• 3 •

Background

This chapter begins with the typology of stress and stress rules, then treats the basic ideas of metrical theory, and concludes with specific theoretical proposals that will be important in what follows.

3.1 TYPOLOGICAL PROPERTIES OF STRESS

The preceding chapter reviewed evidence that stress has distinct phonetic characteristics that motivate assigning it a rather different phonological representation. The phonological patterning of stress leads to the same conclusion, as is argued in this section, based on earlier literature. The typological patterns discussed here provide a number of criteria of adequacy for proposed representations of stress.

(A) CULMINATIVITY. One distinctive phonological characteristic of stress is that it is normally **culminative,** in the sense that each word or phrase has a single strongest syllable bearing the main stress (Liberman and Prince 1977, 262).

The requirement of culminativity typically exempts grammatical words; consider English *the,* normally realized as stressless [ðə]. Arguably, this is because grammatical words are phonologically cliticized to neighboring content words (e.g. as in Hayes 1989a); that is, the requirement of culminativity applies to phonological, not grammatical words. Note that when function words are pronounced alone, they are typically stressed. For example, the isolation form of *the* is [ðʌ́ː] or [ðíː].

The domain of culminativity may differ from language to language. For example, in English, stress is culminative at the word level (every content word has a single strongest stress), at the level of the intonational phrase, and possibly at other levels as well, such as the phonological phrase (Nespor and Vogel 1986). In French (Dell 1984) and Italian (Nespor 1988, 225–26), stress is culminative at the phrasal level, but not necessarily at the word level, since rules of destressing may eliminate word stresses on the surface.

Possible exceptions to culminativity are noted in the literature. For instance,

Dixon 1977 claims that in Yidiɲ (§ 6.3.9), the multiple stresses that occur in a long word are equal in prominence. The same is said for Central Alaskan Yupik by Woodbury 1987 and for Tübatulabal by Voegelin 1935. Further cases are noted by Hyman 1977b, 38–39. Such cases often lead to disagreement among linguists. For instance, Kenneth Hale (p.c.) notes that in his fieldwork with Yidiɲ speakers, he heard the first of the several stresses in a long word as stronger than the others. Miyaoka 1985 argues that the rightmost stress of a Central Alaskan Yupik word is the strongest; and there is some evidence (§ 6.3.10) that in Tübatulabal, the rightmost stress in a word is stronger than the others. In any event, in the version of metrical theory adopted below, these languages still respect culminativity at least in a modest sense: they all involve parsing each word into metrical feet (§ 3.6) and display culminativity at the foot level. The overall picture, then, is that culminativity may be a universal of stress systems, which is subject to parametric variation for the level at which it holds.

Some languages have been claimed to lack culminativity at all levels; that is, there can be completely stressless utterances. Bickmore 1989, 1992 argues that certain words of Kinyambo are completely stressless. However, since under Bickmore's analysis Kinyambo prosody involves a late conversion from stress to tone, Kinyambo does not violate culminativity in surface forms, but only at the abstract level in which its phonology acts as a stress system. Other languages claimed to have atonic content words include Cayuga and Seneca (§ 6.3.5), Sierra Miwok (§ 6.3.9), and Yupik Eskimo (§ 6.3.8.8). In all of these, I will suggest a tonal account of the facts that preserves the principle of culminativity.

(B) RHYTHMIC DISTRIBUTION. Stress is **rhythmically distributed** (Selkirk 1984), in the sense that syllables bearing equal levels of stress tend to occur spaced at roughly equal distances, falling into alternating patterns. Thus in many languages, six-syllable words are regularly assigned the stress pattern σ́ σ σ́ σ σ́ σ (/σ/ = syllable); but there appear to be no languages in which six-syllable words regularly receive the pattern σ σ σ σ́ σ́ σ́.

Rhythmic distribution of phonological properties other than stress, at least in most cases, involves phenomena that are themselves stress-conditioned. Thus in long English words such as *Apalachicola* [æ̀pəlæ̀čəkólə], the vowel [ə] occurs spaced every other syllable; but this is obviously due to the restriction of schwa to stressless syllables in English, and is therefore parasitic on the even spacing of stress.

(C) STRESS HIERARCHIES. Stress is **hierarchical** (Liberman and Prince 1977, 262), in the sense that most stress languages have multiple degrees of stress: primary, secondary, tertiary, and so on. Such degrees of stress can appear within the phonology, rather than being the result of late phonetic rules. In contrast, ordinary features have a limited, predetermined number of contrasting phonological values, held by some scholars to be just two. An example of multiple "deep" phonological values for stress was presented in the preceding chapter: *Constantinople* (23010) contrasts with *sensationality* (320100), arguably as a result of the cyclic derivation of the latter from *sènsátion.*

(D) LACK OF ASSIMILATION. To my knowledge, it is an exceptionless phonological universal that stress does not assimilate. That is, a stressed syllable does not induce stress on the immediately preceding or following syllable. In this respect stress differs from most substantive features: assimilation of [round] or [back] or [nasal] and so on is a characteristic phonological process. Note that this is not a corollary of (B) above: in exceptional cases, languages do tolerate stresses on adjacent syllables, but the lack of stress assimilation appears to be absolute.

3.2 METRICAL THEORY: STRESS AS RHYTHM

Metrical stress theory posits that the phonetic and phonological differences between stress and ordinary features can be best accounted for if one abandons the assumption that stress is a feature. Instead, the theory represents stress as a hierarchically organized rhythmic structure (Liberman 1975; Liberman and Prince 1977). The discussion of rhythm that follows is based largely on Liberman 1975 for language and Lerdahl and Jackendoff 1983 for music.

3.2.1 Rhythmic Structure

Consider the rhythm of a simple nursery tune:

(1)
```
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    x
This      old       man,                he        played    one,

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    x
He        played    knick-    knack     on        my        thumb,    with a

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    x
Knick-    knack,    pad- dy   wack,     give your dog  a    bone,
```



```
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    x
This      old       man       came      rol-      ling      home
```

Above the words is placed a **metrical grid,** which is intended to depict the temporal structure of the tune. What we see is a sequence of beats (**grid columns**), equally spaced in time, which vary in strength according to their height. Beats alternate in prominence, and syllables and notes tend to begin on stronger beats.

A crucial aspect of a grid is that the **rows** are just as relevant as the columns. For every row of the grid above, the reader will find that it is possible to tap in a natural way, one tap per grid mark, in time to the music. (Tapping to the lowest row may require slowing down the tempo.) Going down through the columns, each level of tapping proceeds twice as fast as the level above. Such behavior is evidence that the various levels of rhythm are intuitively present for the listener, even when not every beat is signaled by a note onset.

Following Halle and Vergnaud (1987b, hereafter HV), I refer to each row of the grid as a **layer.**

Grids such as (1) are useful in characterizing various rhythmic phenomena; see in particular Lerdahl and Jackendoff 1983. To give a simple case, I suggest that syncopation can be roughly defined as the placement of a note onset on a relatively weak early beat when a later stronger beat is available. For example, Pete Seeger (1954) sings the nursery rhyme above with a syncopation on *this old man:*

(2)
```
x
x                   x
x         x         x         x
x    x    x    x    x    x    x    x
This old            man,
```

A number of general characteristics of rhythm can be seen in (1). First, rhythmic structure is **hierarchical,** with sequences of beats having multiple levels of strength. Second, rhythmic structure obeys a tendency to **even spacing** at all intervals of repetition. Third, rhythm obeys a law of **downward implication:** any beat on a high (i.e. broadly spaced) layer must also serve as a beat on all lower layers. Thus (3) is a logically conceivable rhythmic structure, but appears to be unattested.[1]

(3)
```
x         x         x         x         x         x         x
x     x       x     x     x       x     x     x       x     x ...
```

1. "Two against three" structures can occur, but only when two musical voices are present; arguably, each voice has a distinct rhythm.

The three crucial characteristics of rhythm just given are aptly summarized by Liberman and Prince's phrase "hierarchy of intersecting periodicities" (1977, 333): the word "intersecting" crucially conveys the notion of downward implication. These characteristics are invoked for musical rhythm by Lerdahl and Jackendoff 1983, 19–20, and appear to characterize much verse rhythm as well (Piera 1980; Hayes 1988).

A caveat concerning the conception of rhythm just presented is that while it holds for many musical traditions, it is not universal. For discussion of differing, non-hierarchical rhythmic systems, see Liberman 1975, 179–82, and Lerdahl and Jackendoff 1983, 18. The extent to which alternative conceptions of rhythm are linguistically relevant remains unexplored.

3.2.2 Stress as Rhythm

Consider now a grid employed as a representation of stress:

(4)

```
                                ×
×               ×               ×
×       ×       ×       ×       ×       ×
×   ×   ×   ×   ×   ×   ×   ×   ×   ×   ×   ×
```
twenty-seven Mississippi legislators

At first glance, grid formalism may appear to be a notational variant of a multivalued stress feature: for example, we could roughly translate a grid into an *SPE* stress representation by assigning the syllable with the highest column the value [1 stress], the syllable(s) with the second highest column(s) [2 stress], and so on. But when we consider the grid as a rhythmic structure, its essentially different nature becomes clear.

First, it is not just the columns of the grid that are phonologically relevant, but the rows as well. For example, the grid in (4) indicates that the sets of syllables {*twen-*, *sev-*, *Mis-*, *-sip-*, *leg-*, *-lat-*} and {*twen-*, *Mis-*, *leg-*} are phonologically relevant. The cross-linguistic patterning of stress suggests that such sets (i.e. sets defined as containing all the syllables with a given degree of stress or greater) are indeed phonologically relevant. Rules of stress assignment, of intonational pitch accent association, and of rhythmic adjustment (chap. 9) all characteristically refer to notions such as "rightmost syllable with at least *n* degrees of stress" or "consecutive syllables bearing at least *n* degrees of stress." Such notions have a straightforward expression when they are formalized on a grid layer but seem complex and arbitrary when stated on a sequence of [stress] feature values.

Note further that rules referring to predicates such as "consecutive syllables bearing *n* stress OR LESS" or "rightmost syllable bearing AT MOST *n* stress" cannot be straightforwardly formulated in grid notation. Rules of this sort in fact appear to be missing from natural languages.

The relevance of grid rows is a notable characteristic of rhythmic structure in general. In stress patterns, such sequences of beats seem to have a perceptual

reality even for speakers who cannot hear stress, as I have found in teaching beginning phonetics. For example, if a speaker of English is given the word *reconciliation,* which has the stress pattern shown in (5), (s)he will find it natural to tap once, twice, three times, or six times, as indicated; but the task of tapping four or five times produces confusion.

