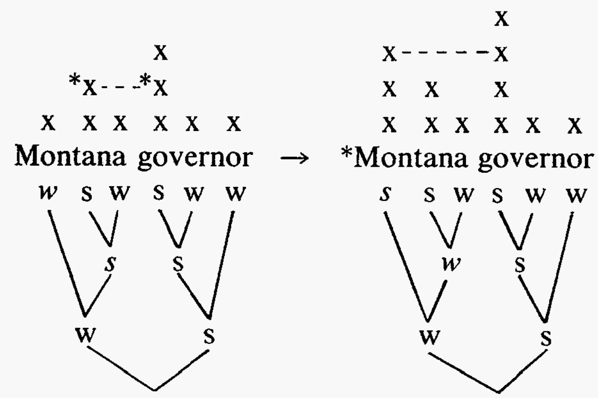
(46)
```
         Rhythm Rule                          Beat Addition
           2  3      1                          2      3          1
    QR:  Mary-Ellen Mathers                 Farrah Fawcett-Majors
         2       3   4   1                  2      3       1
    DR:  almost hard-boiled egg             Peter's three red shirts
          2           3        1             2          3          1
    PR:  remarkably clever suggestion       twenty-seven alligator briefcases
```

The same target can also *preclude* both kinds of rhythmic adjustment. For example, although the Rhythm Rule can normally apply to the word *transistor* in the phrase *tràn-sistor rádio*, in *ten-transistor radio* (2 3 1) relabeling is precluded by the Disyllabic Rule. The Disyllabic Rule similarly blocks the application of Beat Addition to *Ticonderoga* in *Fort Ticonderoga* (2 3 1), as shown above under (36).

Given the variety of examples that come out correctly, (27), (32), and (40) seem to be a good approximation to the rules of eurhythmy in English. I now turn to two problems with the analysis. The first is theoretical: it is arbitrary under my account that eurhythmy should involve target intervals of four and two syllables, rather than, say, seven or three. One feels that there must exist more general principles of which the Disyllabic and Quadrisyllabic Rules are surface manifestations. A possible account is the following, based on an idea in Dell (forthcoming). First, the marks of a eurhythmic grid must be *evenly spaced* at all levels. Second, the marks must be as *densely spaced as possible*, without vacuous duplication of rows. When these rules are followed, a grid obeying the Disyllabic and Quadrisyllabic Rules results automatically. This seems to be a more principled account, but obstacles stand in the way of its specific implementation. First, there exist grids that do not have even spacing on all levels, yet are eurhythmic—for example, (53c), (54b), and (75a) below. In these, the uneven level is simply not selected for scansion. Second, the proposed account fails to explain why there is a Phrasal Rule, not an Octosyllabic Rule. Conceivably, rhythmic pressures are weak at this time scale, and control over stress is usurped by other factors—for example, the need to demarcate the beginnings of phrases. As these remarks are speculative, I will not try to reformulate the eurhythmy rules more abstractly here.

A second problem with the analysis is empirical: the Rhythm Rule typically does not apply to words with the stress contour 210, such as *Montana*. As (47) shows, such an application would in fact increase eurhythmy:

(47) a.



b. *lòquacious tálker
c. *tìtanic stréngth
d. *Àlberta Álbertson

I do not have a complete answer to this problem. However, I think it can be shown that the difficulty with **Mòntana góvernor* does not lie in the definition of eurhythmy proposed here. Note first that the prohibition involved is not categorical. Instead, it appears that words of the *Montana* pattern show *lexical variation* in their ability to undergo the Rhythm Rule. In my speech and that of several consultants, examples like those of (48) are well-formed, in contrast to those of (47):

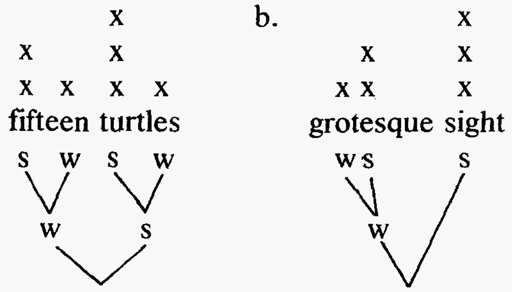
(48) Sàlvation Ármy
trànsistor rádio
còsmetic súrgery
sìmplistic árgument
trànsparent fálsehood[7]

If the examples of (47) are entirely eurhythmic, it is hard to see why the Rhythm Rule

[7] The last three examples are from Bolinger (1981). Naturally, there is idiolectal variation. The important point is that lexical variation holds within idiolects.

should ever apply to the examples of (48). Another fact to notice is that the relabeling of *disyllabic* words is subject to the same lexical variation. While the examples of (49a) relabel readily, those of (49b) do not:

(49) a. b.

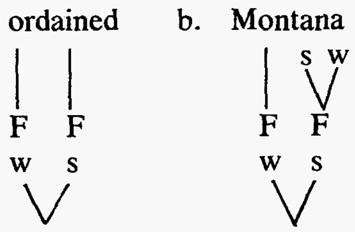


a.	b.
Chìnese índustry	obèse péople
ùnkind cómment	ordàined tíme
Chrìstine Schäefer	forlòrn hópe

Note that under any account, the forms of (49b) are dysrhythmic; in particular, they contain an LP-style stress clash. I would argue that the principles of eurhythmy should not be expected to account for these forms; the necessary changes would result in severe losses of predictive power elsewhere. Instead, the data should be attributed to variation in the ability of word-initial, weak-stressed "upbeat" syllables to receive rhythmic promotion. What holds for the disyllabic words holds for the trisyllabic forms of (47) as well; their reluctance to relabel derives from their initial "upbeat" syllables, not from a defect in the principles of eurhythmy.

The syllables whose promotability vacillates can be characterized clearly within the framework of Selkirk (1980) and Hayes (1982): they are syllables whose maximal prosodic category is a nonbranching foot, as in (50):

(50) a. b.



