11 General Properties of Stress and Metrical Structure

MORRIS HALLE AND
WILLIAM IDSARDI

0 Introduction

The fundamental insight into stress systems remains that expressed by Mark Liberman in his 1975 dissertation. Liberman suggested that stress is not a simple phonetic feature, as had been assumed by most linguists and phoneticians, but rather that it is a phonetic means for marking various kinds of groupings of linguistic elements. Typical examples of the kinds of groupings Liberman had in mind are given in (1).

(1) (a) auto / bio / graphic
ono / mato / poeia
super / cali / fragi / listic / expi / alo / docious
(b) their new Lincoln Continental / was made in California
none of his books / made it to the top of the list

It is not difficult to see that in each of the groups or constituents there is one element that is more prominent than the rest. It is the left-most elements in (1a) and the right-most elements in (1b). We shall use the term "head" to designate the element in the constituent to which prominence is assigned.

In addition, the examples in (1a) differ from those in (1b) with regard to the elements that are being grouped. Syllables are grouped in (1a) and words in (1b). This difference is also reflected in the units that are made to stand out phonetically: it is the head of the syllable in (1a), whereas in (1b) it is the head of the syllable bearing main stress in the word.

In what follows we describe and illustrate a new algorithm – that of Idsardi (1992)[1] – which seems to us to assign stress contours to words and phrases in a manner that might plausibly be attributed to speakers and learners of a language. Our primary purpose here is to show how the framework deals with concrete stress patterns. Hence, most of the examples that we review below have been previously discussed in the literature, most notably in Hayes (1980, 1991), Prince (1983), and Halle and Vergnaud (1987). A defense of the framework and comparisons with some alternatives can be found in Idsardi (1992, 1993).

The simple facts exemplified in (1) suggest that a formal account of stress phenomena will require at least the following three devices: a device for designating the elements in the sequence that are capable of bearing stress; a means for delimiting the groupings of the elements; and a marker to distinguish in each grouping or constituent the prominent head-element from the rest. The remainder of this section will introduce mechanisms that build appropriate representations of stress. These mechanisms – parameterized rules and constraints – constitute our theory of stress assignment.

We propose to satisfy these requirements by representing the stressable elements in a phoneme string as a sequence of abstract marks. These marks will constitute a line that we label line 0. We illustrate this in (2).

(2)

```
x  x  xx  x   x         line 0
|  |  ||  |   |
auto-biographic

         x    x              x              x              x    line 0
         |    |              |              |              |
their new Lincoln Continental was made in California
```

An immediate consequence of this decision is the creation of two parallel sequences of elements: a sequence of phonemes and a sequence of abstract marks. Two parallel lines constitute a plane, and we shall call the plane defined by the parallel sequences of phonemes and abstract marks the metrical plane.

In order to delimit the different groupings we shall employ ordinary parentheses and these will be placed by different rules, to be discussed presently, among the x's that make up the line, as illustrated in (3).[2]

(3)

```
(x  x (xx (x   x         line 0
 |  |  ||  |   |
auto-biographic

         x    x              x)             x              x)   line 0
         |    |              |              |              |
their new Lincoln Continental was made in California
```

In each of the metrical constituents thus generated a special rule will designate the right- or left-most element as the head of the constituent. We mark the head of each constituent by projecting and linking the element to a new element on the next higher line of the grid, as shown in (4).

(4)

```
 x     x  x          line 1
 |     |  |
(x  x (xx (x   x     line 0
 |  |  || |    |
 auto-biographic
```

```
                     x               x    line 1
                     |               |
         x   x       x)        x     x)   line 0
         |   |       |         |     |
their new Lincoln Continental was made in California
```

The x's in line 1 are naturally interpreted as signalling an enhanced degree of prominence. We notice that in the two examples in (4) not all elements with enhanced prominence are of equal prominence. One of these elements bears the maximal prominence in the string. This is the right-most element in both of our examples. To capture this formally we construct a constituent on line 1 and mark its right-most element as the head. In conformity with the procedure followed above we project and link the head elements onto the next line, shown in (5).