(5)

```
                      ×
         ×            ×
         ×       ×    ×
     ×   ×       ×  × ×   ×
         r e c o n c i l i a t i o n
1 tap:                T
2 taps:  T            T
3 taps:  T       T    T
4 taps:          ? ? ?
5 taps:          ? ? ?
6 taps:  T   T   T  T T   T
```

The reason should be clear: there are grid layers corresponding to one, two, three, and six beats, but none for four or five.

A second way in which grid notation differs from a [stress] feature is that the absolute height of a grid column has no intrinsic significance. A three-mark grid column simply indicates a syllable that is rhythmically more prominent than a two-mark column and less prominent than a four-mark column in the same representation. In contrast, the values of the stress feature proposed in *SPE* are intended to be phonologically relevant; and *SPE* indeed contains rules that refer to [3 stress] and other values.

A slight caveat should be mentioned here: phonological rules may refer to notions such as "strongest stress of a word" or "strongest stress of a phrase." However, it is clear that such notions are distinct from actual levels of stress.

A metrical representation of stress allows the special properties of stress reviewed above to be stated perspicuously, as follows.

(A) CULMINATIVITY. Culminativity in stress systems can be deduced from a metrical representation, given certain postulates (Liberman and Prince 1977, 263). The crucial assumption is that parsing of phonological material into hierarchical structure is obligatory at all levels. Examples of this principle in other domains include syllabification (see for example Ito 1986), or the theory of phonological phrasing (i.e. the Prosodic Hierarchy: Selkirk 1980a; Nespor and Vogel 1986; Hayes 1989a).

To bring this principle to bear on metrical phonology, I assume that metrical grids are not simple sequences of columns, but in fact relational structures. Given two grid marks $\times_1$ and $\times_2$ on the same layer, one of the following must hold: either one mark is subordinated to the other, or both marks are subordinated to a third.

(6) a. $\times$ / $\times_1$ $\times_2$ b. $\times$ / $\times_1$ $\times_2$ c. $\times$ / $\times_1$ $\times_2$ $\times_3$

In other words, the forms in (6) depict not simply a sequence of stacks of $\times$'s, but a relative prominence relation between the grid marks on the subscripted layer. This notion of stress as structure will become clearer below in § 3.5, which discusses bracketing structure in metrical theory.

If one assumes that stress involves structure, and that structure is created exhaustively, it is easy to see that stress will be culminative within the domain of the stress rules: since prominence relations are obligatorily defined on all layers, then no matter how many layers there are, there will be a topmost layer with just one grid mark.

In contrast, genuine phonological features such as [round] or [nasal] are not distributed culminatively because they do not form hierarchical domains across the phonological string.

(B) RHYTHMIC DISTRIBUTION. As we have seen, even spacing of beats is characteristic of rhythm in other domains. In addition, note that equal spacing of stresses tends to occur at multiple levels, as can be seen in (4); see Hayes 1984 for further discussion.

(C) MULTIPLE LEVELS. The existence of multiple levels of stress reflects the hierarchical nature of rhythmic structure (Liberman and Prince 1977, 263).

(D) LACK OF ASSIMILATION. The absence of stress assimilation follows from the absence of a feature [stress] to assimilate. In principle, we might expect grid marks to be associated to more than one syllable, but this would go against the nature of rhythmic structure: a rhythmic beat, which is what a grid mark represents, forms a point in time rather than a sequence (Lerdahl and Jackendoff 1983, 18).

The general picture is that a metrical representation is to be preferred to a stress feature for its ability to capture the typological properties of stress.

3.2.3 The Limits of Rhythm in Language

Before going on, a caveat may be useful: while stress appears to be generally rhythmic in character, it should not be imagined that all natural language stress patterns will sound like musical sequences, with perfectly regular intervals. (Speech deliberately produced in this way in fact sounds quite odd.) Dauer 1983, surveying the literature, notes that there is at best only weak evidence to support a tendency toward physically even spacing of stresses. Rather, the even-spacing effect of rhythm makes itself felt primarily in two other areas: (a) the phonological rules of languages tend to space stresses evenly; (b) in the

PERCEPTUAL domain, listeners hear stresses as more evenly spaced than they really are (Lehiste 1977; Donovan and Darwin 1979; Darwin and Donovan 1980); that is, they impose a regular rhythm on the incoming physical signal.

Functionally, there is good reason for stresses not to be produced with perfect rhythm. Stress serves multiple purposes: it creates phonemic contrasts, marks morphological and syntactic structure, signals the distribution of focus, and so on. The timing or duration of speech sounds is also multifunctional, as noted in § 2.1. Thus many factors compete with rhythm in determining the location and timing of stresses, and the outcome can be thought of as a compromise between differing goals. The basic claim being made here is that rhythm plays an important role in stress placement, but it is by no means the only factor.

3.3 THE TYPOLOGY OF STRESS RULES

In this section, I return again to typology, this time focusing not on surface distribution of stress, but rather on the rules that assign it.

In many languages, stress is predictable and therefore can be accounted for by phonological rules. In Polish, for example, words of more than one syllable have penultimate stress; and other languages have different rules, sometimes far more complex. Stress relations among words at the phrasal level are also rule-governed: for example, in English, syntactic phrases typically have a rising stress contour: *tàll trées*. This section focuses primarily on the basic typology of word stress rules; for the typology of stress rules at the phrasal level, see § 9.1–2.

(A) FREE VERSUS FIXED STRESS. The oldest notion in stress rule typology is that of **fixed** versus **free** stress languages. These terms simply refer to the phonemic status of stress in a language: fixed stress is predictable in its location, and may be derived by rule, while free stress is unpredictable and must be lexically listed. I assume that this is typically carried out by placing metrical structure in lexical entries, though as we will see there are other possibilities as well.

Like most such typological distinctions, the fixed/free stress opposition is a blurry one. For example, many languages have phonemic stress, but the possible locations of stress are limited to only certain positions within a word, for instance in Spanish to the last three syllables. In languages with phonemic primary stress, secondary stress often is predictable. Polish (§ 6.2.3) has predictable penultimate stress in most of its vocabulary, yet tolerates a set of mostly borrowed words with antepenultimate stress.

(B) RHYTHMIC VERSUS MORPHOLOGICAL STRESS. Independent of the free/fixed division is a division of stress systems into what I call **rhythmic** and **morphological** varieties. In a rhythmic stress system, stress is based on purely phonological factors, such as syllable weight (§ 3.9.2) or limitations on the distance between stresses and between stress and word boundaries. In a morphological system, stress serves to elucidate the morphological structure of a word. Often, a particular syllable of the root bears the main stress, and affixes are stressless or bear weak stress. The productive morphology of English (i.e. the Level II morphology; Kiparsky 1982a) is a good example of a morphological stress system: main stress falls on whatever syllable of the stem is assigned main stress at the stem level (i.e. Level I), and most affixes are subordinated to this main stress. Thus the fact that *un#bóund#ed#ness* has antepenultimate stress has nothing to do with any rhythmic principles, but merely reflects that fact that the stem syllable is in antepenultimate position in this word.

In another type of morphological system, surface stress is the result of a complex interplay of stem type (accented vs. unaccented) and diacritic properties of affixes: affixes can be inherently stressed, inherently stressless, can remove stresses from the domain to which they are attached, assign a stress to the preceding syllable, and so on. Such systems often have a rhythmically determined default pattern, which is found where none of the morphemes of the word asserts its own accentual preferences. A system of this sort has been described for Indo-European and various of its daughter languages in the work of Halle and others (Halle and Kiparsky 1977, 1981; Kiparsky 1982b; HV). Other systems of this sort are found in Modern Hebrew (Bat-El 1992), Pashto (Bečka 1969), and Cupeño (Hill and Hill 1968).

Naturally, the notions of "morphological" and "rhythmic" stress system are not usually manifested in pure form; most stress systems are a mix of the two. For example, English has a rhythmic stress system in stems (Level I) but mostly morphological stress for productive affixes (Level II).

Morphological stress systems, particularly of the stem-stress type, are fairly common but in my opinion have played a less significant role in the development of parametric metrical theory, since the greatest strength of the metrical approach has been in describing rhythmic influences on stress. I will not treat morphological systems here in detail; see the references just cited and Halle and Vergnaud 1987a for interesting proposals in this area.

(c) Bounded and Unbounded Stress. Consider now the typology of rhythmic systems. These can be roughly divided into **bounded** and **unbounded** types. In a bounded stress system, the stresses fall within a particular distance of a boundary or another stress; stem stress in English (i.e. Level I stress) is an example. In an unbounded system, stress can fall an unlimited distance from a boundary or another stress, provided the appropriate conditions are met. An example of an unbounded system would be the following: stress the rightmost heavy syllable in a word; if there is no heavy syllable, stress the initial syllable. (For "heavy", see § 3.9.2.) A survey of unbounded systems appears in § 7.2.

For a time, unbounded systems were of great interest because they appeared to follow a universal pattern: all languages with "rightmost heavy" conditions appeared to have "leftmost" as their default clause for words with no heavy syllable; and languages with "leftmost heavy" clauses had "rightmost" as their default case. However, this universal has turned out to be an accident of the order in which theorists located the relevant examples in the literature; to my knowledge, there are about as many cases in which the default stress position for all-light words is exactly the opposite, namely, leftmost in leftmost-heavy systems and rightmost for rightmost-heavy systems (see § 7.2). In other words, all four logical possibilities derivable from the choices (right/left)most heavy, (right/left)most default, actually occur.

This completely symmetrical pattern makes it difficult to argue for any really explicit mechanism to derive unbounded stress. Since the facts in this area are quite simple and fill out the logical possibilities, it is hard to develop a theory that goes much beyond just describing the facts. I suggest a particular mechanism, modeled on the proposal in Prince 1983a, in § 7.2.

The cases covered intensively in this book involve only a subset of the typology just outlined: I focus on BOUNDED, RHYTHMIC stress systems, or in the case of mixed systems, the parts of the system that are bounded and rhythmic. It is these systems where rhythmic structure seems to have the most pervasive influence on stress; thus these are the systems that arguably are of the greatest interest from a metrical perspective.

3.4 FORMAL PROPERTIES OF STRESS RULES

I now turn from the descriptive generalizations of stress rule typology to the formal properties of stress rules as expressed in metrical theory.

3.4.1 Locality

Rules of stress assignment differ formally from rules that manipulate features, in several ways. While most featural rules obey constraints of locality, applying between adjacent segments or syllables, stress rules are often non-local. For instance, the rule assigning phrasal stress in English applies roughly as follows: it locates the main stress of the rightmost word in a phrase and promotes it to the strongest of the phrase. In order to locate its target, this rule must often scan several syllables, as in the phrase *hypothètical ímitators,* where the target syllable *im* is four syllables from the end. Other rules of stress assignment are comparably non-local in their application.