Compare *wèll-made súit, gòod-looking lífeguard,* in which the initial syllable bears the maximal prosodic category *Word*, and relabeling takes place quite regularly. In words like *Ånnétte, Åláska*, the initial syllable is not even a foot. It is unpromotable, as a result of the (apparently universal) principle developed in Prince (1980, 523) that feet are always strong with respect to syllables.

A problem I will leave to future research is to define the principles responsible for the lexical variation discussed here. It seems that familiar words and phrases undergo relabeling more freely; and the duration or sonority of the upbeat syllables may also play a role. In addition, it is not clear to me how variable propensity to undergo the Rhythm Rule is to be represented in the grammar. This is a further issue I must leave open.

1.5. Eurhythmy across Languages

The eurhythmy rules invite speculation along the following lines: do they characterize a universally preferred rhythmic form, or are they specific to the phonology of English? Some data from Polish are suggestive. Polish differs sharply from English in its prosody, being a syllable-timed language with fixed stress (on the penult). Nevertheless, Polish has a Rhythm Rule, and the conditions on its application are remarkably similar to those found in English. The most common case of rhythm in Polish involves raising the interstress interval from two to four syllables, as in (51a). If the interstress interval of the input is closer to four syllables, as in (51b), the propensity to relabel diminishes. The same holds if the interstress interval of the output is greater than four syllables, as in (51c):

		3 2 1		2 3 1
(51)	a.	zieloniutki ptaszek	→	zieloniutki ptaszek
				'greenish little bird'
		3 2 1		2 3 1
	b.	zieloniutka ptaszyna	→	?zieloniutka ptaszyna
				(idem)
		3 2 1		2 3 1
	c.	listopadowego dnia	→	?listopadowego dnia
				'November day (gen.)'

The forms have roughly the status of English *Àlabama rélatives*, *Àlabama connéctions*, and *Àpalachicola Árnie*. Something like the Quadrisyllabic Rule is apparently at work in Polish.

In fact, a large proportion of the English data presented so far could be reproduced in Polish. This includes, for example, the continuous nature of the acceptability judgments, the need for Disyllabic and Phrasal Rules, and the reluctance of word-initial upbeats to receive rhythmic promotion. For full details, see Hayes and Puppel (in progress).

French, according to Dell (forthcoming), obeys a "principe d'eurythmie" that is strongly reminiscent of the rules proposed here. Further research would be required to determine if the French eurhythmy principles are indeed the same as the English. One striking difference is the nearly total impossibility of stresses on adjacent syllables in French. This may reflect a difference in the eurhythmy rules. However, it could also result from the difficulty of phonetically realizing adjacent stresses in a syllable-timed language, in which stressed syllables cannot be freely lengthened.

Dauer (1983) has made the striking discovery that impressionistically syllable-timed languages tend to space stresses evenly in the same way that stress-timed languages do. The interstress intervals were basically the same in all the languages Dauer examined:

English and Thai (stress-timed), Spanish, Italian, and Modern Greek (syllable-timed). These intervals correspond roughly to the interval specified in the Quadrisyllabic Rule I have proposed here.[8]

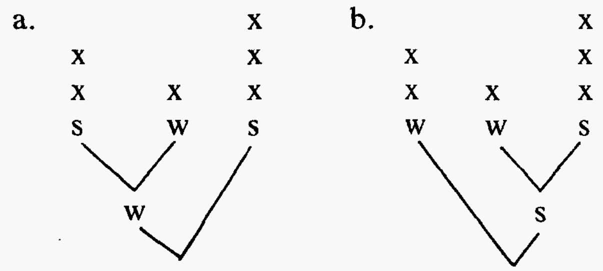
There is some possibility, then, that the rules of eurhythmy are not specified in the grammars of particular languages, but are universal. A further possibility, raised by Dauer, is that the eurhythmy principles are not even specific to language, but are only the linguistic manifestation of more general principles of rhythmic behavior.

2. Rhythmic Adjustment and Tree Structure

I turn now from the target of the rhythmic adjustment rules to the rules themselves. So far, I have assumed unchanged LP's general scheme of things: a set of rules first constructs metrical trees, which then serve as the basis of grid construction. This idea has not escaped criticism in the literature. In particular, the dual nature of LP's stress representations has been perceived as a redundancy—since the stress contour could in principle be read off either the trees or the grids, it is a real temptation to eliminate one or the other. For example, Kiparsky (1979) proposes a trees-only account of the Rhythm Rule, and Prince (1983) and Selkirk (forthcoming) develop comprehensive theories in which grids alone represent stress. Kiparsky's theory, although appealingly simple, is unable to handle many of the facts presented in the previous section.[9] In addition, a theory that includes grids can account straightforwardly for the patterning of stress in English poetry, but tree-based metrical rules run into serious difficulties (see Hayes (1983)). In this section, then, I will concentrate on purely grid-based theories, which are entirely compatible with the results so far. Since I will argue that trees are necessary as well, it may appear that I am defending a redundant theory. But a better understanding of the two representations, I believe, will show that no redundancy exists. In particular, I argue that trees and grids represent different things (stress and rhythm), have different functions, and obey different laws—hence, neither is dispensable.

2.1. Some Crucial Data

Utterances may sometimes have identical grids, but different trees. A simple example of this sort is shown in (52):

(52)


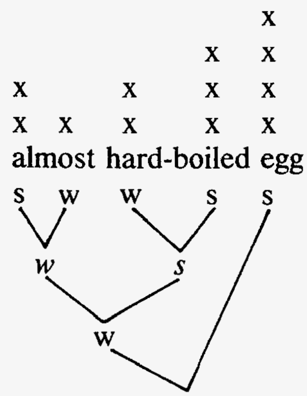
If such differences were reflected in differences in phonological behavior, we would have

[8] When measured phonetically; see the Appendix.

