10 Stress

In this chapter and the next we return to the subject of prosody, examining processes that group syllables (or perhaps more accurately, syllabic nuclei) into larger metrical units. The leading idea pursued in chapter 10 is that stress (especially word stress) reflects such a grouping. Chapter 11 explores the hypothesis that processes of reduplication, truncation, and infixation also parse the string of segments into metrical constituents as a function of its syllable structure.

The discussion of stress in this chapter begins with a brief overview of the subject in generative grammar. We will then see that stress is not properly speaking a feature analogous to [nasal] or [voiced] but rather an abstract relation of prominence. Section 10.2 will introduce a graphic notation for stress (the metrical grid) that accounts for many of its special properties. In sections 10.3–10.5 we will survey the major stress patterns found in the languages of the world. Two competing models for casting these stress patterns in terms of the grid will be considered: one (developed by Halle and Vergnaud (1987) and independently by Hammond (1984)), crucially relies on metrical grouping, while the other (explored by Prince (1983), Selkirk (1984), and others) does not explicitly refer to grouping. In section 10.6 we will discuss some of the evidence that supports the grouping theory. Sections 10.7 and 10.8 will introduce the Halle-Vergnaud theory's device of conflation, which brings languages with just one stress per word into the metrical fold. In section 10.9 we will examine evidence that alternating stress is a rhythmic phenomenon. In section 10.10 we will compare the rhythmic and Halle-Vergnaud conceptions of stress with respect to several analytic and theoretical issues. Finally, in section 10.11 we will consider certain extensions and simplifications of the Halle-Vergnaud model that manipulate metrical brackets.

10.1 Background and Basic Properties

As with other aspects of phonological structure, the chief theoretical problem posed by stress is to discover a representation which permits the facts to be stated clearly so that generalizations emerge which provide the basis for an explanatory theory. The study of stress has been pursued from the beginning of generative grammar (Chomsky, Halle, and Lukoff 1956) and has always played an important part in the theory. Before we examine the contemporary conception of stress, a brief historical setting is in order. Since the work of Trager and Smith (1951), Newman (1946), and other structuralists, it was well known that English speakers

can make quite subtle judgments about degrees of stress that correlate systematically with internal syntactic constituency. For example, the three-morpheme string composing *light + house + keeper* receives different interpretations depending on the stress contour: 1-3-2-4 is associated with *lighthouse keeper* (someone who keeps a lighthouse), while 2-1-3-4 is associated with *light housekeeper* (a housekeeper who is light in weight). (In this transcription 1 denotes primary stress, 2 secondary, etc.) For the structuralists, such contours were described by means of a series of four stress phonemes of decreasing strength: [´], [ˆ], [`], [˘]. While it is reasonable to analyze the three segments of *pin* in terms of phonemes (distinctive-feature bundles) with relatively well defined phonetic correlates, treating stress in the same fashion gave rise to a number of anomalies. For one thing, the phonetic correlates of stress proved quite elusive, so much so that even trained phoneticians could not detect the presence of [´] vs. [`] vs. [ˆ] without knowing the intended meaning.

In their paper Chomsky, Halle, and Lukoff showed how the distribution of the various stress levels could be predicted from a simple [±stress] distinction by remarkably precise and general rules. These rules crucially take into account the organization of the lexical items into hierarchical syntactic constituents. Such information was strictly off limits to phonemic analyses that adhered to classical structuralist tenets. The success of the Chomsky-Halle-Lukoff analysis encouraged the exploration of hypotheses that later became methodological cornerstones of generative phonology: in particular, the propositions that phonological structure can be described by general and formal rules; that the nature of these rules should be entirely a matter of empirical investigation rather than being circumscribed by a priori methodological restrictions; that the rules compute representations that may not have straightforward phonetic (material) correlates but nevertheless constitute psychologically genuine distinctions.

The rules for phrasal prominence sketched by Chomsky, Halle, and Lukoff (1956) were elaborated in Chomsky and Halle's landmark study *The Sound Pattern of English* (1968). *SPE* was the first full-scale exposition of the generative phonological model – illustrated by an in-depth description of the major phonological alternations found in English. In addition to working out the phrasal stress contours in greater detail, *SPE* demonstrated that the distribution of stressed and unstressed syllables within the word could be predicted in a large number of cases by simple and elegant rules. While the *SPE* analysis of English stress was a spectacular descriptive success, the theoretical treatment of stress in the same terms as the other distinctive features (i.e., as [±stress] analogous to [±nasal] or [±coronal]) ironically repeated the same sort of mistake made by the structuralist conception of stress as a phoneme analogous to [p]. It soon became clear that stress – especially when viewed cross-linguistically – displays a suite of properties that set it apart from other phonological features. The special status of stress remains unexplained in the *SPE* model that represents it as [±stress]. Let us enumerate some of the properties that make stress special.

First, it is well known that stress is the most phonetically elusive phonological feature. It has no invariant phonetic cues. Rather, stress is realized through the offices of other phonetic features, typical choices being the pitch contour of an intonation pattern or vowel/consonant length. Sometimes more subtle features of a given linguistic system such as (the lack of) vowel reduction or the implementation of consonantal allophones are sufficient to elicit the perception of stress.