The non-locality of stress rules can be explicated on the basis of the hierarchical nature of metrical representation (Liberman and Prince 1977, 262–63), because in a metrical grid, the higher layers are phonologically relevant. The English phrasal stress rule amplifies the highest grid mark that is string-adjacent to the right phrase boundary (Prince 1983a, 27).

(7)
```
a.                                      b.
                                                      ×
       ×    ×                                    ×    ×
  ×    ×    ×   ×              →          ×     ×     ×   ×
  × ×  × × × ×  × × ×                     × ×  × × × ×  × × ×
  hypothetical imitators                  hypothetical imitators
```

For purposes of locality, the rule need only "see" the highest layer of the input grid. On this representation, its application is local:

(8)
```
a. [      ]  →  b. [    × ]
   [ ×  × ]        [ ×  × ]
```

The ability of metrical representations to capture superficially non-local rule application with local mechanisms is quite crucial in light of other developments in modern phonological theory. In particular, it appears that long-distance SEGMENTAL phenomena (e.g. assimilation and dissimilation) are likewise best treated as only apparent; they, too, constitute local phenomena when treated within a hierarchical model of segmental representation (see, for example, Clements 1985 and Steriade 1987). At this stage, many investigators believe that locality is a property that holds for all areas of phonology, and that the formal devices proposed in *SPE* that achieve non-local rule application on a brute force basis (e.g. parentheses, variables, ⟨ ⟩, ( )*) should be dispensed with. Metrical theory forms part of a general research program to define the ways in which phonological rules may apply non-locally by characterizing such rules as local with respect to a particular representation.

3.4.2 The Continuous Column Constraint and Its Consequences

Another property of stress rules is a tendency to exaggerate pre-existing contrasts, by making strong syllables stronger and weak ones weaker. Part of the research program in metrical phonology, initiated by Prince 1983a, is to deduce this pattern from basic theoretical postulates.

The central idea here is to impose an inviolable constraint on metrical representations, to the effect that a grid column may never have a gap. This idea, due to Prince 1983a, 33, can be expressed as in (9):

(9) **Continuous Column Constraint**
A grid containing a column with a mark on layer $n + 1$ and no mark on layer n is ill-formed. Phonological rules are blocked when they would create such a configuration.

Intuitively, the Continuous Column Constraint imposes the following requirement: if a syllable forms a rhythmic beat on a given layer, it must also form a rhythmic beat on all lower layers. As we have seen (§ 3.2.1), this principle of downward implication seems to be a basic characteristic of rhythmic structure, and thus arguably has extralinguistic motivation. In what follows, I discuss a number of areas in which the Continuous Column Constraint predicts the pattern of making the strong stronger and the weak weaker.

(A) LANDING SITES FOR STRESS SHIFT. One such area involves cases of stress shift, as in the Rhythm Rule of English (§ 2.3.4). This rule accounts for the appearance of leftward-shifted stress in certain words and phrases when a stronger stress follows, as in *thirtéen,* but *thìrteen mén;* see § 9.5 for full discussion. Prince 1983a, 33, suggests that such rules of stress shift take the form **Move X.** This rule schema can be defined as in (10):

(10) **Move X**
Move one grid mark at a time along its layer. Where Move X resolves a stress clash, movement must take place along the row where the clash occurs.

As Prince points out, the Move X schema and the Continuous Column Constraint together make the following prediction: if there is more than one possible "landing site" for a retracted stress, the site onto which stress actually retracts must be that which already bears the strongest pre-existing stress (Prince 1983a, 33). Consider for example the phrase *Sunset Park Zoo,* from § 2.3.4. In this form, the retracted stress must land on *Sun-* rather than *-set:*

(11)
```
a.                  ×                         ×
               ×    ×          ×              ×
     ×         ×    ×     →    ×        ×     ×
     ×    ×    ×    ×          ×   ×    ×     ×
     Sunset Park Zoo           Sùnset Park Zóo

b.                  ×                         ×
               ×    ×                ×        ×
     ×         ×    ×     →    ×        ×     ×
     ×    ×    ×    ×          ×   ×    ×     ×
     Sunset Park Zoo           *Sunsèt Park Zóo
```

As can be seen in (11b), if the moved /×/ were to lodge on the syllable *-set,* it would create a discontinuous grid column. Thus the Continuous Column Constraint predicts the correct landing site, *Sun-*. Note that this is an instance of "making the strong stronger."

The pattern of seeking out the highest available landing site for retracted stresses is found widely across languages. Move X and the Continuous Column Constraint derive the pattern from general principles, which is clearly an improvement over stating it as a set of language-particular idiosyncrasies.

(B) IMMOBILITY OF STRONG BEATS. Another universal predicted by Move X and the Continuous Column Constraint is that when stress clashes are resolved, it is always by movement of the weaker, rather than the stronger stress. Since Move X must occur within the layer of the clash (i.e. where neighboring ×'s occur), movement of the stronger stress cannot take place without creating a discontinuous column (Prince 1983a, 33). Thus, for example, movement is impossible in (12):

```
(12)      ×                  ×                           ×
          × ×                    × ×              ×          ×
     ×    × ×   ×    →      ×    × ×   ×          ×       × ×   ×
     ×  × ×  × ×××          ×  × ×  × ×××         ×    × ×  × ×××
   kangaroo imitators    *kangaroo imitators,  *kangaroo imitators
```

In this example, neither of the two highest ×'s on the syllable *-roo* is movable. Assuming with Prince that only one × may move at a time, the impossible output **kángaroo ìmitators* is avoided; and similarly in other cases.

(C) MAIN STRESS PLACEMENT. Another pattern of the "strong gets stronger" type is as follows: stress rule A selects some subset of the syllables of the word to bear stress; stress rule B then selects the left- or rightmost of these stressed syllables as the main stress. This is shown schematically in (13):

```
(13)                                                      ×
                       →    ×  ××  ×     →     ×  ××  ×
   σ σ σ σ σ σ σ σ       σ σ σ σ σ σ σ σ      σ σ σ σ σ σ σ σ
```

In certain cases, it can be argued that this "bottom up" stressing is the only plausible analysis, since assigning the main stress directly would lead to an extremely complex rule. Languages with this property include Cairene Arabic (§ 4.1.3), Seminole/Creek (§ 4.1.2), Wargamay (§ 6.1.4), Munsee/Unami (§ 6.3.3), Eastern Ojibwa (§ 6.3.4), and Malecite-Passamaquoddy (§ 6.3.4). The crucial point is that the Continuous Column Constraint guarantees that the higher grid mark may only be assigned to a syllable that already bears stress; otherwise, representations like (14) are derived:

```
(14) *                  ×
        ×  ××   ×
     σ σ σ σ σ σ σ σ
```

(D) DESTRESSING. The Continuous Column Constraint implies "make the weak weaker" when it governs destressing rules. As Prince 1983b and Hammond 1984a point out, such rules appear always to involve the removal of one stress on a syllable adjacent to another stress; that is, they resolve "stress clashes." Another universal property is that if the two stresses are unequal in strength, it is always the weaker stress that is removed (Hammond 1984a). Suppose that we constrain destressing in the same way that Move X is constrained above: it must apply within the layer where the clash occurs. Under such a proposal, the general schemata for Destressing in Clash are as in (15):

(15) **Destressing in Clash**
a. $\times \rightarrow \emptyset$ / ___ $\times$
b. $\times \rightarrow \emptyset$ / $\times$ ___

It is easy to see that when combined with the Continuous Column Constraint, these schemata predict that only the weaker of two adjacent stresses may delete, because application to a stronger stress would create a discontinuous column. In (16a), the cyclically assigned stress on the stem *párent* is deleted under clash with the following stress. Deleting the stronger stress (16b) is impossible: deletion on the top layer is impossible because there is no clash there, and deletion on the middle layer is blocked by the Continuous Column Constraint.

```
(16) a.   ×              ×
          × ×            ×
          × ×  ×    →   × ×  ×
        parental       parental

     b.   ×                          ×
          × ×           × ×          ×
          × ×  ×    →   × ×  ×      × ×  ×
        parental      *parental,  *parental
```

In this book, I posit destressing rules in a number of languages. In several instances I invoke the general schemata of (15), relying on the Continuous Column Constraint to ensure that the rule only removes weaker stresses adjacent to stronger, and not vice versa; see Spanish (§ 5.1.7), Egyptian Radio Arabic (§ 6.1.2), Cahuilla (§ 6.1.3), Wargamay (§ 6.1.4), Lenakel (§ 6.1.8.3), and Icelandic (§ 6.2.2.4). The same strategy has earlier been applied to Italian by Nespor and Vogel (1989).[2]

To summarize, the Continuous Column Constraint crucially constrains the application of three rule schemata: Move X, Destressing in Clash, and main stress assignment (formalized in § 3.12 as the End Rule). The interaction of these principles has as a result the general pattern noted earlier, whereby the strong get stronger, the weak weaker.

3.5. GROUPING IN METRICAL STRUCTURE

Traditional notions of rhythmic structure often attribute more to rhythm than just a hierarchy of beats: rhythm is held to involve grouping of consecutive beats into phrases as well. This is true, for instance, of the theories of musical rhythm developed in Cooper and Meyer 1960 and Lerdahl and Jackendoff

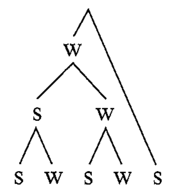
2. Looking ahead slightly, note that in a theory with bracketed grids (§ 3.5), the Destressing schemata given above would always violate the Faithfulness Condition (24). For this reason, I will assume that by convention, Destressing removes the brackets associated with the deleted grid mark.

1983. In both theories, grouping structure forms a hierarchy, corresponding closely to the hierarchy of strong and weak beats.

The existence of grouping in metrical stress theory has been the subject of a debate between "tree theory" (e.g. Liberman and Prince 1977; Hayes 1981), which includes bracketing, and "grid theory" (e.g. Prince 1983a; Selkirk 1984), which excludes it. Below, I review the evidence in favor of bracketing. First, however, I will discuss how to formalize it.

Earlier work in metrical theory (e.g. Liberman 1975; Liberman and Prince 1977; Hayes 1984) adopted a tree formalism (as in (17)) as the basic linguistic representation of stress.

(17)

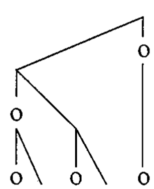


Mississippi mud

The nodes of the tree were labeled s(trong) and w(eak) to mark relative prominence; grids were essentially read off the tree, serving as a kind of extraphonological rhythmic interpretation. Subsequently, work in pure-grid theories (Prince 1983a; Selkirk 1984) made clear that grids cannot be extraphonological, since there are language-particular phonological rules that are best formulated to refer to the grid. This led to efforts to create hybrid representations, in which bracketing (i.e. tree-like) information was incorporated into the structure of the grid.