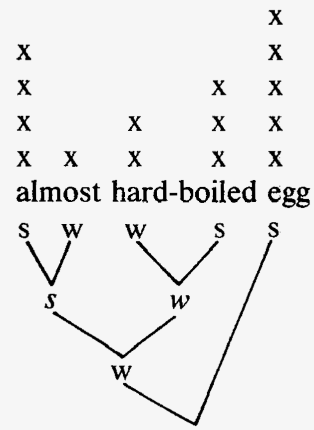
[9] The reader who wishes to collect counterexamples and lacunae should examine (6b,d), (9), (15), (16), (21), (25), (26), (33), (36), and (48).

a good argument that trees are independently needed. To this end, let us consider three contrasting forms. In *almost*^{2} *hard*^{3}*-boiled*^{4} *egg*^{1} there is a double application of the Rhythm Rule, which satisfies all three rules of eurhythmy.

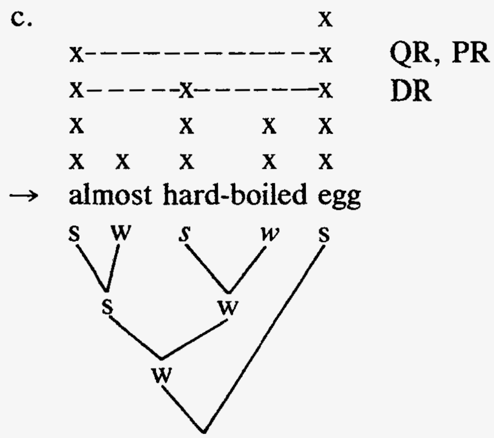
(53) a.



b.

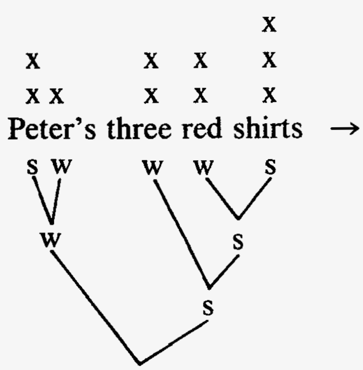


c.

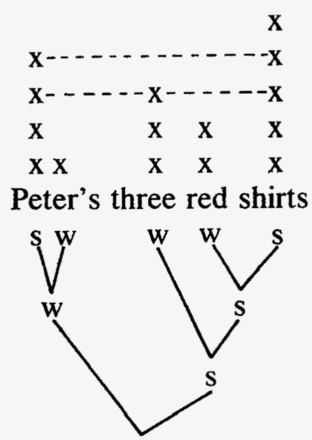


In *Peter's*^{2} *three*^{3} *red*^{4} *shirts*^{1}, multiple applications of Beat Addition achieve the same end:

(54) a.

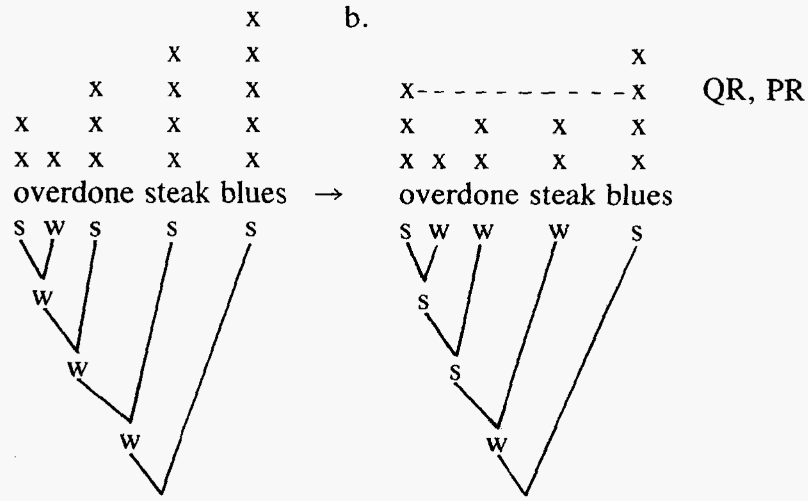


b.



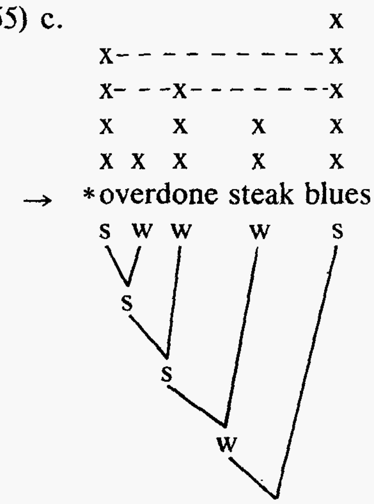
Consider now the text *overdone steak blues*. Here, two applications of the Rhythm Rule lead to the representation (55b):

(55) a.



This satisfies the Quadrisyllabic and Phrasal Rules of eurhythmy. Now, on the basis of all that has gone before, it should be possible at this point in the derivation to apply Beat Addition to (55b), thus satisfying the Disyllabic Rule as well:

(55) c.



But such a rendition (*$\overset{2}{\textit{over}}\overset{3}{\textit{done}}\ \overset{4}{\textit{steak}}\ \overset{1}{\textit{blues}}$) is impossible. The stress contour of (55b) has to be retained, as $\overset{2}{\textit{over}}\overset{3}{\textit{done}}\ \overset{3}{\textit{steak}}\ \overset{1}{\textit{blues}}$. The difference between (53) and (54), on the one hand, and (55c), on the other, appears to follow solely from the difference in their tree shapes. The potential importance of this contrast for the theory of trees should be clear.

The constraining effect of tree shape on Beat Addition is robust and reproducible.