Given the indirect relation between stress and its phonetic implementation, we might pause to ask what kinds of evidence can determine the stress properties of a given syllable. Of primary importance are the perceptions and judgments of the native speaker. For example, most English speakers discern three levels of prominence in a word such as *Alabama*. The second and fourth syllables are the weakest, while the third [bam] is judged the strongest. The initial syllable seems intermediate in character: it is not as prominent as [bam] but feels stronger than the other syllables. Of equal importance are the ways in which the syllables of the word are treated by the grammar of the language. For example, in many languages vowels reduce in unaccented positions. The patterns of reduction can be used to establish the stress contour. In *Alabama* we note that the second and fourth syllables – the ones perceived to have the weakest prominence – are reduced to schwa, while the first and third have full [æ] vowels. If we let the acute and grave accents stand for primary and secondary stress levels, then *Alabama* may be transcribed as [æ̀ləbǽmə]. Another source of evidence for stress are various adjustments a language may resort to in order to avoid a sequence of stressed syllables. A well-known rule of English transforms a word with a [...secondary...primary...] stress contour to [...primary...secondary...] when a stressed syllable follows. Thus, *ràccóon* shifts to *ráccòon* in the collocation *raccoon coat*. But the word *maroon* does not alter its stress in *maroon coat*. The contrasting behavior of *raccoon* and *maroon* is explained by the fact that these words have different stress patterns: *raccoon* has a secondary accent on the initial syllable while the initial syllable of *maroon* is unstressed. Most English speakers readily perceive this difference in prominence. This judgment is also supported by the fact that the vowel of the initial syllable is reduced in *maroon* but remains [æ] in *raccoon*. We will return to this rhythmic alternation later. Finally, in many languages intonation contours are distributed over words and phrases by reference to the strongest stress. For example, Liberman (1975) analyzes the so-called vocative chant (used to call someone out of sight) in terms of a MHM tone sequence in which the high maps to the stressed syllable and the mid tones autosegmentally associate to the surrounding syllables. The English speaker's percept that the primary word stress jumps between the first syllable in *'Isadore* and the third syllable in *Isad'ora* is dramatically highlighted by the evocations displayed in (1).

```
(1)  oh 'Isadore!          oh Isad'ora!
     |   | |/               \|/    | |
     M   HM                  M     HM
```

We have noted two respects in which stress differs from other features: the lack of uniform and precise phonetic correlates and greater-than-binary discriminations that are crucial to the operation of phonological rules. Another unusual aspect of stress is its striking long-distance effects. Most other features have local phonological determinants. For example, in many English compounds the major stress is located on the first word: *the téacher's ùnion* vs. *the tèacher's fríend*. When the compounds are left-branching, the prominence of the first member keeps

increasing cyclically in proportion to the depth of embedding. (We shift to a numerical notation in (2), where the magnitude of the numbers reflects degree of prominence so that 2 is stronger than 1, 3 is stronger than 2, etc.)

```
(2)  teachers' union
        2        1

     [teachers' union] president
        3        1        2

     [[teachers' union] president] election
        4        1        2          3
```

In the compounds of (2), the stress on *teachers'* modulates with respect to the stress values of the other elements even though the stresses of the latter can be located a considerable distance away. No other phonological property, with the possible exception of tone, exhibits such long-distance effects. An adequate theory of phonology should explain why stress has this propensity for action-at-a-distance.

To take another example, consider the stress pattern of Cairene Arabic (Mitchell 1960).

(3)	šájara	'tree' pausal form
	šajarátun	nonpausal
	šajarátuhu	'his tree'
	šajaratuhúmaa	'their dual tree'
	ʔadwiyatúhu	'his drugs'
	ʔadwiyatúhumaa	'their dual drugs'

In this dialect stress falls on one of the last three syllables of the word. But unlike many other systems with such a three-syllable window, in Cairene the assignment of stress must take into account the number and character of the syllables that precede the stressed syllable. For example, for words terminating in two light syllables, the stress varies between the second-last (penultimate) and the third-last (antepenultimate) syllable, depending on which is preceded by an even number of syllables from the beginning of the word. Thus, in four- and six-syllable words such as *šajarátun* and *šajaratuhúmaa*, the penult is stressed. But in three-syllable *šájara* and five-syllable *šajarátuhu*, the antepenult is stressed. Furthermore, the stress location at the right edge of the word can be changed by varying the weight of the syllable at the left edge: while five-syllable *šajarátuhu* has antepenultimate stress, five-syllable *ʔadwiyatúhu* has penultimate stress. In a sense to be made precise later, the prosodic shape of the entire word must be taken into account in order to determine the location of stress in Cairene Arabic.

Still another characteristic of stress is that in many languages a given syllable will bear stress not by virtue of its own make-up but simply due to its position in the word or phrase. For example, in Polish primary accent is regularly associated with the penultimate syllable of the word: *nauczýciel* 'teacher' nom.sg.

When a suffix is added, the accent appears to shift from the [czy] syllable to the [cie] one: *nauczyciél-a* gen.sg. In *nauczyciel-ówi* (adjectival) the stress has moved off of the stem entirely. This "shift" of stress is motivated by the relative positions of the syllables with respect to the end of the word. Once again, other phonological features such as [±nasal] or [coronal] do not behave in this way. Other common positional patterns include stress on the initial syllable of the word (e.g., Czech, Finnish, Georgian) or the final syllable (e.g., Turkish, French, Farsi).

In many languages stress involves the repetition of a basic pattern or motif. For example, the Australian language Maranungku that has figured in many generative discussions of stress is characterized by Tryon (1970b) as having primary stress on initial syllables and a secondary stress on every other syllable thereafter. The canonical prosodic shape of Maranungku words is thus CV́CV, CV́CVCV̀, CV́CVCV̀CV, CV́CVCV̀CVCV̀. Such an alternating stress pattern can be characterized as the repetition of a stressed+unstressed motif across the word. Syllables occupying an odd-numbered position are accented while those occupying an even-numbered position are unaccented. A similar phenomenon occurs on a smaller scale in English. (4) lists words with primary stress on the final or the penult.

(4) a. Kàlamazóo
Mànitawáuk

b. Tàtamagóuchi
Wìnnipesáukee

c. Àpalàchicóla
càlifràgilístic

In (4a) the words have final stress and in (4b) penultimate stress. In both cases three syllables precede the major stressed syllable and a secondary accent appears on the initial syllable. But in (4c) four syllables precede the primary stress. Here we find two secondary accents: one on the first syllable and another on the third syllable. The pretonic string ***Àpalàchicóla*** displays the same strong-weak (trochaic) rhythm found in Maranungku. The syllable [la] in *Àpalàchicóla* thus bears a stress simply by virtue of its odd-numbered position in the word and not by virtue of any inherent property it possesses.