Here, I adopt representations of this type, called **bracketed grids,** as developed by Hammond 1984a and HV. Bracketed grids are similar to the pure-grid representations of Prince and Selkirk but include brackets at all layers of the grid to indicate the constituency that would appear in a metrical tree. Examples (18a, b) depict a bracketed grid for an English phrase, in the formats used by Hammond and by HV. These may be compared to the pure tree representation in (17) and the pure grid representation in (18c).

(18) a. **Bracketed Grid** (Hammond 1984a)



Mississippi mud

b. **Bracketed Grid** (HV)

```
               ×
(×             ×)
(×    ×     )(×)
(× ×)(×   ×)(×)
```

Mississippi mud

c. **Pure Grid** (Prince 1983a, Selkirk 1984)

```
                ×
×               ×
×     ×         ×
×  ×  ×   ×     ×
```

Mississippi mud

I adopt HV's representations below, altered for brevity as follows: the bottom row of /×/'s (which serve only as place markers) is eliminated, and /./ is used to mark the location of completely stressless syllables. In the grids that result, all pairs of brackets enclose just one grid mark:

(19)

```
(            ×)
(×         )(×)
(×  .)(×  .)(×)
```

Mississippi mud

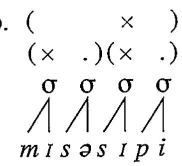
Both the HV representation and the abbreviated notation proposed in (19) are only graphic conveniences, which leave unsettled in a number of crucial cases just what is intended. I briefly describe a more precise notation here; see HV chapters 4–5 for a formalized interpretation. Taking the text *Mìssissíppi,* we first incorporate phonemic transcription and syllable nodes:

(20) a.

```
(     ×    )
(× .)(×  .)
```

Mississippi

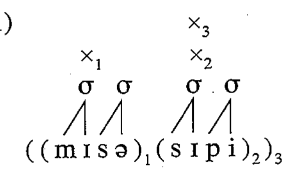
= b.



More elaborate syllable structure could be added here, depending on the theory adopted.

The next version shows the crucial step: like HV (p. 41), I regard the brackets of metrical representation as actually enclosing elements of the terminal string (with the difference that for me, the terminal string consists of actual syllables, rather than a sequence of terminal grid marks).

(21)



The form in (21) can be read: (mɪsə) is a metrical constituent (for clarity, indexed 1), whose "head" is a rhythmic beat on the lowest layer of the grid, namely the × indexed 1. (sɪpi) is a metrical constituent, whose head is $\times_2$; and (mɪsəsɪpi) is a metrical constituent, whose head is $\times_3$. Vertical alignment of ×'s and σ's has formal significance, indicating alignment of syllables and beats in time.

We will see below that in certain cases, more precise predictions can be made from the formalism if we examine "official" representations like (21), with bracketing on the terminal string. However, for clarity I normally use representations like (20a).

3.6 THE METRICAL FOOT

How are metrical bracketings determined? At the phrasal level, this is fairly straightforward: metrical bracketing is based on syntactic bracketing; or alternatively, on the phonological bracketings motivated for phrasal phonology by Selkirk 1980a; Nespor and Vogel 1986; and others. In simple morphological stress systems (§ 3.3), metrical bracketing within the word tends to be based on morphological bracketing.

The interesting cases are the systems of rhythmic word stress, where the metrical bracketing is not based on any pre-existing structure. The key to determining bracketing in such cases is a close examination of the rules that assign stress.

One of the seminal ideas in metrical stress theory is this: the best way to express stress rules might not actually be the most direct one, that is, to place stress on a particular syllable. The alternative is to state the possible structures for metrical constituents and construe stress placement as the parsing of a word into such constituents. These constituents, the minimal bracketed units of metrical theory, are called **feet.**

Let us consider a simple case: in many languages, the appropriate foot for assigning rhythmic word stress is disyllabic, with prominence on the initial syllable:

(22) (× .)
σ σ

If we parse the syllables of a word into a sequence of such feet, placing the feet adjacent to one another, we derive alternating stress: on odd syllables if the direction of parsing is from left to right (23a), and on the (2nd, 4th, 6th, . . .) from the end if parsing is from right to left (23b).

(23) a. (× .)(× .)(× .)(× .)(× .)
σ́σ σ́σ σ́σ σ́σ σ́σ . . .
⟶

b. (× .)(× .)(× .)(× .)(× .)
. . . σ́σ σ́σ σ́σ σ́σ σ́σ#
⟵

Example (23a) would correspond, for example, to the stress pattern of Pintupi (§ 4.1.1), (23b) to Nengone (§ 6.2.3). I argue in § 3.8.3 and § 4.5 that there are explanatory advantages to assigning stress by foot-parsing, rather than directly.

The notion of assigning stress by parsing into accentual units has apparently been invented a number of times independently; e.g. by Scott 1948; Lehiste 1965; Miyaoka 1971; Allen 1973; and Dixon 1977. As a formal concept within generative phonology, the foot appears in Prince 1976a; Halle and Vergnaud 1978; McCarthy 1979a, 1979b; Selkirk 1980b; and other early work. The issue of what kinds of feet exist, and what their role is in the theory, is the central one of this book.

Summing up so far, the version of metrical theory adopted here is a bracketed grid theory. It involves (a) a hierarchy of rhythmic beats, expressed as a grid; and (b) a grouping structure: feet serve as the lowest metrical constituent, and they are grouped into higher level units, which are themselves grouped into still higher units, and so on.

3.7 THE FAITHFULNESS CONDITION

What is the relation between grid structure and bracketing structure? Earlier work in bracketed grid theory (Hammond 1984a; HV) postulates that there is a one-to-one correspondence between the two: in terms of informal representations like (19), every domain encloses a single grid mark, and every grid mark is enclosed by a single domain. This requirement is termed the **Faithfulness Condition** by HV (pp. 15–16); I state it as in (24):

(24) **Faithfulness Condition**
Grid marks must be in one-to-one correspondence with the domains that contain them.

A more precise version of the Faithfulness Condition is proposed in § 9.4.2. My use of the condition basically follows HV, except that I intend to impose it as a well-formedness condition on all stages of the derivation, rather than just on the output. Thus, the condition is capable of blocking the application of rules that would create violations of it.

On occasion I will refer to the grid mark that is paired with a particular domain as the "head" of that domain, following HV.

The Faithfulness Condition makes it unnecessary to include indices (cf. (21)) in representations of metrical structure, because in a grid that obeys it, it is always possible to tell which domain is paired with which grid mark (see § 9.4.2 (30)).

3.8 ARGUMENTS FOR BRACKETING STRUCTURE IN METRICAL THEORY

Bracketing structure is harder to support empirically than grid structure, because it has no directly observable correlates. Any arguments for bracketing will necessarily be indirect; that is, by positing bracketing we can attain a deeper account of phenomena that would otherwise seem arbitrary. In this section, I review general arguments that support the existence of bracketing.

3.8.1 Deletion of Stressed Vowels

Until recently, most phonologists would not have imagined that rules of vowel deletion could apply to stressed vowels. However, recently the existence of a fair number of cases of this sort has become clear. The cases found so far behave contrary to naive expectation: the stress borne by the deleted vowel does not disappear, but migrates to the right or left.

This preservation of stress under vowel deletion is a plausible consequence of grid theory. As HV note (pp. 28–30), grid marks may be interpreted as having an existence independent of the segmental string, and thus may survive the deletion of the segments supporting them. In essence, the theory views stress as partly autosegmental (HV 5), so that one finds "stress stability" as an analogue to the well-known phenomenon of tonal stability (Goldsmith 1976). For arguments from speech errors anticipating this result, see Fromkin 1977.

What is especially interesting about these cases is that one can apparently predict whether the dislodged /×/ will reassociate with the syllable to its left or to its right. In languages whose stress pattern must be analyzed with initially stressed feet, migration is rightward; whereas in languages with finally stressed feet, migration is leftward, as shown in (25):

```
(25) a.  (×  .)(×  .)        (×  .)(   ×)
         CVCV CVCV     →     CVCV CØCV

     b.  (.  ×)(.  ×)        (×   )(.  ×)
         CVCV CVCV     →     CVCØ CVCV
```

As HV 28–30 observe, the direction of migration is a direct consequence of bracketed grid theory, in that movement in the opposite direction is excluded by the Faithfulness Condition. For example, if the stranded /×/ in (25a) moved leftward instead of rightward, the constituent on its left would have two heads and the constituent it abandoned would have none. Note that the foot bracketing is in many cases independently establishable, in that only one bracketing can account adequately for the stress pattern, so that a genuine prediction is being made here.

A number of instances of bounded stress migration have been presented in the literature and interpreted metrically: Tiberian Hebrew (Prince 1975; Churchyard 1990), Bedouin Hijazi Arabic (Al-Mozainy 1981; Al-Mozainy, Bley-Vroman, and McCarthy 1985), Bani-Hassan Bedouin Arabic (Kenstowicz 1983; Irshied and Kenstowicz 1984; § 8.10), Tripoli Arabic (§ 6.3.7), and Seminole/Creek (Tyhurst 1987; § 4.1.2).[3] Below, I discuss some additional cases: Unami (§ 6.3.3), Central Alaskan Yupik (§ 6.3.8.6), Pacific Yupik (§ 8.8.5), Asheninca (§ 7.1.8.2), and Cyrenaican Bedouin Arabic (§ 6.3.7). The Bedouin Arabic dialects are particularly instructive, in that they share one of the segmental rules that deletes stressed vowels. In Bani-Hassan and Hijazi, the

3. In addition, Halle and Vergnaud note examples of stress migration under deletion in Russian, Sanskrit, and Lithuanian. These cases carry less force because the constituency involved is unbounded (1987a, 53). As § 3.3 argues, constituency for unbounded systems is difficult to prove. In addition, the Sanskrit and Lithuanian examples involve pitch accent rather than stress, and could have an alternative tonal analysis (see discussion in Al-Mozainy, Bley-Vroman, and McCarthy 1985 and § 8.9.6).

feet can independently be shown to be stress-initial, and stress migration is to the right. In Cyrenaican, the feet are stress-final, and stress migration is to the left. This difference is predicted by the Faithfulness Condition.