Some examples similar to (53)–(55) are listed below:

```
                2          3    4        1
(56) a.   [[nineteen [twenty-four]] Chevy]
                2          3     4     1
     b.   [Norbert's [twenty [old shirts]]]
               *2          3     4       1
     c.   [[[nineteen twenty] Ford] shop manual]           (must be 2–3–3–1)
              2        3      4       1
(57) a.   [[lovingly [oven-baked]] bread]
              2         3        4  1
     b.   [Benjamin [didn't [see Alice]]]
               *2            3       4     1
     c.   [[[Benjamin Franklin] Road] exit ramp]           (must be 2–3–3–1)
                  2          3   4         1
(58) a.   [[remarkably [well-buttered]] toast]
             2        3   4     1
     b.   [Oliver's [ten [little kids]]]
               * 2             3    4          1
     c.   [[[Washington-grown] apple] shipping carton]     (must be 2–3–3–1)
```

Furthermore, the left-branching *sww* sequence that resists Beat Addition need not be derived by the Rhythm Rule, as the following examples show:

```
              *2        3      4     1
(59) a.   [[[Apple Juice] Board] lobbyist]        (compare (53), (54))
                   *2    3          4    1
     b.   [[[oratorio singer's] day] festival]    (compare (57a,b))
               *2          3      4       1
     c.   [[[battering ram] maker's] standards]   (compare (58a,b))
```

These data form a prima facie case that trees are necessarily involved in the formulation of the Rhythm Rule—the *constituent structure* of a phrase determines whether a specific grid target may be achieved. In particular, the following descriptive generalization appears to hold:

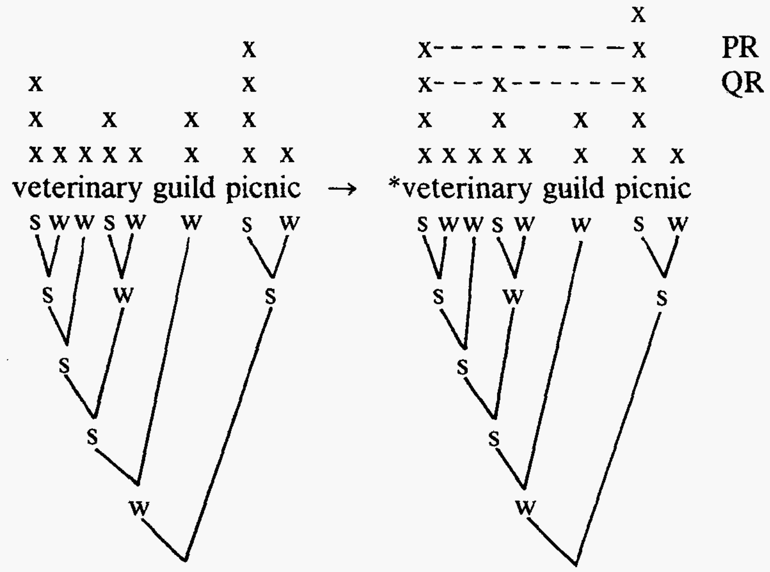
(60) *Right Branch Constraint*

Beat Addition may not add to a column if the maximal constituent of which it is the strongest element is a right branch.

For instance, (54) may undergo Beat Addition because the crucial constituent *three* forms a left branch; whereas in (55) Beat Addition is prevented from adding marks to right branch *done*. Similar remarks hold for the other examples.

A purely grid-based theory clearly faces less embarrassment if the right branches referred to in the constraint may be construed as *syntactic* right branches, rather than the branches postulated by tree theory on purely phonological grounds—it goes without saying that syntactic phrasing may affect phonological rule application. But the constraint holds as well for right branches that have only phonological motivation—for example, the right branch *-nary* in (61):

(61)



Similar examples are listed below:

(62) a. *Kalamazoo Farms Sausage (2 3 4 1)

b. *Illilouette Falls Rafting Outfitters (2 3 4 1)

c. *preparatory school choices (2 3 4 1)

d. *Manitowoc lover's bumper sticker (2 3 4 1)

From these cases, it appears that the bracketing relevant to the constraint is metrical, not syntactic.

2.2. *An Arboreal Account*

The facts presented so far constitute a potential argument for a theory that includes tree structure as well as grids. The compact formulation of the Right Branch Constraint is quite difficult, though not impossible, to restate in a grid-based theory. But differences in elegance should take second place to differences in explanatory adequacy: the real challenge for any theory is to explain *why* the Right Branch Constraint should hold. It seems unlikely that the constraint is learned by induction from the primary data, since the examples that motivate it are of the kind only linguists ever say. But the acceptability judgments are robust: even naive informants who claim they cannot hear differences in stress will respond differently to (53) and (55) when asked to tap on a table in time to their speech. (53) comes out as (63a) and (55) as (63b), where *t* marks tapped syllables.

(63) a. almost hard-boiled egg (t t t)

b. overdone steak blues (t t t t)

The crucial task for any theory is to show how the contrast follows from principles that can be independently learned or (better yet) are universal. In the last part of this article I will show that the tree theory is equal to this task.

My proposal is that Beat Addition does not apply to grids, but is instead an arboreal rule.[10] The rule will alter the trees only; the new grids will result from rules (4a–c), which, following LP, I take to be well-formedness conditions that reapply whenever necessary. The appropriate change in the trees can be expressed as a metrical *adjunction*. Adjunction as a metrical operation is well-attested in the literature; examples are the "Stray Syllable Adjunction" proposed by LP and other forms of adjunction developed in Hayes (1981; 1982). What is significant for our purposes about these cases of adjunction is that the adjoined element is always labeled *w*. This, I would suggest, is a general property of metrical adjunction, and need not be stipulated in individual rules or conventions.