In other cases syllables bear an accent regardless of their location in the word. The most common determinant of such *inherent stress* is syllable weight: syllables with a long vowel are always stressed while the stressability of short-voweled syllables depends on location with respect to the edge of the word or to another heavy syllable. Syllables closed by a consonant pattern with long vowels in some systems and with short vowels in others. It is noteworthy that while stressability is almost invariably a function of the syllable nucleus, such properties as vowel quality are rarely taken into account (and if they are, it is to determine the degree of prominence rather than the presence or absence of stress). A language in which back vowels defined heavy syllables would be strange indeed. Again, an adequate theory will explain this fact. In addition to being determined by syllable weight, the inherent accent of a syllable may be simply an arbitrary, unpredictable prop-

erty of the lexical item in which the syllable is located. Russian and Japanese have many such lexically determined accents.

Finally, in languages that allow multiple stresses per word, one is typically perceived as more prominent than the others. As our discussion of the English rhythm rule indicated, this contrast between primary and secondary accent is crucial to explaining why there is no shift of accent in *maroon coat* in contrast to *raccoon coat*. Let us look at a few more cases in which this contrast in stress levels is crucial in English. First, we note that there are large numbers of English nouns containing two stressed syllables that contrast in terms of which stress is primary (marked by the acute).

(5)

húrricàne	Tènnessée
pédigrèe	kàngaróo
mátadòr	pàlisáde
cántalòupe	màgazíne
cávalcàde	chàndelíer

Second, there are alternations between the [...V̀...V́...] and [...V́...V̀...] stress contours. These take place at the phrasal level (*Tènnessée* but *Ténnessèe Ernie*) as well as in the word phonology (*Ísadòre* but *Ìsadóra*). Third, the normal method of stress enhancement at the phrasal level is for the stress of the second word of a collocation to be increased. This process is known as the nuclear stress rule (NSR). Some examples are listed in (6).

(6)

red barn	John's shirt	Mary's salamander	basic mathematics
1 2	1 2	2 3 1	2 1 3
eat meat	be happy	judged sacrosanct	visit Alabama
1 2	1 2	2 3 1	2 1 3

As we can see from some of these examples, when the second word has two stresses, it is uniformly the stronger one that is enhanced. In *Mary's salamander* the initial syllable of *sálamànder* has been enhanced. But in *basic mathematics* it is the second stress – the one on the penult – in *màthemátics* that has been increased. An adequate theory of phonology will explain why stress, in contrast to any other phonetic property, lends itself so easily to mirroring the syntactic constituent structure in this way and why only the highest stress in a word is subject to such enhancement under the NSR.

10.2 The Metrical Grid

Liberman's (1975) *metrical grid* is a notation that permits the special aspects of stress to be represented in a particularly perspicuous manner. For the metrical grid, stress is neither a feature nor an inherent property of syllables. Rather, stress is defined in terms of an abstract two-dimensional array that plots metrical positions for levels of prominence. Syllabic nuclei "bear" a stress by autosegmentally associating with one of these metrical positions. In this way, stress is largely autonomous from the phonemic string. In many languages the metrical grid defines three levels of prominence for the word. Following the notation of Halle and Vergnaud (1987), the grid levels are represented as lines of asterisks. Line 0 is the basic level and denotes a potentially enhanceable position. In general, every syllable in a word projects a line 0 position, though in some languages (e.g., Indonesian; Cohn 1989) schwa-like syllables may be systematically ignored. Such accentually inert syllables do not project a position on the grid and hence do not figure in any stress computations. Line 1 is sometimes called the *foot level* and line 2 the *word level*. The words *Apalachicola, Tennessee,* and *hurricane* have the metrical grids in (7).

```
(7) 2  ___________*_     ______*     *____
    1  *   *      *      *     *     *   *
    0  *  * *   * **     *  *  *     * * *
       Apalachicola      Tennessee   hurricane
```

As in a grid, we can think of the representations in (7) as assigning every syllable a plus or minus value for each of the prominence levels. (A plus value is denoted by an asterisk and a minus value by the absence of an asterisk.) However, the metrical grids are scalar: an asterisk on any line n implies an asterisk on line $n-1$.

Now let us consider how some of the properties of stress noted earlier are naturally explained by this kind of notation. First, it is clear that the metrical grid does not treat stress as an inherent phonetic property of phonological segments analogous to features such as nasality and tone. Rather, it defines an autonomous level of representation. Second, the fact that a syllable may bear stress simply in virtue of its position in the word reflects the grid's horizontal dimension as a sequence of metrical (stressable) positions. A syllable comes to bear a stress solely in virtue of being associated with this metrical position. Third, the fact that stress encodes greater-than-binary distinctions is reflected directly in the grid's vertical dimension.

Finally, the metrical grid permits many of the long-distance features of stress to be assimilated to the more familiar, local kind of relation that we have come to expect of linguistic structure. For example, the phenomenon of stress enhancement observed in the nuclear stress rule can be accounted for very simply by assuming that each level of syntactic embedding defines a new line in the grid. Since the grid is scalar, it makes sense that the asterisk associated with the new line will attach to the most prominent element of the preceding line. Thus, to characterize the long-distance relation between the stressed syllables of *discovered* and *Mississippi* in *discovered Mississippi,* we need only stipulate that the second word in the collection is enhanced. The line 3 asterisk marking this enhancement is automatically attracted to the penult, because the penult is the only syllable in the word with a line 2 registration.

```
(8) 3 _____________________*_   NSR
    2     *                *
    1     *           *    *
    0  *  * * *    *  *  *  *
       discovered Mississippi
```


Finally, consider how the rhythmic shift in *the Míssissìppi River* can be characterized. After the NSR enhances the stress on *River,* we have the grid in (9a).

```
(9) a. 3 ___________*_   RR →  b. _____________*_
       2       *    *              *         *
       1   *   *    *              *    *    *
       0   * * * *  * *            * *  * *  * *
         Mìssissíppi River         Míssissìppi River
```

With the grid representation, the rhythm rule (RR) can be thought of as a process that slides the line 2 asterisk leftward to the next available landing site in response to the stress clash created by the following stressed syllable in *River* (Prince 1983). In this way, the rhythmic alternation in *Míssissìppi River* also defines a local phonological relation – between positions that happen to be adjacent at a certain level in the metrical grid. For example, in (9a) the stresses associated with the [sip] and [Riv] syllables are adjacent on line 2. (No other asterisk intervenes between them.) Locality is also respected by the movement process itself: the asterisk shifts to the adjacent line 1 position. The precise definition of a stress clash is a complicated issue; see Liberman and Prince 1977, Hammond 1984, and Hayes 1984 for useful discussion.