A class of cases that should probably be kept distinct is those involving hiatus resolution; that is, deletion or gliding of a vowel next to another vowel. Examples of this occur in Modern Greek (/ɣríɣora **é**rxome/ → [ɣríɣor**á**rxome] 'quickly I-come'; Kaisse 1982, 66), and in Chicano Spanish (/kom**í** **u**bítas/ → [kom**yú**βítas] 'I-eat grapes'; Hutchinson 1974, 186). As Kaisse 1982 and Clements and Keyser 1983 suggest, such examples arguably involve a special mechanism: the merger of two adjacent syllables into one, with inheritance of the prosody of the input syllables. Under such an account, these examples would not necessarily be problematic for the Faithfulness Condition.

There is independent evidence from tonal phonology that hiatus resolution is carried out by syllable merger. When tones are set adrift by hiatus resolution, they do not dock at random; rather, they land on the vowel that "triggered" the deletion (Clements and Ford 1979, 207). Such an outcome follows straightforwardly if hiatus resolution is syllable merger, but would otherwise require a global constraint, so that the floating tone could "remember" the vowel that triggered its stranding.

Summing up, the migration of stress under vowel deletion appears to be predictable in a large set of cases. Where vowel deletion resolves hiatus, the mechanism is syllable merger with inheritance of prosody. In other cases of vowel deletion, stress migrates to an adjacent syllable, obeying the Faithfulness Condition.

3.8.2 Constituency in Phrasal Phonology

Bracketed grids can also explain an observation made in Hayes 1984 concerning an odd property of the English Rhythm Rule. Examples like (26) show that Move X applies to position a stress in the middle of a four-syllable interval, dividing it into two equal sequences. In this derivation, the even division of a quadrisyllabic interval takes place with the second application of Move X, going from (26b) to (26c).

```
(26) a.                         ×              b.                         ×
           ←──────────×         ×                     ×                   ×
           ×          ×         ×      →              ×        ←×         ×      →
         . ×     .    × ×       ×                   . ×    .    × ×       ×
        a hundred thirteen men                     a hundred thirteen men

     c.                         ×
           ×                    ×
           ×          ×         ×
         . ×     .    × ×       ×
        a hundred thirteen men
```

Given that rhythmic pressure for equal spacing induces the second application of Move X in this and similar examples, it is surprising that Move X should not apply in (27):

```
(27) a.                 ×              b.                    ×
                   ×    ×                  ←———————×         ×
        ←—×        ×    ×    →             ×           ×     ×    →
        × .  ×     ×    ×                  × .  ×      ×     ×
        overdone steak blues               overdone steak blues

     c.                 ×              d.                    ×
        ×      ?        ×                  ×                 ×
        ×    ←—×        ×    →             ×    ×            ×
        × .  ×     ×    ×                  × .  ×      ×     ×
        overdone steak blues              *òverdòne steak blúes
```

The transition from (27c) to (27d) is essentially the same as that from (26b) to (26c), yet (27d) and similar examples are ill-formed. The output representation must remain (27c), despite the uneven division of the quadrisyllabic interval. Arguably, there must be some overriding factor that blocks Move X in (27d). This factor must have something to do with the different phrasal bracketing of (26) and (27), as there is otherwise no potentially relevant difference between the two.

I claim that the relevant factor is the Faithfulness Condition. In (28) and (29), the examples of (26) and (27) are assigned bracketed grids based on their phrasal structure. In (28), where Move X is not blocked, both applications of the rule are confined within the constituent of which the moved element is the head, so the Faithfulness Condition is not violated:

```
(28) a.   (                   × )          b.   (            )(     × )
          (←———————  × )(  × )                  (×               )( × )
          (×      ) (  × )(  × )   →            (×      ) ( ↔× )(  × )   →
        . (×   .  ) (×)(× )(  × )             . (×    .) ( ×)(× )(  × )
        a hundred thirteen men                 a hundred thirteen men

     c.   (                   × )
          (×              )(  × )
          (×      )(×     )(  × )
        . (×   .  )(×)(× )(   × )
        a hundred thirteen men
```

But the application of Move X taking (29c) to (29d) violates the Faithfulness Condition, since the constituent *overdone* has two heads and the second-layer constituent *steak* has none. Thus the surface representation must remain as in (29c).


```
(29) a. (                × )          b. (                × )
        (           × )( × )             ( ←—————————× )( × )
        ( ←—× )(×  )( × )   →            (×          )(×  )( × )   →
        (× .)(× )(× )( × )               (× .)(× )(×  )( × )
        overdone steak blues             overdone steak blues

     c. (                × )          d. *(               × )
        (×        ?   )( × )             (×            )( × )
        (×      ←)(×  )( × )   →         (×    × )(    )( × )
        (× .)(× )(× )( × )               (× .)(× )(×  )( × )
        overdone steak blues             ˘ òverdòne steak blúes
```

This argument is made in greater detail in § 9.5.1, where the structure of the crucial input representations is defended as part of a more general theory of phrasal stress assignment.

Summarizing, the Faithfulness Condition constrains the migration of stress both (a) within the foot, when stressed vowels are deleted; and (b) within phrasal phonology, where movement is specified by versions of the rule schema Move X.

3.8.3 "Natural Classes" in Stress Rules

Another argument for constituency can be based on the typology of word stress patterns. For expository purposes I adopt here the notion of **predicted natural class.** Just as a particular theory of features predicts that certain combinations of segments will form natural classes, so does a particular parametric metrical theory predict this of certain combinations of stress patterns. In feature theory, we can test whether a predicted natural class is valid by examining the sets of segments that pattern together in phonological rules. In this section, I describe the natural classes predicted by different versions of metrical stress theory, and discuss which predicted natural classes are empirically confirmed.

Consider the stress patterns of (23), repeated below as (30): (30a) is stressed on odd-numbered syllables, counting from the left, while (30b) is stressed on the second, fourth, sixth, etc. syllables from the end.

```
(30) a.  (× .)(× .)(× .)(× .)(× .)          b.    (× .)(× .)(× .)(× .)(× .)
         #  σ́σ  σ́σ  σ́σ  σ́σ  σ́σ ...              ...  σ́σ  σ́σ  σ́σ  σ́σ  σ́σ #
           ————————→                                              ←————
```

In a theory where stress is assigned by foot parsing, these two patterns form a predicted natural class, since both involve an initially stressed disyllabic foot template:

```
(31) (× .)
      σσ
```

Another predicted natural class consists of the pair of stress patterns in (32): even-numbered syllables counting from the left (32a), and the first, third, fifth, etc. from the end (32b). Both would involve parsing with the final-stressed template in (32c).

(32) a. (. ×)(. ×)(. ×)(. ×)(. ×)
σσ́ σσ́ σσ́ σσ́ σσ́ . . .
⟶

b. (. ×)(. ×)(. ×)(. ×)(. ×)
. . . σσ́ σσ́ σσ́ σσ́ σσ́ #
⟵

c. (. ×)
σσ

Compare now a theory that predicts a different set of natural classes. In Prince 1983a, grids lack any kind of bracketing and are constructed directly by rule. Here, the predicted natural classes follow from Prince's parameter **peak first versus trough first,** meaning 'start the alternation with stress' versus 'start the alternation with stresslessness'. The peak first versus trough first system predicts the natural classes of stress patterns in (33):

(33) a. **Peak First**

i. Right to Left
× × × ×
. . . σσ́σσ́σσ́σσ́#
⟵

ii. Left to Right
× × × ×
#σ́σσ́σσ́σσ́σ . . .
⟶

b. **Trough First**

i. Right to Left
× × × ×
. . . σ́σσ́σσ́σσ́σ#
⟵

ii. Left to Right
× × × ×
#σσ́σσ́σσ́σσ́ . . .
⟶

What facts might we use to assess different predicted natural classes? First, consider cases where a language has two stress rules, assigning stress in different contexts. If the foot structure of a language forms a basic organizing principle of its phonology (see § 4.5.3, § 5.4.1), then we would expect that the two rules should typically use the same foot type, and the stress patterns defined in (30) and (32) will be empirically confirmed as natural classes.

Lenakel (§ 6.1.8) is a case that bears on this issue. In Lenakel, the pattern of (30a) is found in verbs and adjectives, whereas the pattern of (30b) is found in nouns. Other languages that have both (30a) and (30b) in different contexts include Modern Greek (§ 6.2.3), Polish (§ 6.2.3), Auca (§ 6.2.1), and Southwest Tanna (§ 6.1.9).

This asymmetry has an immediate formal interpretation in the foot theory: the foot type is (31), and it may be assigned in both directions. In a theory without constituency, there is no plausible account of the co-occurrences. In particular, we must suppose that for some reason the peak first/trough first parameter switches its value whenever direction is reversed. There appear to be no languages that show the predicted natural classes of the peak first/trough first theory.

A second way to test the predicted natural classes of a stress theory is

through typology. It turns out that stress patterns that can be described by (31) occur widely, in either direction (§ 6.2), whereas stress patterns derived by (32c) are quite rare (§ 6.3.11). The foot-based theory can state that the unmarked foot type is (31), thus capturing the generalization about markedness in a single statement. In contrast, a theory based on the notion of peak first versus trough first must suppose that (for some reason) peak first alternation is unmarked from left to right, but trough first from right to left.

3.8.4 Prosodic Morphology

Another source of evidence for grouping in metrical structure is the role it plays in the theory of **Prosodic Morphology** (McCarthy and Prince 1986, 1990). The central notion of this theory is that the categories that are relevant for templatic morphology (i.e. reduplication, Semitic-type word formation, truncation, etc.) are precisely the categories made available by prosodic theory in general, including mora, syllable, and prosodic word.

Crucially for present purposes, the set of categories also includes a purely metrical constituent, the foot. As McCarthy and Prince show, many templatic morphological processes have the foot as their prosodic target; in fact, the set of feet they suggest as the set of targets coincides precisely with the feet that I argue for here (chap. 4) on the basis of stress.

Typically (though not universally), the kind of foot required by a language's morphological system is the same as that required by its stress system; thus in many languages where stress is derivable using the foot of (31), reduplication is carried out by copying the first two syllables of a word, that is, by parsing out a foot. Such connections could not be made under a theory of stress where stress is simply assigned to the appropriate syllables.

3.8.5 Word Minima

The following argument is due to McCarthy and Prince 1986. In many languages, there is a minimum placed on the size of a word. For example, in Mohawk (Michelson 1988), every content word must contain at least two syllables. In Fijian (§ 6.1.5), every word must contain at least two moras; that is, it must consist of at least one heavy syllable or two lights (for heavy and light syllables, see § 3.9.2). In the version of metrical theory developed here, these requirements can be stated simply as the requirement that every word contain at least one foot. The connection between the two can be made straightforwardly if the stress assignment rules work by parsing syllables into feet (i.e., every word must undergo parsing); but is arbitrary under a theory that has no bracketing, and whose rules simply place stress in the right locations.