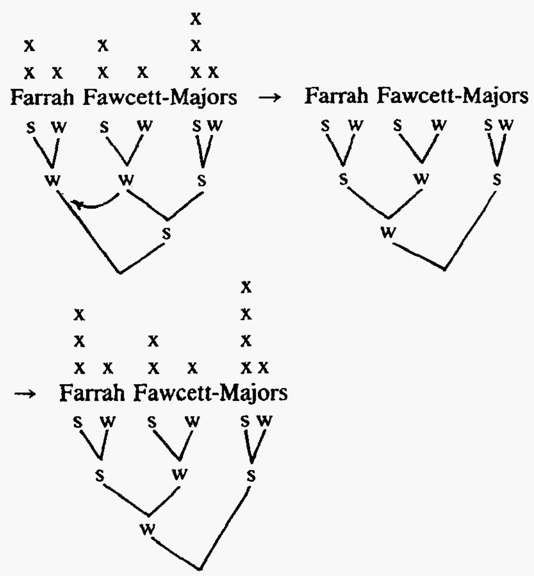
I would argue that the arboreal version of Beat Addition should be formulated explicitly as the adjunction rule in (64). To keep the two rules distinct, I have named the new one *Rhythmic Adjustment*. In the rule, *X* and *Y* stand for any metrical constituents, and *DTE* represents the strongest syllable (designated terminal element) of the phrase in which the rule applies.

(64) *Rhythmic Adjustment*

In the configuration . . . X Y . . . DTE . . . , adjoin Y to X.

In the case of *Farrah Fawcett-Majors*, the rule would take X to be the constituent *Farrah*, Y to be *Fawcett*, and DTE to be *Majors*. When the rule applies, the grid construction procedure automatically adds marks to conform to the new tree, thus duplicating the effects of Beat Addition.

(65)



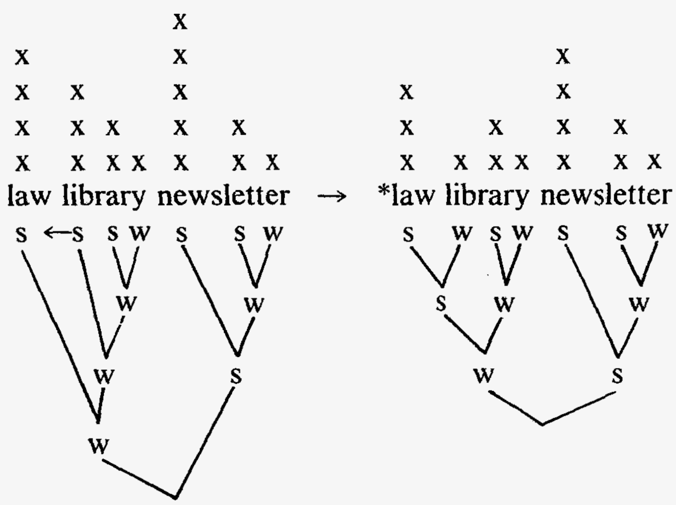
[10] See Giegerich (1981) for a rather different development of this notion.

The new approach yields two important advantages in a tree-plus-grid framework. Note first that the old rule of Beat Addition essentially recapitulated provision (4c) of the rules of grid construction. To say that Beat Addition "preserves the relative prominence relations of the tree" is to incorporate provision (4c) directly into the Beat Addition rule. By reformulating Beat Addition as Rhythmic Adjustment, we derive the extra grid marks from the ordinary rules of grid construction, thus removing the redundancy. Second, replacing Beat Addition with Rhythmic Adjustment allows for a more constrained framework. Under the old theory, metrical rules were allowed to apply either to the tree or to the grid representation. The only rule of the latter type was Beat Addition. By reformulating Beat Addition as a tree-based rule, we can maintain the more restrictive theory that metrical rules may apply only to trees.

This result reinforces the hypothesis advanced earlier about the role of grids and trees in metrical theory: grids are not strictly speaking a linguistic representation at all, but instead represent rhythmic structure. They are projected from trees by conventions (4a–c), and they may influence the application of phonological rules through the rules of eurhythmy. However, the phonological rules may apply only to the trees, which form the phonological representation of stress.

There are good conceptual reasons, then, to prefer Rhythmic Adjustment to the old rule of Beat Addition. However, as it stands Rhythmic Adjustment overgenerates wildly. For example, in (66) the rule could adjoin the constituent *li* to *law*, giving *$\overset{2}{\textit{law}}$ $\overset{3}{\textit{library}}$ $\overset{1}{\textit{newsletter}}$.

(66)



With similar derivations, it would also be possible to produce such strange stress contours as those of (67):

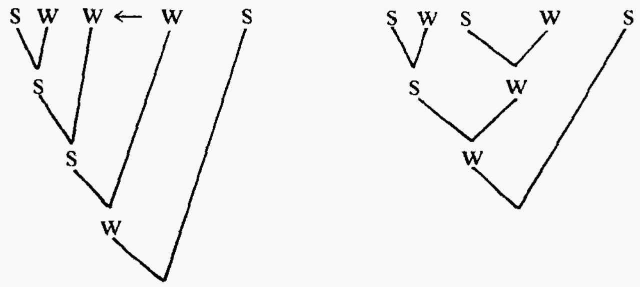
(67) a. *$\overset{2}{\text{law}}$ $\overset{3}{\text{newsletter}}$ $\overset{1}{\text{library}}$

b. *$\overset{2}{\text{ten}}$ $\overset{3}{\text{index}}$ card $\overset{1}{\text{dossier}}$

2 3 1
c. *two pomegranate juice daiquiris
? 4 3 1
d. *anti-[journal editor] viewpoint

Another problem with Rhythmic Adjustment is that, just like Beat Addition, it allows for violations of the Right Branch Constraint. For example, if in (68) *done* is analyzed as X and *steak* as Y, the same unacceptable output results:

(68)
overdone steak blues → *overdone steak blues (2 3 1)



It would be possible to fix these problems by adding more information to the rule—in particular, it could be stipulated that X must be a left branch (to fix the Right Branch violations) and that Y must be labeled weak (to fix (66)–(67)). But a more general principle can be found that covers both cases, requiring no change whatever in the rule. My proposal is as follows:

(69) *Maximality Principle*

Rules that manipulate tree structure must analyze maximal terms.