10.3 Some Basic Parameters

In this section we will explore the basic parameters underlying the construction of metrical grids. For data we will rely heavily on the survey of the descriptive literature found in Hayes 1981. This study convinced many phonologists that the myriad stress systems of the world's languages involve variations on a small number of basic themes and hence that a parametric approach is appropriate. The chief problem is to develop a system that generates the common patterns in a simple fashion yet is robust enough to derive the more complex ones from the combinatory work of the simple ones. Considerable guesswork is involved in this enterprise. Many of the decisions that have been made in the literature are quite underdetermined by the data. Consequently, any exposition of the theory is tentative and subject to revision (sometimes radical) as new facts are discovered. One crucial issue has been whether the notion of metrical constituency needs to be recognized; another is the way in which quantity figures in stress patterns. The nature of much of the rest of the system is determined by one's position on these issues.

As noted earlier, stressed and unstressed syllables often distribute themselves in an alternating fashion. Hayes (1981) identified four basic patterns, samples of which are cited in (10).

(10) a. Maranungku (Tryon 1970b): Primary stress falls on the initial syllable, and secondary stress falls on every other syllable thereafter.

tíralk 'saliva', mérepèt 'beard', yángarmàta 'the Pleiades', lángkaràtetì 'prawn', wélepènemànta 'kind of duck'

b. Weri (Boxwell and Boxwell 1966): Primary stress is assigned to the final syllable, and secondary stress is assigned to each preceding alternate syllable.

ŋintíp 'bee', kùlipú 'hair of arm', ulùamít 'mist', àkunètepál 'times'

c. Warao (Osborn 1966): Main stress falls on the penult, with secondary stress appearing on alternating syllables before the main stress.

yiwàranáe 'he finished it', yàpurùkitàneháse 'verily to climb', enàhoròahàkutái 'the one who caused him to eat'

d. Araucanian (Echeveria and Contreras 1965): Main stress falls on the second syllable, and secondary stress falls on alternating following syllables.

wulé 'tomorrow', ṭipánto 'year', elúmuyù 'give us', elúaènew 'he will give me', kimúbalùwulày 'he pretended not to know'

(11a) schematizes the stress contours each system assigns to four- and five-syllable words; (11b) distills the distribution of stressed ['V] versus unstressed [V] syllables in each type without regard to magnitude of stress.

```
(11) type 1   a.  V́ V V̀ V    V́ V V̀ V V̀    b.  'V V 'V V    'V V 'V V 'V
     type 2       V V̀ V V́    V̀ V V̀ V V́        V 'V V 'V    'V V 'V V 'V
     type 3       V̀ V V́ V    V V̀ V V́ V        'V V 'V V    V 'V V 'V V
     type 4       V V́ V V̀    V V́ V V̀ V        V 'V V 'V    V 'V V 'V V
```

Notice that a given stress contour appears twice in the table. For instance, the four-syllable ['V V 'V V] appears in both type 1 Maranungku and type 3 Warao. The languages differ in the stress contour they assign to five-syllable (or more generally to odd-numbered) words: in Maranungku ['V V 'V V] combines with ['V V 'V V 'V]; in Warao it combines with [V 'V V 'V́ V]. Similarly, five-syllable ['V V 'V V 'V] combines with ['V V 'V V] in type 1 Maranungku, but with [V 'V V 'V] in type 2 Weri. Since each contour appears twice, the occurrence of any one contour is independent from the appearance of the others. This fact suggests that the entire system results from the free combination of two more elementary factors: whether the initial assignment maps a syllable to a stressed or an unstressed position and whether the assignment starts at the left or the right edge of the word.

If stress prominence is a function of the metrical grid, then one way to build up the grids to generate the four alternating patterns of (11) is to define a mapping of syllables onto a primitive rhythmic alternation of peaks and troughs (Prince 1983). Imagine a tape of successive weak and strong positions, as depicted in (12a).

```
(12) a.      *   *   *
         ... * * * * * * * ...
```

b. [peak-first, trough-first]

c. [left-to-right, right-to-left]

The alternating stress patterns in (11b) can be generated by setting the two parameters in (12b,c). (12b) tells whether the mapping starts with a rhythmic *peak* (i.e., a position marked by a line 1 asterisk) or with a *trough* (a position lacking a line 1 asterisk). The second parameter (12c) specifies the direction of assignment. The four basic patterns arise from the parameter settings in (13).

(13)	type 1	[peak-first, L-R]
	type 2	[peak-first, R-L]
	type 3	[trough-first, R-L]
	type 4	[trough-first, L-R]

To briefly illustrate this method of grid construction, consider how the type 1 language Maranungku would be generated. According to (13), we start at the left edge of the word and map the first syllable to a rhythmic peak in the tape of (12a); remaining syllables in the word are then matched one to one with subsequent positions in the tape, as illustrated in (14a). A four-syllable word thus receives the grid in (14b).

```
(14) a. 1        *   *
        0   ... * * * * * ...
                 ↗ / / /
                V V V V ...

     b. 1     *   *
        0     * * * *
             'V V 'V V

     c. 2         *
        1     * → * / # ___

     d. 2     *
        1     *   *
        0     * * * *
              V V V V
```

Enhancement of one of the line 1 asterisks introduces a distinction between primary and secondary stress. Typically, it is a marginal line 1 element that is strengthened. Maranungku and Araucanian enhance the leftmost line 1 asterisk, Weri and Warao the rightmost. The word stress rule for Maranungku is stated in (14c). It transforms (14b) into (14d).