(5)

```
          x          line 2
          |
 x     x  x)         line 1
 |     |  |
(x  x (xx (x   x     line 0
 |  |  || |    |
 auto-biographic
```

```
                                     x    line 2
                                     |
                     x               x)   line 1
                     |               |
         x   x       x)        x     x)   line 0
         |   |       |         |     |
their new Lincoln Continental was made in California
```

The arrays of x's and parentheses constructed in this manner are called metrical grids and they contain the information about the grouping of elements into constituents, about the headedness of the constituents, and about the different degrees of prominence of the elements in the string. In constructing the grids we have employed only two formal mechanisms: the placement of grid marks and the placement of parentheses. Note in particular that we locate the heads of constituents by placing a mark on a line in the grid, that is, by the same formal mechanism that marks elements in the phoneme sequence as stress-bearing.

1 Projection, Edge Marking, and Head Location

To provide some practical experience with the devices just presented we will consider how they might be used to account for the stress pattern of words in the Koya language (Tyler 1969; Hayes 1980), described in (6), where the stress-bearing elements are the syllable heads.

(6) Stress falls on the head of every closed or long syllable as well as on the head of the initial syllable. Main stress is on the initial syllable.

According to (6) a typical Koya word will have the stress pattern shown in (7).[3]

```
(7) 2 x
    1 x     x     x
    0 x x x x x x x x x x x
```

In the following abstract examples, C stands for a consonant, V for a vowel and X for a post-vocalic element which contributes to syllable weight. An abstract word – a string of phonemes organized into syllables – compatible with (7) will therefore appear as in (8) where the square brackets represent syllable constituents.

(8) [CV] [CV] [CV] [CVX] [CV] [CV] [CVX] [CV] [CV] [CV] [CV]

To capture the effects of syllable structure on stress there must be an interface between the metrical grid and strings of phonemes such as the string in (8). The mechanism implementing this interface is called *projection*. Projection adds an element to the grid and links it to the element which is projected. Since words are sequences of phonemes organized into syllables, the projection mechanism involves both phonemes and syllables, in particular, syllable boundaries.

As already noted, not all phonemes are capable of bearing stress. We reflect this fact in the formalism by projecting onto the metrical plane only phonemes that can bear stress. In most languages the stress-bearing phonemes are the phonemes that are heads of syllables, and therefore in these languages it is syllable heads that are projected onto the metrical plane as its first line – line 0. We implement this by means of (9).

(9) *Line 0 mark projection*
Project a line 0 element for each *syllable head*.

In Koya only the head of a syllable is capable of bearing stress. Elements within syllables other than heads can be stress-bearing in some languages. In such languages such elements will also be projected onto line 0 by a suitably extended version of (9).

In many languages, including Koya, syllable boundaries play a role in the computation of the stress contour of words. Since only elements that appear on the metrical plane can be involved in the computation of stress we need a means for projecting syllable boundaries onto the metrical grid. This is accomplished with the Syllable Boundary Projection parameter, (10).

(10) *Syllable Boundary Projection parameter*

Project the $\left\{\begin{matrix}\text{left}\\ \text{right}\end{matrix}\right\}$ boundary of *certain syllables* onto line 0.

The projection of syllable boundaries governed by (10) is independent of the projection of grid marks governed by (9). Therefore, though all languages with stress invoke some form of (9), some languages fail to invoke any form of (10). Notice, therefore, that it is not the case that every parameter has a setting in every language. In these languages differences in syllable structure have no effect on stress. Languages differ in what kind of syllables trigger (10), but the effect of (10) on line 0 is always the same: it projects syllable boundaries onto line 0, inserting parentheses among the grid marks in the appropriate places. Languages also choose which of the two syllable boundaries to project; some project the right boundary, others project the left boundary. Likewise, as noted above, some languages use a variation of (9) to project more than one grid mark for some syllables. Again, the effect on the grid side of the interface is the same – the presence of extra metrical elements.

Thus, to account for the stress on heavy syllables in Koya we will project the left boundary of syllables that are either closed or contain long vowels, that is, we set (10) as in (11).

(11) Project the *left* boundary of [... VX] syllables onto line 0.

This setting for Syllable Boundary Projection will contribute a left parenthesis to the left of each x linked to the head of a heavy syllable, as shown in (12).

```
(12)   x     x     x  (  x      x     x  (  x      x     x     x     x   line 0
       |     |     |     |      |     |     |      |     |     |     |
     [CV]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CV]  [CV]
```

To mark the head element in each metrical constituent, we introduce the Head Location Parameter, (13).

(13) *Head Location parameter*

Project the $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$-most element of each constituent onto the next line of the grid.