Maximality is defined as in (70):

(70) Let R be a rule whose SD contains the terms $t_1, t_2, \ldots t_n$.

Let T be a tree containing the constituents $c_1, c_2, \ldots c_m$ $(m \leq n)$, matched up to the appropriate terms of R.

c_i of T is *maximal* iff there is no node c_i' that

a. satisfies R

b. dominates c_i

c. does not dominate any other member of the sequence $c_1, c_2, \ldots c_m$.

The intuitive sense of (70) is that rules will not apply to small constituents if larger ones are available that do not overlap. The Maximality Principle correctly trims back all the cases of overgeneration presented above. For example, in (66) Rhythmic Adjustment cannot analyze *li* as Y, since the constituent *library* dominates *li* without dominating X (*law*) or DTE (*news*). In (68) Rhythmic Adjustment cannot analyze X as *done*, since the constituent *overdone* dominates *done* without dominating *steak* or *blues*. The only possible application of Rhythmic Adjustment to these forms is vacuous, recreating the structure of the input.

The Maximality Principle thus neatly solves the problems that were raised by the arboreal reformulation of Beat Addition. In addition, it allows us to avoid explicitly stipulating the Right Branch Constraint. When Rhythmic Adjustment is formulated arboreally in the simplest possible way (i.e. as in (64)), all violations of the Right Branch Constraint are automatically excluded by the Maximality Principle.

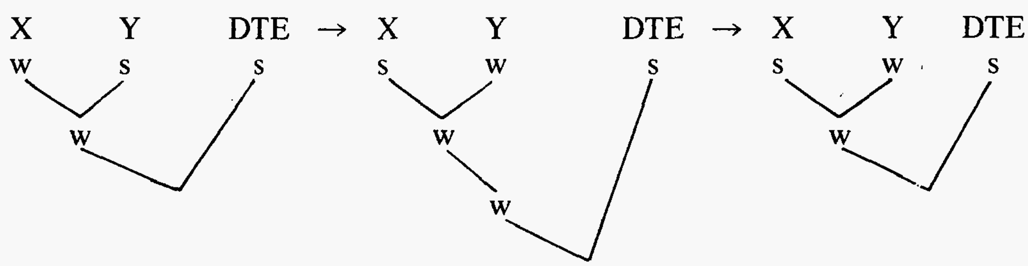
The Maximality Principle may also be supported by evidence from syntax. It has long been recognized (cf. Chomsky (1964)) that syntactic rules normally apply to the largest constituents possible when multiple structural analyses are available. Bresnan's (1976) Relativized A-over-A Condition is an explicit formulation of this notion, which makes accurate predictions in a wide variety of cases. Interestingly, it appears that all of the empirical consequences of Bresnan's condition follow from the Maximality Principle as well. In fact, the Maximality Principle improves on Bresnan's formulation, because it need not refer to the distinction between "context" and "target" predicates, as Bresnan's condition must. As an example, consider the facts of Heavy NP Shift. Bresnan shows that this rule actually applies to phrases of the form $\begin{bmatrix} X'' \\ -V \end{bmatrix}$; that is, to PP as well as to NP. The following examples from Bresnan's article show that the rule must apply to the largest such expression available, thus respecting maximality:

(71) a. He considers [e] stupid [many of my best friends]$_{NP}$
b. *He considers [many [e]] stupid [of my best friends]$_{PP}$
c. *He considers [many of [e]] stupid [my best friends]$_{NP}$

My conjecture is that the Maximality Principle is a constraint that applies across linguistic components, restricting the way in which any rule may analyze constituent structure. The fact that maximality can be generalized across both phonology and syntax might be taken as an indirect argument in favor of metrical trees, since a purely grid-based theory of stress could never capture this parallelism.

A final argument for the approach I have taken involves the relationship of the Rhythm Rule and what was earlier referred to as Beat Addition. When Beat Addition is reformulated as Rhythmic Adjustment, it turns out to incorporate the Rhythm Rule as a special case: the Rhythm Rule is simply Rhythmic Adjustment when X and Y happen to be sisters. In such a configuration, adjunction is vacuous as far as constituent structure goes, but the universal requirement that adjoined elements be labeled weak induces a shift of labeling. This is shown schematically under (72).

(72)



The adjunction of Y to X in (72) creates a nonbranching *w* node. As this node defines no prominence relation, I assume it is pruned by convention.[11]

There is crosslinguistic evidence that the collapsing of the Rhythm Rule and Beat Addition constitutes more than just a gain in elegance. According to Kiparsky (1966), the German version of the Rhythm Rule may shift stress rightward as well as leftward, as shown in the examples of (73):

(73) a. *Leftward Shift*

```
       2  3     1          2  1
der halbtote Mann        (halbtot)    'the half-dead man'
      2   3     1          2  1
er fing an zu reden      (fing an)    'he started to speak'
```

b. *Rightward Shift*

```
1  3    2                  1   2
unsichtbar               (sichtbar)   'invisible'
         1   3  2          1  2
den Rock anziehen        (anziehen)   'put on the skirt'
```

In this respect, German differs from English, in which stress may shift only leftward—the English analogues to (73b) (**spórts contèst, *láw libràry*) are ill-formed. German also has a Beat Addition rule, which, like the Rhythm Rule, applies bidirectionally:

(74) a. *Leftward Beat Addition*

```
                                           x
                x                  x       x
x     x     x                      x   x   x
x     x     x    x                 x   x   x   x
Hand [voll Kirschen]   →         Hand voll Kirschen
                                 'hand full of cherries'
```

b. *Rightward Beat Addition*

```
                                 x
x                                x        x
x      x     x                   x    x   x
x      x     x   x               x    x   x   x
[Handschuh]macher     →         Handschuhmacher
                                'glove maker'
```

Again, English is different: though Beat Addition may apply leftward in examples like

[11] This argument can be made more rigorous by providing a precise definition of adjunction. The following formulation, I think, accords fairly well with intuitions on the matter:

(i) In the configuration . . . X . . . Y . . . , where X and Y are metrical nodes, *adjoin Y to X* means:

a. Replace X with a new constituent X′ of the form [X Y]. X′ retains the old labeling of X and is internally labeled *s w*, by convention.

b. Delete the original copy of Y. Prune any nonbranching nonterminal nodes that may result.