According to the view just sketched (essentially the proposal of the influential study by Prince (1983)), stress is primarily a rhythmic phenomenon. There is no explicit notion of metrical grouping. Any given peak is equally related to the troughs on either side and any trough is equally related to its adjacent peaks. An alternative view analyzes a series of alternating stressed and unstressed syllables into binary units known as *metrical feet*. The feet differ in terms of whether the stressed position (the *head* of the foot) occurs at the left or the right edge.

```
(15)  metrical foot     *              *   line 1
                      (* *)          (* *)  line 0

                   left-headed    right-headed
                   (trochaic)     (iambic)
```

In some versions of this general approach (e.g., Halle and Vergnaud 1987, Anderson and Ewen 1987) the head is said to *govern* the adjacent unstressed position, much in the way a verb governs an adjacent direct object noun phrase. As in the first view, a {left-to-right, right-to-left} parameter specifies the direction in which syllables are grouped into metrical feet.

Consider first how a type 1 language such as Maranungku is generated in a theory employing metrical constituents. The metrical feet are left-headed and assigned from left to right. For words with an even number of syllables, the division into binary feet encompasses all the syllables in the word (16a). But when the word contains an odd number of syllables, one position is necessarily left over at the end of the parse (16b). In a type 1 language this syllable is stressed, and so it is natural to allow these leftover (orphan) syllables to form *degenerate feet* of just one syllable, assuming that the parsing is exhaustive. Since the degenerate foot is stressed, the requirement that every syllable have a head (stressed position) is still satisfied. With provision made for degenerate feet, the four- and five-syllable schemata of a type 1 language are analyzed by foot theory as in (16).

```
(16)  a.  1                     *     *
          0   * * * *    →    (* *) (* *)
              | | | |          | |   | |
              V V V V         'V V  'V V

      b.  1                     *     *     *
          0   * * * * *  →    (* *) (* *) (*)
              | | | | |        | |   | |   |
              V V V V V       'V V  'V V  'V
```

A type 2 language arises in exactly the same way, except that the feet are assigned from right to left.

Since in a metrical constituent the head is typically signaled by greater prominence, it is natural to construe the enhancement of a line 1 asterisk as a process that organizes the asterisks of line 1 into a metrical constituent. Since the number of stressed syllables in a Maranungku word may exceed two, the resultant constituent is of *unbounded* size, taking in the entire word. The rule "organize line 1 asterisks into an unbounded left-headed constituent" transforms the grids of (16) into those in (17).

```
(17)  a.  2   *                  b.  2   *
          1  (*     *)               1  (*     *     *)
          0  (* *) (* *)             0  (* *) (* *) (*)
              Ý V   Ỳ V                  Ý V   Ỳ V   Ỳ
```


To briefly summarize, the leading idea behind this alternative view is that stress reflects a grouping of the grid positions into headed constituents.

The analysis of type 3 and type 4 languages under the grouping theory is more complicated. Consider type 3. If the feet are left-headed and assigned from right to left and the parsing is exhaustive, then the leftover syllable at the beginning of the word will be assigned to a degenerate foot. We incorrectly predict that words with an odd number of syllables should begin with two successive stressed syllables. (For a type 4 language the situation is symmetric, with a stress clash predicted at the right edge.)

```
(18)  type 3 [left-headed, R-L]
      1                     * *     *
      0   * * * * *   →   (*)(* *) (* *)
          V V V V V        V 'V V  'V V
```

Grouping theory must invoke a rule to remove the stress clash by deleting the line 1 asterisk from the degenerate foot. Rules of this form must be allowed in any case in order to remove stress clashes arising at the phrasal level from the collocation of separate words. For example, in Icelandic (Gussmann 1985) compounding of *v'erk* 'work' and *m'aður* 'man' produces a clash that is removed by deleting the second stress in *v'erk#maður* 'good worker'; compare *v'erka#k'ona* 'female worker'. Nevertheless, the theory positing a metrical foot requires a more complex analysis of the type 3 stress pattern. An extra stress is assigned and then must be removed by another rule. The alternative "grid-only" theory, which assigns syllables directly to the alternating peaks and troughs, generates the type 3 language in one step. Other things being equal, it might appear at this point that the introduction of metrical constituency is a needless complication.

Proponents of the foot theory have argued that there are good reasons to introduce the metrical constituent in spite of the apparent complexity that arises in the analysis of a type 3 language such as Warao. First of all, it is simply untrue that languages always avoid stress clashes. An example is provided by the Algonquian language Ojibwa (Kaye 1973, Piggott 1980). Ojibwa words lacking a long vowel have stresses on even-numbered syllables counting from the left. In addition, the final syllable of every word is stressed, entailing a stress clash in words with an odd number of syllables.

```
(19)  a.  nagámò          'he sings'
          ni-níbà         'I sleep'
          ni-bímosè       'I walk'
          ni-nágamò-mìn   'we sing'

      b.  1    *     *           *     *     *
          0  (* *) (* *)       (* *) (* *) (*)
             V'V   V'V         V'V   V'V   'V
```

Parsing syllables into binary right-headed feet from left to right produces the grids in (19b) for four- and five-syllable words. In this case the theory positing metrical constituents produces the surface stress patterns directly. No subsidiary rules are required to adjust the grid that arises from the initial imposition of metrical structure. But since Ojibwa words contain a clash of stresses at the right edge, the "grid-only" theory that assigns syllables to the primitive rhythmic alternation of peaks and troughs cannot generate this pattern directly. Another rule must be stipulated to deliver a line 1 asterisk to the final syllable of every word. We conclude that when a larger class of languages is examined, the initial advantage that the grid-only theory seemed to enjoy disappears. (In fairness, however, it should be noted that Ojibwa appears to represent the marked situation; the avoidance of a stress clash at the edge of the domain appears to be the predominant pattern.)