The Head Location parameter is the grid-internal interface between layers of the grid. Recall that projection is our interface mechanism; to build further layers of the grid, we must again project certain elements. The Head Location parameter is the only grid-internal interface and thus each constituent is restricted to a single projected element. Koya sets Head:L as the interface between lines 0 and 1, giving (14).

```
(14)                     x                   x                                   line 1
       x     x     x  (  x      x     x  (  x      x     x     x     x   line 0
       |     |     |     |      |     |     |      |     |     |     |
     [CV]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CV]  [CV]
```

As a comparison with (7) shows, the constructed grid in (14) correctly reproduces all the secondary stresses in the abstract Koya word, but fails to reproduce the initial main stress in the word. To achieve the initial stress we need a means for adding a left parenthesis before the left-most element. Universal Grammar provides the Edge-Marking Parameter, given in (15), which will place a parenthesis at one edge of a sequence of marks.

(15) *Edge-Marking parameter*

Place a $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$ parenthesis to the $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$ of the $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$-most element in the string.

For line 0, Koya sets Edge:LLL, that is, it places a *left* boundary to the *left* of the *left*-most element. The grid in (16) is the result after the application of the line 0 parameters and the universal principles: Projection, Edge-marking, and Head Location.

```
(16)   x                 x                   x                                   line 1
      (x     x     x  (  x      x     x  (  x      x     x     x     x   line 0
       |     |     |     |      |     |     |      |     |     |     |
     [CV]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CVX]  [CV]  [CV]  [CV]  [CV]
```

To obtain initial main stress we need to apply Edge Marking and Head Location to line 1. In Koya the line 1 settings are Edge:LLL, and Head:L, giving (17).

```
(17)  x                                                         line 2
      (x          x              x                              line 1
      (x    x    x  ( x     x    x  ( x     x     x     x     x line 0
       |    |    |    |     |    |    |     |     |     |     |
     [CV] [CV] [CV] [CVX] [CV] [CV] [CVX] [CV]  [CV]  [CV]  [CV]
```

We summarize the action of the Koya parameters in (18). To reduce the clutter in the diagrams, we will adopt the typographical convention that H stands for a heavy syllable in the language (one subject to (10)), and L stands for a light syllable in the language (one not subject to (10)).

```
(18)  Line 0  Project:L  |  x x x(x x x(x x x x x    line 0 |
                         |  L L L H L L H L L L L           |
                         |----------------------------------|
              Edge:LLL   | (x x x(x x x(x x x x x    line 0 |
                         |  L L L H L L H L L L L           |
                         |----------------------------------|
              Head:L     |  x     x     x            line 1 |
                         | (x x x(x x x(x x x x x    line 0 |
                         |  L L L H L L H L L L L           |
                         |----------------------------------|
      Line 1  Edge:LLL   | (x     x     x            line 1 |
                         | (x x x(x x x(x x x x x    line 0 |
                         |  L L L H L L H L L L L           |
                         |----------------------------------|
              Head:L     |  x                        line 2 |
                         | (x     x     x            line 1 |
                         | (x x x(x x x(x x x x x    line 0 |
                         |  L L L H L L H L L L L           |
```

A given set of stress patterns can be consistent with more than one parameter setting. So, we should ask at this point, Could Koya be right-headed on line 0? That is, could we obtain the skeleton grid (7) by means of right-headed constituents. Indeed, we could. This would, of course, require changes in the other parameters. In particular, Koya would have to project the right boundary of heavy syllables instead of the left one. Likewise, the Edge parameter would have to be set to put a *right* parenthesis to the *right* of the *left*-most mark on line 0, to ensure that the initial element gets stress. The derivation for this alternative is shown in (19).

(19)

Line 0	Project:R	x x x x) x x x) x x x x L L L H L L H L L L L	line 0
	Edge:RRL	x) x x x) x x x) x x x x L L L H L L H L L L L	line 0
	Head:R	x x x x) x x x) x x x) x x x x L L L H L L H L L L L	line 1 line 0
Line 1	Edge:LLL	(x x x x) x x x) x x x) x x x x L L L H L L H L L L L	line 1 line 0
	Head:L	x (x x x x) x x x) x x x) x x x x L L L H L L H L L L L	line 2 line 1 line 0

For the facts of Koya stress, both systems will work. So which one does the speaker actually have? In her review of Halle & Vergnaud (1987), Blevins (1992) points out that many other kinds of evidence could bear on this issue. Various morphological processes such as reduplication could give evidence for foot structure. Likewise, phonological processes other than stress can be sensitive to metrical structure, and can affect metrical structure. For example, assume that we found out that some vowels were deleted. If a vowel in a stressed syllable happened to be deleted what would happen to its stress? The two sets of parameter settings differ in their predictions of where the stress would migrate. As we see in (20), left-headed feet would predict rightward shift, right-headed feet leftward shift.