The adjunction of X to Y is defined analogously.

When this definition is assumed, the rule of Rhythmic Adjustment correctly derives the effects of both Beat Addition (as in (12)) and the Rhythm Rule (as in (2)).

Fàrrah Fawcett-Májors, it does not apply to right-branching structures like *láw degrèe requìrement chànges* (see LP, 324). Polish fits the German pattern, having bidirectional versions of both the Rhythm Rule and Beat Addition (see Hayes and Puppel (in progress)). If collapsing the Rhythm Rule and Beat Addition is correct for English, then it would be plausible to do the same for German and Polish—the rule would be the same as (64), only generalized through mirror-image notation. It then follows that the English-German/Polish directional asymmetry should hold for both the Rhythm Rule and Beat Addition, since they are the same rule. If these results hold true in other languages, we would be led to conclude that relabeling rules should be excluded from metrical theory, to be replaced by the more general mechanism of adjunction.

3. Conclusion

To summarize, I will return to some questions posed earlier. First, why should the otherwise general rule of Beat Addition be subject to an idiosyncratic Right Branch Constraint? Under the account I have proposed, the constraint need not be stipulated arbitrarily, but is an inevitable consequence of the theoretical framework. The grids form a purely rhythmic representation, hence are unavailable as a domain for phonological rules. This means that there is no way that Beat Addition could be formulated other than as an adjunction—that is, as something like Rhythmic Adjustment. As an arboreal rule, Rhythmic Adjustment is necessarily subject to the Maximality Principle, of which the Right Branch Constraint is a direct consequence. Confidence in the analysis is increased by two further results: the strange derivations of (66)–(67) are ruled out, and the Rhythm Rule and Beat Addition can be collapsed.

The larger issue I addressed was the relative merit of grids-only versus grid-and-tree frameworks for the description of stress. This issue will ultimately be decided only through comparing the explanatory power of the two theories in a large number of cases. In this particular instance, the trees appear to justify themselves: as far as I can tell, a grid theory can avoid Right Branch Constraint violations only at the cost of brute force, ad hoc modification of the rules. In addition, the proposed analysis has blunted one of the principal arguments for grid theory—that trees are redundant—by assigning trees and grids to separate cognitive domains.

The research strategy pursued here is one familiar from work in syntax, but novel in phonology: complicated arrays of facts can sometimes be explained by positing separate subsystems of rules that are internally simple, yet interact to yield complex results. The theories of eurhythmy and of arboreal adjustment proposed here are a rudimentary phonological analogue of the subtheories (e.g. Case theory, θ-theory) proposed in the Government-Binding theory of syntax (see Chomsky (1981)). As in Government-Binding theory, the approach can yield principles that hold across subcomponents: the Maximality Principle plausibly holds both for phonological adjunction and for syntactic movement rules. Future research will show if the modular approach bears fruit in other areas of phonology.

Appendix: The Phonetic Spacing Hypothesis

In this appendix I will present a hypothesis about eurhythmy that was excluded from the main text, so as not to obscure the outline of the argument. I have assumed that the rules of eurhythmy are based on syllable count. But there is an alternative to syllable counting that I believe deserves serious consideration. This is that the spacing requirements of eurhythmy are phonetic, either based on actual physical time, or perhaps some more abstract phonological timing measure. The change would involve reformulating the Quadrisyllabic and Disyllabic Rules to refer to particular time intervals, either replacing or supplementing reference to syllable count. Under such a theory, the arguments presented above would still hold, but a number of other phenomena fall into place as well.

Consider first the expressions *Korbel champagne, Korbel tequila, Korbel whiskey*. The propensity to relabel *Korbél* seems to depend on the *phonetic* distance to the following stress—*whískey* induces relabeling most readily, followed by *tequíla*, followed by *champágne*. Similarly, words like *Àdiróndàck, Màssapéquòd*, with a phonetically long final syllable, are considerably more reluctant to undergo relabeling than words with short finals, such as *Mìssissíppi, àchromátic*. The long final syllables of the former pair place their stressed penults at a greater phonetic distance from any following stress. Although it may be possible to formulate these differences phonologically, a phonetic explanation certainly deserves to be considered.

Perhaps the strongest argument for phonetic spacing is one pointed out by LP (p. 320): additional phonetic length often appears in positions where eurhythmy would be increased. For example, when speakers are asked to enact texts that are eligible for the Rhythm Rule without actually carrying the rule out, their response is usually to lengthen the interval between the two principal stresses. In *fourtèen wómen*, for instance, the syllable *teen* is considerably longer than it would be in the relabeled form *fòurteen wómen*. A somewhat lesser lengthening effect can be perceived on the sequence *sippi* in comparing *Mississìppi législature* with *Mìssissippi législature*. This can be explained by assuming that the rules of phonetic length assignment are part of the means of achieving eurhythmy—a monosyllabic or disyllabic interval on the level of scansion is more tolerable when it is phonetically longer. Another case is an example noted in Liberman (1975): when *John struck out my friend* is enacted with a 23401 contour, the word *John* is considerably longer than when a 24301 contour is employed. The lengthening of *John* permits an acceptable scansion even when the verb *strike out* undergoes relabeling. Notice that the grid levels are scanned by different rules in the two versions.[12]