This argument has a potential hole in it: we might say as an alternative that in languages with word minima, EVERY WORD MUST BE ABLE TO UNDERGO THE STRESS RULE. For example, in Mohawk the word minimum is two syllables, and the stress rule, stated without bracketing, is as in (34):

(34) $\sigma \rightarrow \overset{\times}{\sigma} \;/\; \_\_\_\_ \; \sigma\,]_{word}$

The principle that every word must be stressable would also establish a connection between word length and stress pattern.

To see why this alternative will not work, consider cases like Bidyara/Gungabula, Pitta-Pitta, and Wangkumara, all from § 6.2.3. Here, the word minimum is again two syllables, but stress is different, falling on the first, third, fifth, etc. syllables. In parsing terms, we would say that the feet are disyllabic and initially stressed:

(35)
$$\begin{array}{l} (\times\ .)(\times\ .)(\times\ .)(\times\ .)(\times\ .) \\ \#\ \sigma\sigma\ \sigma\sigma\ \sigma\sigma\ \sigma\sigma\ \sigma\sigma\ \ldots \\ \longrightarrow \end{array}$$

The word minimum matches the foot that is needed for stress assignment. Now, in a theory that lacks bracketing, the stress rules would be something like this:

(36) a. **Main Stress** b. **Secondary Stress**

a. $\sigma \rightarrow \overset{\times}{\underset{}{\overset{\times}{\sigma}}} \;/\; [_{word}\ \_\_\_\_$

b. $\sigma \rightarrow \overset{\times}{\sigma} \;/\; \sigma\, \overset{\times}{\sigma}\ \_\_\_\_$ (iterative)

Such a theory fails to exclude monosyllables, since they can perfectly well undergo the main stress rule (words do not have to undergo the secondary stress rule, as is shown by the absence of secondary stress in disyllables). The upshot is that only a bracketing-based theory of stress can capture connections between stress patterns and word minima.

3.8.6 Summary

The arguments above—stress shift under deletion, phrasal stress shift, foot typology, prosodic morphology, and word minima—are what I take to be the main general reasons for adopting bracketing structure in metrical theory. There are also interesting language-specific arguments in the literature, summarized below: see Everett 1988 on Pirahã (§ 7.1.7) and Leer 1989 and Rice 1990 on Pacific Yupik (§ 8.8).

3.9 SYLLABLES AND SYLLABLE QUANTITY

The metrical theory of stress is tightly bound up with the theories of syllable structure, particularly those aspects of syllable theory concerned with weight. I review relevant parts of such theories below.

The general relevance of syllables to rules of stress assignment has long been clear (see for instance McCawley 1974; Kahn 1976). A theory in which stress rules refer only to the structural properties of syllables is far more constrained than a theory (such as that of *SPE*) in which stress rules refer directly to segments. In addition, the attempt to write stress rules using segments alone

often leads one to recapitulate the syllable structure of the language in virtually every stress rule one writes. An example of this loss of generality is found in *SPE,* where the recurring expression for a "weak cluster" introduces the principles of English syllable division on an ad hoc basis into several of the English stress rules.

3.9.1 The Syllable as Stress-bearing Unit

Following earlier work (e.g. Jakobson 1931), I adopt the view that in stress languages, the stress-bearing unit is the syllable. This means, for instance, that in disyllabic words there are only two possibilities for stress placement, irrespective of how many segments the word contains. Formally, I assume that syllables are the units which are grouped together in metrical structure and to which grid marks are associated.

Halle and Vergnaud's view on stress-bearing units is quite different: they argue that stress rules may include statements of the form "the stress-bearing elements are X," where X can be for example vowels (HV, p. 49), phonemes in the rhyme (p. 61), or lexically designated segments (p. 193). I suggest that this proposal states as part of language-particular grammars what arguably should be part of universal grammar. It seems unlikely that we would ever find a language in which the stress-bearing units are consonants, or nasals, or coronals, and so on.[4] The phenomena that lead HV to suppose that segments can be stress-bearing can be better accounted for by adopting an explicit theory of syllable structure and syllable weight.

There are in fact languages in which actual contrasts of accentual pattern within the syllable may be found; that is, a heavy syllable may have rising or falling prominence. Examples include Ancient Greek, Lithuanian, Hopi, and some dialects of Serbo-Croatian. Superficially, such languages might be taken as evidence that units smaller than the syllable may bear stress. However, these cases have traditionally been analyzed as **pitch accent** languages (see, for example, Jakobson 1931). In generative phonology, they can be treated as involving tonal representations within the word phonology, either in addition to or instead of metrical representations. An example is Lithuanian, analyzed by HV (pp. 190–203) as involving segment-level stress, but by Halle and Kiparsky 1981 and Blevins 1991 as involving tone.

From the evidence of pure-tone languages, it is uncontroversial that tones may associate to elements smaller than the syllable. Because pitch accent languages are tonal in character, they do not counterexemplify the claim that the STRESS-bearing unit is universally the syllable.

The invocation of pitch accent is not some kind of terminological escape hatch. Pitch accent languages must satisfy the criterion of having **invariant**

4. Cohn 1989, 174–75, suggests that the schwa vowel of Indonesian is non–stress-bearing, which would force us to add to the grammar of this language a statement that only syllables with full vowels may bear stress. However, Cohn notes the possibility that schwa in Indonesian is epenthetic, which would also account for its stresslessness.

tonal contours on accented syllables, since tone is a lexical property. This is not so for pure stress languages, where the tonal contours of stressed syllables can vary freely, being determined postlexically by the intonational system (cf. chap. 2, (8)). In § 8.9, I discuss a case where an improved metrical analysis is made possible by dealing explicitly with the tonal component of a pitch accent system.

Besides disallowing stress-bearing units smaller than the syllable, I also follow earlier work (e.g. Prince 1976a) in assuming that rules of foot construction may not split syllables; for example, we cannot allow the first part of a heavy syllable to belong to one foot and the second part to belong to the next. For further discussion, see § 3.11, § 5.6.2, and § 6.1.3.

3.9.2 Syllable Weight

Among the more interesting stress rules are those that refer to a distinction between **heavy** and **light** syllables. By this it is meant that all syllables may be grouped into two such classes, and it is the class membership (heavy or light) of a syllable, rather than its segmental content, that determines the syllable's influence on stress. Heavy syllables characteristically attract stress, whereas light syllables receive stress only in the absence of an eligible heavy syllable.

A well-known example is the stress rule of Latin. In Latin, a syllable is heavy if it contains a long vowel or if it is closed; otherwise it is light. Words with a heavy penultimate syllable receive penultimate stress, words with a light penult receive antepenultimate stress, and in all cases where a word is too short to obey these laws, stress falls as far as possible to the left. The examples below are from Mester 1992 and Jacobs 1989, 7.

(37) a. **Heavy Penultimate Syllable, Penultimate Stress** (CVː)

a.míː.kus	'friend, kind'
gu.ber.náː.bunt	'they will reign'

b. **Heavy Penultimate Syllable, Penultimate Stress** (CVC)

or.na.mén.tum	'equipment'
sa.pi.én.teːs	'wise (nom.pl.)'

c. **Light Penultimate Syllable, Antepenultimate Stress**

i.ni.miː.kí.ti.a	'hostility'
sí.mu.laː	'simulate (2 sg.imp.)'
do.més.ti.kus	'belonging to the house'

d. **Initial Stress in Disyllables**

mán.daː	'entrust (2 sg.imp.)'
ká.nis	'dog'
hé.ri	'yesterday'

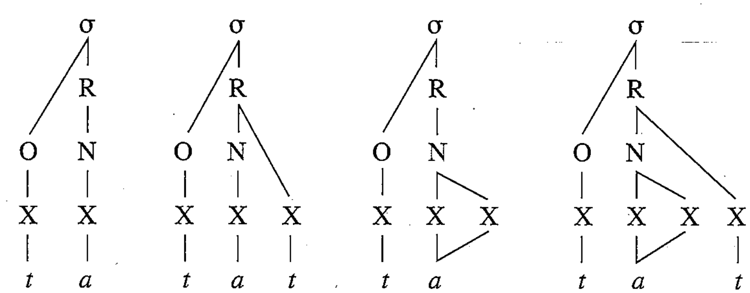
Note that for purposes of weight computation, the segment count of a syllable is quite irrelevant, in that a light syllable can sometimes have more segments than a heavy one; thus /tri/ is light but /iː/ and /it/ are heavy.

The Latin weight system, where closed syllables are grouped together with long-voweled syllables in the heavy class, is quite common across languages. The other system that is commonly found is a division between long-voweled and short-voweled syllables, irrespective of whether a syllable is closed. An example is St. Lawrence Island Yupik (§ 6.3.8.1). Numerous examples of both types appear in this book.

What is common to both systems is the principle that prevocalic segments in the syllable (i.e. onset segments) are **prosodically inert:** that VC is prosodically equivalent to CVC and CCVC, Vː to CVː and CCVː, and so on. While this claim is not fully valid at the observational level (§ 7.1, § 7.4), it is so well supported across languages that it serves as the central observation for formal theories of syllable weight.

Two approaches dominate such formal theorizing. In the theory of syllabic constituency (Pike and Pike 1947; McCarthy 1979a; Levin 1985a), the syllable is assigned a particular internal constituent structure, and it is stipulated that only certain constituents may be prosodically active. If constituents like those in (38) are assumed, then the heavy/light distinction exemplified by Latin may be characterized as **branching versus non-branching rhyme.** The weight criterion that counts vowel length only may be characterized as **branching versus non-branching nucleus.** The representations below use an X-tier (Prince 1984; Levin 1985a) as a representation for the segmental level; a long segment is interpreted as a single feature complex linked to two X-slots (O = Onset, R = Rhyme, N = Nucleus).