A similar conclusion can be drawn from alternating stress patterns in which the clash posited by foot theory is resolved, not by destressing the degenerate foot, but rather through the destressing of the head of the adjacent binary (nondegenerate) foot. For example, the Australian language Garawa (Hayes 1981) is described as having an initial primary stress and secondary stress on the penult; a tertiary stress ('V) is said to lie on alternating syllables preceding the penult.

```
(20) a. yámi                           'eye'
        púnjala                        'white'
        wátjimpàŋu                     'armpit'
        náriŋinm'ukunj'inamìra         'at your own many'
     b. 'VV
        'VVV
        'VV'VV
        'VVV'VV
        'VV'VV'VV
        'VVV'VV'VV
```

In (20b) the various levels of prominence are suppressed; only the distribution of stressed versus unstressed syllables of prototypical Garawa words is displayed. When this is done, the distribution of accented and unaccented syllables in Garawa looks very similar to that in Warao: both accent the penult and alternating syllables preceding the penult. For words with an even number of syllables, stressed and unstressed positions are distributed alike. The languages differ in their stressing of words with an odd number of syllables. In Garawa the initial syllable is accented (e.g., 'V-V-V-'V-V) while in Warao the second syllable is (e.g., V-'V-V-'V-V). Under the theory that groups metrical positions into binary feet, both languages can be analyzed as being of essentially the same type [left-headed, R-L]. They differ in the way the stress clash is resolved: Garawa deletes the second line 1 asterisk, Warao the first.

```
(21)              *   *    *
                 (*) (*  *)(* *)

       Garawa    'V   V  V'VV
       Warao      V  'V  V'VV
```


Since the grid-only theory is designed to keep stresses apart, it cannot produce a sequence of stressed syllables directly. The Garawa stress pattern thus represents a complication. It can be generated with the help of two additional rules: one to accent the initial syllable of the word and a second to relieve the resultant stress clash through the deletion of the second of two adjacent asterisks. A five-syllable word thus receives the three-step derivation sketched in (22).

```
(22)             *   *       * *   *       *   *
      * * * * * → * * * * * → * * * * * → * * * * *
```

Thus, both approaches generate the appropriate stress patterns. They differ in their interpretation of adjacent stresses. The theory positing metrical constituents regularly generates stress clashes in the course of assigning every syllable to a metrical foot. The grid-only theory must produce clashing stresses via additional rules. Which of these two general approaches is correct continues to be a major issue in stress theory. We will return to this question in section 10.10.

Some of the strongest arguments for metrical constituency are based on the readjustments to the stress pattern that take place upon the deletion or the insertion of another syllable. Since the metrical grid, like an autosegmental tone pattern, defines a level of representation separate from the phonemes, the loss of a vowel (or syllable) will not necessarily entail the loss of the corresponding grid column; only the lowest level will be erased, since that is a projection of the syllable (nucleus). Higher grid marks may persist. In a theory with metrical constituents, it is natural that if the vowel associated to the metrical head is deleted but the stress pattern is preserved, then the stress will appear to migrate to the adjacent syllable in the foot. Consequently, we expect a correlation between the type of foot structure and the direction of accent shift. If the accented vowel in (23a) governs the vowel to the right, then, upon deletion, the accent should shift to the right (23b). But if the feet are right-headed, then the accent should shift to the left (23c). In a theory that does not impose any metrical constituency, no such correlation is predicted.

(23) a. $\ldots V_1\ \acute{V}\ V_2 \ldots$
b. $\ldots V_1)\ (\acute{V}\ V_2) \rightarrow V_1\ \acute{V}_2$
c. $\ldots V_1\ \acute{V})\ (V_2 \ldots \rightarrow \acute{V}_1\ V_2$

Several instances of the phenomenon depicted in (23) have been reported in the literature. We will review one later. If they are not simply coincidental, they constitute powerful support for the hypothesis of metrical constituency.

Even though the available evidence for metrical constituency is far from compelling (see Kenstowicz 1993 for a survey), we will adopt this hypothesis in our exposition of the theory of stress. This decision represents a guess that such an approach will prove more revealing and closer to the truth. To summarize the discussion so far, we have examined four basic alternating stress patterns. We have analyzed them in terms of two parameters: {left-to-right or right-to-left} parsing of syllables into {left-headed or right-headed} binary feet. Stress clashes may but need not be removed by an additional rule suppressing one of two adjacent grid marks.

10.4 Heavy Syllables

In the examples examined so far, syllable quantity has played no role. But in many languages the location of stress depends on a division of the syllables into light and heavy classes. Invariably, the heavy syllables attract a stress (in our terms, are assigned a more prominent grid position). To take a simple example, the Uto-Aztecan language Tübatulabal is described by Voegelin (1935) as stressing all syllables containing a long vowel, all final syllables, and alternating syllables preceding a stressed syllable.

(24) a.

ipónihwɨ́n	'of his own skunk'
witáŋhatál	'the Tejon Indians'
wítaŋhátalá:bacú	'away from the Tejon Indians'
yú:dú:yú:dát	'the fruit is mashing'
haní:lá	'the house' (obj.)
tá:háwilá:p	'in the summer'
wašá:gáhajá	'it might flame up'
ánaŋí:nínɨmút	'he is crying wherever he goes' (distr.)
pɨɨtípɨtɨ́:dinát	'he is turning it over repeatedly'

b.

```
      *          line 1
* → * / ___      line 0
         |
         V:
```

The most straightforward account of this language simply postulates a rule stressing long vowels independent of their position in the string. Halle and Vergnaud (1987) postulate the rule (24b). We must now investigate how such inherently accented syllables group with adjacent syllables into metrical feet. The forms *pónihwɨ́n* and *witáŋhatál* show that Tübatulabal forms binary right-headed feet from right to left. It is thus a type 2 language. Consider the case of a long vowel in an even position counting from the right edge of the word. Two examples are cited in (25). After the application of (24b), these forms have the following grids.

```
(25) a. 1     *          b. 1      *
        0   * * *           0   * * * * *  *
           hani:la               anaŋi:ninɨmut
```

Halle and Vergnaud examine two initially plausible methods to parse grids. One breaks the parse down into a two-step procedure. The first step locates the line 1 asterisks and groups them with the appropriate adjacent syllables into constituents with the long-voweled syllable as head. Since Tübatulabal feet are binary and right-headed, this initial parse derives the grids in (26a).


```
(26) a. 1      *                 *
        0   (*  *)  *        * (*  *)  *  *  *

     b. 1      *   *         *     *)  *     *
        0   (*  *) (*)      (*) (*  *) (*)(*  *)
            ha ní:  la       á  na ŋí:  ní nɨm út
```

In the second step the remaining unmetrified syllables are parsed from right to left to derive the grids in (26b).