[12] Other idiosyncratic informant judgments can be explained on a similar basis. For example, the speakers I have consulted who have the stressing *Fort Ticonderoga* (2 3 1), rather than *Fort Ticonderoga* (2 3 1) as claimed above, assign greater length to the syllable *Fort*, producing a grid that is eurhythmic in the same way that (75b) is. Conceivably the greater length these speakers assign to *Fort* means that for them *Fort Ticonderoga* is a phonologically unintegrated compound, along the lines of *pie school*, rather than an integrated compound like *high school* (see Kiparsky (1977, 222)).

```
(75) a.                     x
        x-------------x      QR
        x--------x-----x     DR
        x     x    x     x
        x     x    x   x  x
        John struck out my friend
     b.                           x
        x------------------x     PR
        x--------x---------x     QR
        x            x    x      x
        x            x    x   x  x
        Johhhhhnnnn struck out my friend
```

LP's argument fits neatly into the system proposed here, which assumes that the crucial element of eurhythmy is horizontal spacing of marks. In contrast, phonetic lengthening never resolves a stress clash, and must be treated as a separate factor in a theory based on clashes.

If this account of lengthening is correct, it provides strong evidence that eurhythmic targets should not be directly encoded in the phonological rules that achieve them. The rule of Rhythmic Adjustment is only a coconspirator in a broader plot that includes the rules of phonetic length assignment as well.

A strong prediction of the phonetic spacing hypothesis is that Rhythmic Adjustment should be sensitive to the output of low-level rules of length assignment, for example the rule that shortens syllables ending in voiceless obstruents. This prediction has in fact been tested by Bolinger (1962). Bolinger's method was to elicit judgments of the eurhythmy (i.e. "Which sounds better?") of expressions having the form *A and A N*. Bolinger found fairly strong rhythmic effects with this method: by wide margins, subjects preferred *mad and senseless slaughter* to *senseless and mad slaughter*, or *curt and hurried note* to *hurried and curt note*. The effect can be attributed only in part to pressure to place the longer of two conjuncts second, since in phrases like *All war is* (*mad and senseless/senseless and mad*), the degree of preference was greatly diminished. This initial result can be explained by the Disyllabic Rule, as shown by the comparison under (76):

```
(76) a.              x
        x----------x     QR, PR
        x-----x----x     DR
        x  x    x  x  x
        curt and hurried note
     b.              x
        x----------x     QR, PR
        x-----*x--x
        x  x  x    x  x
        hurried and curt note
```

Bolinger's crucial experiment, however, involved comparing conjuncts consisting of nonsense monosyllables of varying phonetic length, for example (*plap and plam*/*plam and plap*) *house*, (*broat and broe*/*broe and broat*) *moan*, where the length difference results from the shortening of syllables closed by voiceless obstruents. If the degree of stress clash is based wholly on syllable count, then the phonetic length of the clashing syllable should make no difference to rhythmic preferences. But Bolinger found that there was a substantial preference for placing the monosyllable closed by a voiceless obstruent *first*, a positioning that divides the scansion-level interval more evenly:

(77) a.
```
                        x
 x- - - - - - - - - - - x
 x- - - - - - - -*x - - x
x x             x   x   x
a plammmmm and plap house
```
b.
```
                            x
 x- - - - - - - - - - - - - x
 x- - - - x - - - - - - - - x
x x   x    x                x
a plap and plammmmm house
```

In general, the application of Rhythmic Adjustment in English is closely tied to speaking rate, with faster speech undergoing more adjustment. By monitoring casual speech, one hears examples of adjustment that may sound implausible when presented to informants for judgments. My collection includes the following:

(78) a. When Nèro Wolfe finally sits dówn . . .
b. I'm a dìscreet kind of gúy.
c. She'll have to fòrgo Téxas.
d. I dìslike her pólitics. (not contrastive with *like*)
e. . . . is planned an ìnternational stúdent house.

The distinction could plausibly be traced to the difference in speaking rate between casual utterances and elicited examples, since faster speech places the grid peaks closer together.

The assumption that the spacing requirement is phonetic may also be sufficient to account for the observed interactions of rhythmic adjustment with syntactic boundaries. LP observe that resistance to relabeling increases with boundary strength in triplets like *Màrcel Próust–??Màrcel's bóok–??Màrcel léft*. The same holds true of other stress configurations as well:

(79) a. the Àlabama législature
?Àlabama's législature
??Àlabama législated it.
b. the Bìll Stevens Fán Club
?Bìll Stevens' fán club
??Bìll Stevens fánned it.

LP point out that the phonetic material at the end of a syntactic unit receives extra length, roughly in proportion to the salience of the boundary involved (see Klatt (1976)). If eurhythmic intervals are phonetically defined, then it is plausible that syntactically induced lengthening could itself satisfy the spacing requirement, thus eliminating the pressure for rhythm. This is shown schematically in (80):

```
(80) a.              x                  b.          x
            x- - - - x                         x- - -x
            x    x    x    x             x     x       x    x
            x x x  x x x x x             x x  x    x x x x x
            Alabama legislature          Alab a m a legislated
```

Again, this result fits neatly into a horizontal-spacing theory of eurhythmy, but not into a stress clash theory. Selkirk (forthcoming) attempts to save the stress clash theory by adopting an elaborate set of rules for inserting extra grid marks at syntactic boundaries, so that clashes can still be invoked. It is not clear how this proposal could be generalized to handle the above facts involving speaking rate or shortening before voiceless obstruents.

We see, then, that the hypothesis that the spacing requirements of eurhythmy are phonetic is an attractive one on several grounds. Extensive phonetic work clearly would be required to validate it. One interesting aspect of a purely temporal principle of eurhythmy would be its independence from linguistic units. If, as I have claimed, the metrical grids are a representation of rhythmic structure (not necessarily linguistic), then it is plausible that the rules of eurhythmy might not be purely linguistic either, representing instead general principles of well-formed rhythmic behavior.

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