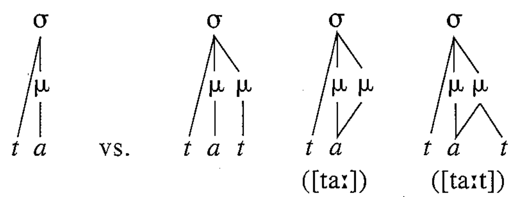
(38) a. /ta/ b. /tat/ c. /taː/ d. /taːt/



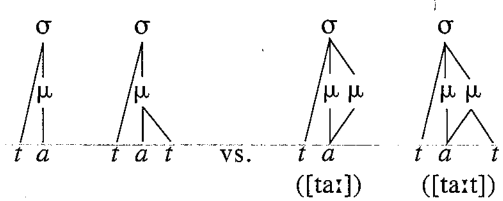
a.	b.	c.	d.
1 segment in Nucleus and Rhyme:	1 segment in Nucleus; 2 segments in Rhyme:	2 segments in Nucleus and Rhyme:	2 segments in Nucleus and Rhyme:
light everywhere	heavy in Latin; light in St. Lawrence Island Yupik	heavy everywhere	heavy everywhere

Another approach is to posit explicit units of syllable weight in the representation, namely, moras (McCawley 1968; Prince 1976a, 1983a; van der Hulst 1984; Hyman 1985; McCarthy and Prince 1986; Hayes 1989b; J. Ito 1989; Zec 1988). In this approach, the segments that are prosodically active in a particular language are marked as such by assigning them a mora (or two, for long vowels). The moras are the units to which metrical structure may refer. Cross-linguistic differences in the criterion of syllable weight are expressed by language-specific conditions on mora assignment: languages like Latin allow a postvocalic consonant within the syllable to bear a mora (symbolized /μ/), whereas languages like St. Lawrence Island Yupik do not. Thus weight distinctions can be made on the basis of the mora count of a syllable:

(39) a. **CV Light; CVC, CVV, CVVC Heavy**



b. **CV, CVC Light; CVV, CVVC Heavy**



Hayes (1989b) uses the term **Weight by Position** to refer to the rule or principle of syllabification that assigns a mora to a postvocalic consonant within the syllable; thus (39a) illustrates a language that has Weight by Position; (39b), a language that lacks it. Crucially, in no language is a mora licensed by an onset consonant, which accounts for the universal absence of syllable quantity distinctions based on onsets (for discussion of apparent exceptions, see § 7.1, § 7.4).

The debate concerning how syllable weight is to be represented (constituency theory vs. moraic theory) is bound up with a related debate concerning the representation of contrastive segment length. The syllabic constituency theory is characteristically coupled with an "X-theory" account of segment length, where the length of a segment is depicted by the number of X's it is associated with. In moraic theory, the syllabic terminals are usually fewer in number than the segments, and long segments are defined simply as multiply

linked. Note that a moraic theory could in principle invoke syllabic constituents, too. But since the main purpose of constituency is to depict weight, and this can be done by the moras alone, moraic theories usually dispense with constituency.

There are two central arguments in favor of the moraic theory.

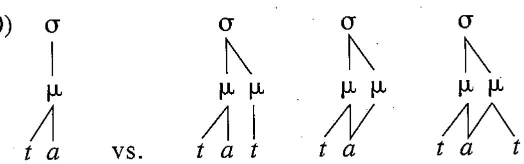
First, there is the argument of **counting,** from McCarthy and Prince 1986. Phonological processes that count moras are commonplace: stress assignment, weight-based segmental rules, minimal word requirements, quantitative meter. But it appears that there are no phonological processes that count segments, in the sense defined by X-theory. Such a process would treat, for example, the strings /aː/, /ta/, and /at/ as equivalent, since they all bear two X's. Moraic theory predicts this absence, since its representations do not depict segment count.

Second, there is the argument from **moraic conservation,** stated in its most general form in Hayes 1989b. I define a compensatory process as one in which one segment is shortened or deleted, with another becoming simultaneously longer. The world's languages include a very wide array of such processes. Crucially, in every case, the number of moras in the input string is equal to the number of moras in the output. Moraic theory derives this result straightforwardly, under the assumption that compensatory processes are expressed as the rearrangement of segmental material with respect to an invariant moraic frame. In contrast, compensatory processes do not conserve the number of X's in the representation, so the law of moraic conservation is essentially an accident under the X-theory.

For these reasons, I use moraic theory here as the account of syllable weight. However, recent work has made it clear that moraic theory in the pure form described above is insufficiently powerful as a theory of syllable weight; in particular, it cannot account for languages in which both criteria for heavy syllable status are found for different phonological processes (Crowhurst 1991a; Steriade 1991). Two options, then, are to try to constrain X-theory appropriately, or to try to extend moraic theory to account for multiple criteria of syllable weight. Since the former strategy seems unworkable, I pursue the latter here; see § 7.3.

Moraic theory comes in more than one version. In the representations of (39), onset consonants are attached to the syllable node, following McCarthy and Prince 1986 and Hayes 1989b. Another possibility (Hyman 1985; Zec 1988; J. Ito 1989; Katada 1990) is to attach onset consonants to the initial mora, as in (40), a revised version of (39a):

(40)



The arguments in favor of associating onsets to the syllable nodes (see Steriade 1988a and Hayes 1989b, 298–99, for review) hinge on the need to depict formally the notion **weight-bearing segment.** That is, we want the representations in (40) to indicate that it is the vowel /a/ that is weight-bearing, not the preceding consonant. Possibly some other means could be adopted to do this (e.g. by labeling the segmental daughters of a mora for relative sonority, as in Kiparsky 1979). Assuming this is the case, we can adopt representations like (40), where onsets belong to the first mora. These seem conceptually simpler for purposes of stress assignment, since to determine weight one can simply count the daughters of the syllable node, without any kind of stipulation that onsets are ignored.

Although this book uses moraic representations, I emphasize that many of the issues to be addressed are independent of any particular theory of syllable quantity (i.e. any theory that encodes the distinction between light and heavy syllables). To underscore this, in the representations of metrical structure I will usually just use the traditional symbols macron /–/ and breve /◡/ to designate heavy and light syllables respectively.

3.10 PARAMETRIC METRICAL THEORY

A notion that has been crucial to metrical studies of word stress is the idea of **parameterizing** the theory. In a parametric theory, a rule system is regarded as a particular choice from a limited list of options, or parameters. To give an idea of the kind of parameters that have been proposed, here is a sample list, incorporating proposals from throughout the literature.

(41) a. **Choice of foot type**

i. SIZE	Maximally unary/binary/ternary/unbounded
ii. QUANTITY SENSITIVITY	Heavy syllables (may/may not) occur in weak position of a foot
iii. LABELING	Feet have (initial/final) prominence
iv. OBLIGATORY BRANCHING	The head of a foot (must/need not) be a heavy syllable

b. **Direction of parsing** Left to right/right to left
c. **Iterativity** Foot construction is (iterative/once only)
d. **Location** (Creates new metrical layer/applies on existing layer)

By setting all the relevant parameters, one derives a stress rule. For example, the alternating stress rule found in one variety of Hungarian (§ 8.6) sets the parameters as in (42):

(42) a. i. Feet are maximally binary.
ii. Heavy syllables may occur in weak position.

iii. Feet have initial prominence.
iv. The head of a foot need not be a heavy syllable.
b. Parsing is left to right.
c. Foot construction is iterative.
d. Creates new layer.

This set of parameter settings places stress on odd-numbered syllables, going from left to right:

(43) (× .)(× .)(× .)(× .)(× .)
σσ σσ σσ σσ σσ . . .
⟶

A parametric theory can be contrasted with a theory such as that of *SPE* or the syntactic theory of Chomsky 1965: such theories posit a set of primitives with which rules may be expressed, and all rules are allowed which are well-formed combinations of those primitives. A parametric theory is usually more constrained and capable of stronger predictions.

An interesting problem within parametric metrical theory is to what extent the parameters characterize rules versus grammars. Here, we will conservatively assume that parameters characterize rules. However, the possibility that they have more general scope, as suggested by HV, is an appealing one: for example, it predicts that when more than one rule creates feet, the feet created should be the same. This in general appears to be true, though a difficult case is found in Onondaga, § 6.3.11.

A proposed parametric theory of stress is successful to the extent that it is well defined, is maximally restrictive, and is capable of describing all the stress systems of the world's languages. The latter criterion is the most difficult, as the stress systems of many languages are remarkably complex. A theory that reduces such complexity to a small set of general principles is a substantial result. Moreover, such a theory may help account for the ease with which children acquire complex stress systems, in that a system can be learned by setting the parameters one by one (Dresher and Kaye 1990).

Important early work in parametric metrical stress theory includes Prince 1976a, 1976b, McCarthy 1979b, and perhaps most influentially, Halle and Vergnaud 1978. Halle and Vergnaud laid out a number of parameters, including choice of foot shape, labeling conventions, parameters for the representation of quantity, and the **Obligatory Branching** parameter (41a.iv).

Hayes 1981 attempted to extend the parametric research program along two fronts: to broaden the database, and to constrain the theory by cutting back on the range of parametric choices. Most crucially, Hayes argued that the inventory of foot templates can be limited to **binary** and **unbounded,** with ternary templates excluded. Since the number of logically conceivable ternary templates is quite large, the exclusion of ternary units has a correspondingly large constraining effect on the theory. A brief review of the Hayes 1981 theory, comparing it to the present proposal, appears in § 4.3.1.

The central content of this book is a parametric theory, presented in the next two chapters. On the basis of the typology of rhythmically based bounded stress rules, I attempt to develop a theory that matches the data closely, at the same time being as constrained as possible. The theory shares some of the foot types proposed in earlier theories but is quite different in various other respects.

3.11 EXTRAMETRICALITY

The proposal I make here inherits from Hayes 1981 the restriction that feet come in only two maximal sizes, binary and unbounded. Such a restriction appears to be tenable only if the theory includes a subtheory of **extrametricality.** I briefly review this subtheory here.

To begin with an example, Estonian (§ 8.5) has a complex stress system that refers to the distinction between light (CV) and heavy (CVC, CVː, and longer) syllables. I will not review the Estonian rules here, but note only the following crucial fact: in word-final position, a special definition of heavy versus light is used: final CVC counts as light rather than heavy.

To illustrate this fully would require complete discussion of the Estonian stress pattern. Instead, I will use the diagnostics in (44), which are justified and refined in § 8.5.

(44) a. **Nonfinal Syllables** The third syllable of a word may be stressless only if it is light.

b. **Final Syllables** If the third syllable is also the final syllable, it is stressless if light and stressed if heavy.

These diagnostics seem arbitrary in isolation but fall into place in a complete analysis. The examples in (45) illustrate the basic pattern (page references from Hint 1973).

(45) a. **CV Is Light in All Contexts**

Nonfinal:	*pímestavàle* (or *pímestàvale*)	H 161
Final:	*ósava*	H 157

b. **CVC Is Heavy in Nonfinal Syllables, Light Finally**

Nonfinal:	*válusàttele* (only)	H 161
Final:	*pálaval*	H 157

c. **CVV Is Heavy in All Contexts**

Nonfinal:	*váraseìmattèle* (only)	H 163
Final:	*lúːlettài*	H 157

d. **CVCC Is Heavy in All Contexts**

Nonfinal:	(no examples found)	
Final:	*sóːyemàks*	H 157

The crucial case is (45b), where CVC is shown to be heavy nonfinally but light finally. Parallel examples where final CVC is exceptionally light occur in English (Hayes 1982b), Arabic dialects (McCarthy 1979a; § 4.1.3; § 6.1.1; § 6.1.2), a dialect of Hindi (Hayes 1981, 79–81, citing Mohanan 1979), Spanish (Harris 1983, 1992), Romanian (Steriade 1984), Ancient Greek (Steriade 1988b), and Menomini (§ 6.3.4).