An alternative procedure maintains a single right-to-left parse. But since a metrically dependent position cannot be more prominent than the head, a syllable with a line 1 asterisk may never be made sister to a head. Consequently, when such a syllable is encountered, the foot construction procedure must begin anew, assigning it to a head position. (In effect, the parsing of line 0 asterisks monitors for a line 1 asterisk.) As an example of this alternative interpretation, let us follow the parse of *ánaŋí:nínɨmút* in detail. First, the [mut] syllable is assigned as head, with [nɨ] as dependent (27a). Then the next [ni] is assigned to head (27b); but the [ŋi:] may not be assigned to a dependent position since it bears a line 1 asterisk and thus is barred from such a weak metrical position. Consequently, a degenerate monosyllabic foot is created, with [ni] as head (27b). The parsing procedure continues and [ŋi:] is assigned to a head position with the preceding [na] as its sister (27c). Finally, the initial syllable is assigned to head position and the parse terminates in (27d).

```
(27) anaŋi:ninɨmut      anaŋi:ninɨmut       anaŋi:ni  nɨmut
     | | |  | |  |      | | |  | |  |       | | |  |  |  |
     * * *  * *  *  →   * * *  *(*  *)  →   * * * (*) (*  *)  →
         *                  *       *           *  *      *
                 (a)                 (b)                   (c)

     anaŋi: ni nɨmut      anaŋi:ni  nɨmut
     | | |  |  |  |       | | |  |  |  |
     *(* *) (*) (* *)  → (*)(* *)(*) (*  *)
         *   *     *       *    * *      *
                  (d)
```

Both procedures thus succeed in assigning the correct grid structure to the representations in (25). They predict different results, however, for an initial representation such as (25b) if the parse proceeds from left to right. The two-step procedure will first organize the second and third syllables into a foot; then the initial syllable is parsed to yield a representation such as (28a). Under the one-step approach, the first and second syllables parse into a right-headed foot and then the third syllable forms a foot by itself, since it has already been supplied with a line 1 asterisk. This procedure generates the grid of (28b).

```
(28) a.            *   *          b.          *  *
                  (*) (*  *)                (*  *) (*)
                   |   |  |                  |  |   |
         V V V: →  V   V  V:       V V V: →  V  V   V:
```

Crucial evidence for the second approach is furnished by Ojibwa. Like Tübatulabal, Ojibwa stresses all long-voweled syllables and thus has rule (24b) assigning such syllables a line 1 asterisk. The language also permits adjacent stressed syllables to surface phonetically.

(29) bimósè: 'he walks'
ni-bímosè:-mìn 'we walk'
ni-níbà:-mìn 'we sleep'

We learned from (19) that Ojibwa feet are right-headed and assigned from left to right. Words with two short syllables followed by a long one will decide between the alternative parsing procedures. Forms such as *bimósè:* and *ni-níbà:-mìn* argue for the second approach in which metrical organization arises exclusively from a syllable-by-syllable transition from one edge of the word to the other.

Languages such as Tübatulabal and Ojibwa that tolerate a stress clash are significant since they permit the underlying assignment of stresses to surface directly. A point worth bringing out here is that the theory predicts a correlation between the type and direction of foot assignment for short-vowel words and the position of stress clashes with respect to a long vowel. To appreciate this point, consider Tübatulabal again. The stress contours in *pónihwɨ́n* and *witáŋhatál* suffice to establish that binary feet are right-headed and assigned from right to left. Consider now the stress in *tá:háwilá:p*. Stressing long vowels produces the grid in (30a).

```
(30) a. 1 *     *         b. 1  *   *    *
        0 * * * *            0 (*) (*) (* *)
```

Since feet are right-headed and assigned from right to left, exhaustive parsing groups the penult with the final syllable and places the antepenult in a foot by itself. It follows that the bisyllabic interval between long vowels must stress the first syllable: 'V:VV'V: → 'V:'VV'V:. This theory not only predicts the correct form *tá:háwilá:p;* it also predicts that **tá:hawílá:p* could not in principle be the stress assignment. The latter and obviously much stronger claim is supported by the fact that the theory makes exactly the opposite prediction for Ojibwa. In this language *ni-bímosè* and *ni-nágamò-mìn* establish a right-headed, left-to-right foot structure. Since feet are imposed from left to right, we predict that an even-syllabled interval between long vowels will have the stress clash on the right. A form such as *ni-wì:-pimí-takkònà:n* 'I'll carry it along' confirms this prediction.

If the Tübatulabal and Ojibwa methods of filling in such short-vowel intervals represent the general state of affairs, then we derive strong support for our general approach to stress. After all, given a [V́: V V V́:] string, it is not obvious why a language should systematically favor stressing one of the two intervening short vowels. It is even less obvious that the particular decision adopted should inversely correlate with the way short-voweled words are stressed. For example, since short syllables pair up as (V'V) in Tübatulabal, one might mistakenly expect a short-vowel interval in [V́:-V-V-V́:] to have the stress clash on the right rather than on the left. The correct results are obtained only if each of the various

parameters in the theory holds – in particular, that stress results from the metrical organization of all syllables in the word in a sweep from one edge to the other.

Some further support for this approach is furnished by certain Tübatulabal stems with an irregular stress. For example, the final syllable of the stem [tuguwa] 'meat' is always stressed regardless of its position in the word: *túguwá-n* 'his meat', *túguwá-yí-n* obj. The stress on the [wa] syllable is thus an idiosyncratic lexical property that must be recorded as part of the underlying representation of this lexical item. A natural way to do this is to let the [wa] project a line 1 asterisk as part of its underlying representation. The fact that the short syllable preceding the [wa] is always unaccented while a short syllable following may be accented follows from the analysis. The parallel behavior of long syllables and lexically accented syllables in Tübatulabal justifies the decision to analyze both as arising in the same way: by the assignment (either lexical or rule-governed) of a line 1 asterisk.