A unitary treatment of syllable weight in final versus nonfinal position is possible if we are allowed to stipulate that the relevant rules IGNORE a consonant in final position. In (46) I give some abstract forms for final Estonian syllables. The notation ⟨ ⟩ surrounding a consonant (adopted from HV) means that the consonant is ignored:

(46)

a. **Final Position**		b. **Nonfinal Position**	
CV	=	CV	(light)
CV⟨C⟩	=	CV	(light)
CVC⟨C⟩	=	CVC	(heavy)
CVː	=	CVː	(heavy)
CVː⟨C⟩	=	CVː	(heavy)

A formal basis for this procedure is provided by the theory of **extrametricality rules.** Extrametricality as a notion of metrical theory was put forth by Liberman and Prince 1977, and the idea of general rules of extrametricality was proposed in Hayes 1979. Subsequent work in this area includes Hayes 1981; Harris 1983; Archangeli 1984; Poser 1984, 1986; Franks 1985, 1989; Pulleyblank 1986b; Ito 1986; HV; Sauzet 1989; Inkelas 1989; Barker 1989; Buckley 1991; and Roca 1992. An extrametricality rule designates a particular prosodic constituent as invisible for purposes of rule application: the rules analyze the form as if the extrametrical entity were not there. Thus in Estonian, final consonants are extrametrical.

To keep this notion as constrained as possible, Hayes 1981 proposed the restrictions on extrametricality in (47):

(47) a. **Constituency** Only constituents (segment, syllable, foot, phonological word, affix) may be marked as extrametrical.

b. **Peripherality** A constituent may be extrametrical only if it is at a designated edge (left or right) of its domain.

c. **Edge Markedness** The unmarked edge for extrametricality is the right edge.

d. **Nonexhaustivity** An extrametricality rule is blocked if it would render the entire domain of the stress rules extrametrical.

Constraint (47b) was first expressed as a well-formedness condition (rather than as a constraint on the format of extrametricality rules) by Harris (1983), who referred to it as the **Peripherality Condition;** I follow Harris's conception and terminology here. Provision (47c) is supported by a very strong skewing toward right-edge extrametricality in the attested examples. Provision (47d) is included to allow stressing of monosyllables in languages with syllable extrametricality.

Somewhat tentatively, I exclude "mora" from the list in (47a), based on the absence of plausible cases. Unambiguous cases of mora extrametricality can be excluded by rigorous enforcement of the principle that foot boundaries cannot occur syllable-internally (§ 3.9.1). In this view, extrametricality theory comprises two domains: there is segmental extrametricality, which exempts segments from mora assignment, and higher level extrametricality, which exempts syllables and feet from rules creating metrical structure (cf. Roca 1992). For discussion of a possible counterexample, see § 4.1.3.

Here is an example of syllable extrametricality: in Macedonian and other languages listed in § 6.2.3, stress normally falls on the antepenultimate syllable of a word (and on the initial syllable of shorter words). This can be derived by marking final syllables as extrametrical, then forming a binary, left-strong foot:

(48) (× .)
. . . σσ ⟨σ⟩ #

The notation used here for extrametricality rules is given in (49):

(49) $X \rightarrow \langle X \rangle / \_\_\_]_D$

where X is some phonological constituent and $]_D$ is the edge of the domain (usually the word) of the stress rules. This notation is used only in the interest of clarity, since it includes several redundancies: (a) the identity of D is given by the stress rules in general; (b) adjacency to $]_D$ is invariantly required by the Peripherality Condition; (c) given the markedness of left-edge extrametricality, the fact that we have $/\_\_\_]_D$ instead of $/ [_D \_\_\_$ can be assumed as a default specification, in the sense of Archangeli and Pulleyblank, in press.

Extrametricality strikes many people as intuitively non-obvious. Thus special thoroughness in marshaling formal arguments in favor of it is required.

(a) Extrametricality permits a sharp reduction in the class of possible foot templates. For example, it is the principal mechanism that makes it possible to eliminate basic ternary templates from metrical theory (for the residual cases, see chap. 8). A simple example is the case of antepenultimate stress just mentioned, where the extrametricality account permits us to dispense with the ternary template (50a). Syllable extrametricality also allows us to dispense with the ternary template (50b) for Latin and similar cases (§ 5.1.4):

(50) a. (× . .) b. (× . .)
σ σ σ σ ᴗ σ

The crucial point is that what looks like stress assigned by the templates of (50) is in fact found only where the templates would occur at the right edge of a word. A better strategy is to analyze the word-final cases with extrametricality. This avoids foot templates that, when used other than word-finally, generate totally unattested stress systems. For example, if we parse words iteratively from left to right with (50b), we derive a stress system that is nowhere attested.

(b) In measuring syllable weight, word-final position is likewise often a special case: a word-final syllable must have more consonants to be counted as heavy, since word-final consonants are often extrametrical.

(c) Extrametricality is crucial to the theory of syllabification in Ito 1986, which posits that the convention of **Stray Erasure** (Harris 1983) applies to any segment that is neither syllabified nor extrametrical. This allows Ito to derive cases of consonant deletion previously thought to require idiosyncratic deletion rules.

(d) In various languages different lexical classes (e.g. nouns vs. verbs, regular vs. exceptional words) have distinct but related stress patterns. Extrametricality permits us to capture the unifying principles of such systems with the foot template and parsing algorithms, while characterizing the distinct aspects of stress in different lexical classes with extrametricality. Instances of this may be found in English (Hayes 1982b), Spanish (Harris 1983, 1992; den Os and Kager 1986), Romanian (Steriade 1984), Onondaga (Chafe 1977, 175; § 6.3.11), Yawelmani (Archangeli 1984), Djingili (§ 6.2.3), central Macedonian dialects (Franks 1987, 141), Chamorro (Chung 1983), Lenakel (§ 6.1.8), Polish (§ 6.2.3), Paamese (§ 6.1.9), Pirahã (§ 7.1.7), and Cayuvava (§ 8.2). In a dialect of Hindi (§ 6.1.7), optional extrametricality creates free variation in stress.

(e) The Peripherality Condition accounts for cases in which idiosyncratic stressing of a stem is replaced by regular stressing when a suffix is added, as in Spanish, Polish, Yawelmani, and Chamorro. Once suffixation has taken place, an idiosyncratically extrametrical stem-final syllable is no longer peripheral and thus loses its extrametricality. The normal stress rules then apply.

(f) Extrametricality permits a simple account of stress rules that include **avoidance clauses** (Hayes 1982b). In such languages, stress is assigned from the left edge of the word, with an overriding proviso that it not fall on final syllables. Such cases can be analyzed with a normal stress rule computing stress from the left, but with final syllables extrametrical.

(g) As Prince 1983a showed, extrametricality permits a simplification in the theory of **labeling rules,** the rules that determine prominence relations within a single domain. In early metrical theory, it was thought that there must be four basic algorithms:

(51) **Labeling Rules** (Halle and Vergnaud 1978)
  a. Rightmost elements are strong.
  b. Leftmost elements are strong.
  c. Rightmost elements are strong if and only if they branch.
  d. Leftmost elements are strong if and only if they branch.

(An element is said to branch if it contains more than one constituent.)

An example of a rule that was believed to require reference to branching is that responsible for labeling the word layer in English nouns: here, the right node is normally labeled strong if it branches, as in (52a), but if the right node does not branch, prominence lands on a foot to its left, as in (52b):

(52) a. **Branching**
```
( × )
(× .)(× .)
Ìsidóra
```
b. **Non-branching**
```
(×      )
(× .)(× )
Ísidòre
```

Now, on independent grounds it can be shown that the last syllable of English nouns is extrametrical: nouns often display antepenultimate stress, which Hayes 1982b derives in the manner of (48). Assuming that extrametrical elements are not accessible to word layer labeling, the correct outcome is obtained simply by placing the /×/ of the word layer on the rightmost VISIBLE subordinate /×/ at the foot layer, invoking the simpler "right strong" labeling procedure:

(53) a.
```
(   ×)
(× .)(×)
Ìsidó⟨ra⟩
```
b.
```
(× )
(× .)(×)
Ísi⟨dòre⟩
```

As Hayes 1982b notes, the morphological classes that allow antepenultimate stress are approximately the same as those which (in the earlier account) require the "right strong if branching" algorithm (the others simply use "right strong"). This correlation follows directly from the extrametricality account.

All the other cases that earlier appeared to require labeling based on branching can likewise be reanalyzed using extrametricality or other means (see for example Prince 1983a for English compounds, § 4.1.2 for Seminole/Creek, § 4.1.3 for Cairene Arabic, § 7.1.8.4 for Asheninca, and Barker 1989 and § 6.3.10 for Turkish). Thus extrametricality permits labeling theory to be simplified, limiting it to the two fundamental cases "right strong" and "left strong."

It can be seen that the range of phenomena for which extrametricality can provide a formal account is fairly broad. For more on extrametricality, see § 5.2.

3.12 LABELING RULES

As just noted, extrametricality theory makes possible a very simple account of how prominence relations among feet are established. Adapting the terminology of Prince 1983a, I use the term **End Rule (Left/Right)** to describe a metrical rule with the effects listed in (54):

(54) **End Rule (Left/Right)**
  a. Create a new metrical constituent of maximal size at the top of the existing structure.
  b. Place the grid mark forming the head of this constituent in the (leftmost/rightmost) available position.

The English word layer rule can be seen as an instance of End Rule Right, moderated by syllable extrametricality. The notion **available position** in (54b) means a position where a grid mark may be placed without violating the Continuous Column Constraint (9). We will see reasons for revising the End Rule later on (§ 9.4), but for the moment (54) will suffice.

A large number of languages have simple initial or final stress; see the listings in Hyman 1977b. Where there is no secondary stress (e.g. as in Bengali; Hayes and Lahiri 1991a), stress can be assigned exclusively by the appropriate End Rule.

3.13 CONCLUSION

This review of the typology and theory of stress has covered: (a) parallels between stress and rhythmic structure, and how they are characterized in grid notation; (b) universal patterns of stress behavior and how they are characterized by grid theory, particularly by the Continuous Column Constraint; (c) the evidence for including grouping structure in metrical representations (i.e. bracketed grids); (d) the notion of a parametric metrical theory, with an inventory of foot templates as its central content; (e) theoretical notions crucial to parametric metrical theory: syllable weight and its formal representation, extrametricality rules, labeling rules. In the next two chapters, I present a proposal for a parametric metrical theory of word stress rules.