The discussion can be summarized by stating the following rules of grid construction (Halle and Vergnaud 1987).

(31) Tübatulabal
a. Syllable nuclei project a line 0 asterisk.
b. Assign a line 1 asterisk to syllables with a long vowel.
c. Parse line 0 asterisks into binary right-headed feet from right to left and mark the heads with a line 1 asterisk.

Ojibwa
a. Syllable nuclei project a line 0 asterisk.
b. Assign a line 1 asterisk to syllables with a long vowel.
c. Parse line 0 asterisks into binary right-headed feet from left to right and mark the heads with a line 1 asterisk.

10.5 Unbounded Constituents

In this section we will extend the metrical approach to a larger class of languages. Consider first the languages that are described as having a single accent per word located on the initial or the final syllable, such as Latvian and Czech or French and Farsi. (Some may have secondary accents, but we assume that at least a subset have just a single accent per word.) In a theory that does not countenance metrical constituents such languages can be described simply by postulating a rule to assign a line 1 asterisk to the initial or final syllable. A word-level rule then singles out the only line 1 asterisk as the host for a line 2 asterisk. An initially accented word has the derivation sketched in (32).

```
(32)                                      2 *
                       1 *                1 *
      0 * * * *        0 * * * *          0 * * * *
        V V V V   →      V V V V    →       V V V V
```

A rather different interpretation emerges from the grouping theory. Recall that it views stress as reflecting the imposition of constituency on the metrical positions in the grid. In particular, stress marks the head of the constituent. Given this leading idea, it is natural to see initial stress as marking the head of an unbounded constituent that encompasses the remaining unstressed syllables and hence takes in the whole word. The metrical structure of a V́VVV word is thus as shown in (33).

```
(33) 2  *
     1  (*)
     0  (* * * *)     left-headed
```

If we accept this position and allow for unbounded constituents, then it is natural to require that line 0 positions be exhaustively analyzed into metrical constituents, much as we assumed that the string of phonemes is exhaustively parsed into syllables. In this way, we understand why a language such as Tübatulabal assigns stresses to light syllables even when the word has a long vowel and hence an inherent stress. While the existence of unbounded feet thus follows rather naturally from the assumption of metrical constituency, it must be recognized that to date the most impressive independent evidence confirming metrical constituency has been found in systems with binary feet. In the next section we will review three of the best cases.

10.6 Metrical Constituency

10.6.1 Dorsey's Law in Winnebago

The Siouan language Winnebago illustrates a number of issues in the metrical theory of accent. Our data come from the descriptions of Miner (1979) and of Hale and White Eagle (1980). If we restrict attention to words with just short vowels, then we find that stress appears on every odd-numbered syllable except for the first (i.e., on the third, the fifth, etc.). The one exception to this general statement is that in disyllabic words the final syllable is accented.

(34)

wajé	'dress'	hipirák	'belt'
wijúk	'cat'	hišjasú	'eye'
hočįčį́nįk	'boy'	hijowíre	'fall in'
hirawáhazrà	'the license'	hakirújikšą̀ną	'he pulls it taut'
hokiwárokè	'swing' n.		

Winnebago accent is obviously alternating. But unlike words in the previously examined patterns, the Winnebago word may begin with two unstressed syllables before a stressed one is encountered. Disyllabic words are the only exceptions to this generalization. Both peculiarities could be explained if the parsing skips the initial syllable. Then Winnebago becomes identical with a type 4 language such as Araucanian: both assign binary right-headed feet from left to right. Accordingly, we postulate a provision to exempt certain syllables from the metrical parse. Mechanically, we will assume a feature [+*extrametrical*], which renders a syllable's line 0 asterisk invisible to the parsing procedure. Clearly, such a feature must be used sparingly. In the absence of any constraints on which syllable can be ignored, any metrical pattern could be generated and the theory loses its empirical force. Study of many languages has led to the conclusion that only material at the edges of a domain is exempt from the metrical parse. This *peripherality* condition is reminiscent of the behavior of marginal consonants in escaping syllabification and of final vowels in escaping tone spread. It is commonly assumed that the extrametricality feature is only active at the edge of a metrical domain. As soon as a syllable becomes medial (e.g., by affixation), its asterisk becomes "visible" and hence cannot be ignored by the metrical parsing rules.

Given extrametricality, we postulate the rules of (35), which generate the grids in (36). Following the notation introduced by Kager (1989), we mark extrametrical positions with angled brackets.

(35) a. Mark the line 0 asterisk of the initial syllable extrametrical.
 b. Group line 0 asterisks into binary right-headed constituents from left to right.
 c. Group line 1 asterisks into an unbounded left-headed constituent.

```
(36) 2     *            *              *
     1     *          (*  *)          (*       *)
     0  ⟨*⟩(*)     ⟨*⟩(*  *)(*)     ⟨*⟩(*   *)(*   *)
         wa je     ho čį čį nįk     hi ra wa haz ra
```

A later rule of stress clash reduction deletes the line 1 asterisk from the final syllable of *hočįčį́nįk*.

Hale and White Eagle (1980) and Halle and Vergnaud (1987) point to additional material from Winnebago that provides a striking argument for the postulated metrical constituents. Winnebago has a rule known as Dorsey's Law, which inserts a copy of the following vowel within a preceding voiceless obstruent-plus-sonorant cluster. This rule is stated in (37a). It is illustrated by adding the second person prefix [š-] to a stem beginning with a sonorant. Underlying [š-wažok] 'mash' is realized as *šawažók*. In some cases the vowel inserted by Dorsey's Law preserves the accent pattern (37b). But in other cases the stress shifts to the inserted vowel (37c).

(37) a. $CRV_i \rightarrow CV_iRV_i$

b.	[ho-š-wažá]	→	hošawažá	'be sick'
	[ha-ra-kí-š-rujìk-šną̀]	→	harakíšurujìkšąną̀	'pull taut' 2d
	cf. ha-ki-rújik-šą̀ną			'pulls taut' 3d