(20)

	Head:L	Head:R
Project	x (x x ... V ... V ... V	x x) x ... V ... V ... V
Deletion	x (x ... V V	x) x ... V V
Head	x x (x ... V V	x x) x ... V V

But what if no such evidence is available? Notice that all parameter settings involve the choice between *left* and *right*. When all parameters are set to the same value, we shall say that the settings are *homogeneous*. Other settings will be referred to as *heterogeneous*. It appears that there is a universal preference for homogeneous parameter settings of the type found in (18) over heterogeneous settings such as those in (19).[4] Thus, in the absence of other evidence, we claim that Koya speakers have the homogeneous parameter settings of (18). Though homogeneous languages seem to be more common than heterogeneous ones, languages are not restricted to being homogeneous. Winnebago (discussed below) is one example of a heterogeneous language. In Winnebago the left boundaries of certain syllables are projected, but the heads of line 0 metrical consistuents are located on the right

Since we have hypothesized that bracketed grids consist of two kinds of elements – grid marks and parentheses – our theory so far counts as valid any sequence of marks and parentheses. Although this does not pose any immediate empirical problems because we have such a limited set of mechanisms for inserting marks and parentheses, this is still not an ideal state of affairs. Specifically, we want to eliminate the possibility of distinctions based on the number of parentheses beside a grid mark. It is plausible that Universal Grammar disallows certain configurations of marks and brackets. The vacuous constituents ((,)), and ( ) are obvious candidates for universal prohibition. Should such vacuous constituents arise during a derivation, the situation will be remedied by deleting the bracket defining the vacuous constituent. There are also metrical configurations which are banned in particular languages, but allowed in others. These language-particular disfavored configurations will be treated in a similar fashion, discussed in detail below.

2 Case Studies in Edge Marking

A host of stress patterns can be elegently accounted for with different settings of the Edge parameter. Consider the stress patterns in the three languages in (21): Koya, Selkup (Kuznecova, Xelimskij, and Gruškina 1980; Halle and Clements 1983) and Khalkha Mongolian (Street 1963; Hayes 1980). Each of these languages has some words which have initial stress.

(21)	Koya	Primary stress on the initial vowel. Secondary stresses on long vowels and vowels in closed syllables.
	Selkup	Stress on the right-most long vowel, otherwise on the initial vowel.
	Khalkha	Stress on the left-most long vowel, otherwise on the initial vowel.

Recall the parameter settings for Koya, repeated in (22).

(22)	Line 0	Project:L	Edge:LLL	Head:L
	Line 1		Edge:LLL	Head:L

In (23) we see the application of the Koya parameters to two abstract words, one containing only light syllables, the other including two heavy syllables.

(23)	Line 0	Project:L	x x x x x L L L L L	x(x x x (x x L H L L H L
		Edge:LLL	(x x x x x L L L L L	(x(x x x (x x L H L L H L
		Head:L	x (x x x x x L L L L L	x x x (x(x x x (x x L H L L H L
	Line 1	Edge:LLL	(x (x x x x x L L L L L	(x x x (x(x x x (x x L H L L H L
		Head:L	x (x (x x x x x L L L L L	x (x x x (x(x x x (x x L H L L H L

To capture the Selkup facts we propose the parameter settings in (24).

(24)	Line 0	Project:L	Edge:LLL	Head:L
	Line 1		Edge:RRR	Head:R

Thus, Selkup and Koya have the same line 0 parameters, but differ in the line 1 parameters. In (25) we show the Selkup derivations for the same two kinds of words.

(25)	Line 0	Project:L	x x x x x L L L L L	x(x x x (x x L H L L H L
		Edge:LLL	(x x x x x L L L L L	(x(x x x (x x L H L L H L
		Head:L	x (x x x x x L L L L L	x x x (x(x x x (x x L H L L H L
	Line 1	Edge:RRR	x) (x x x x x L L L L L	x x x) (x(x x x (x x L H L L H L
		Head:R	x x) (x x x x x L L L L L	x x x x) (x(x x x (x x L H L L H L

As shown in (25), the settings in (24) locate main stress on the right-most long vowel, but in words without long vowels, stress is located on the first syllable. In addition to main stress, however, the parameter settings in (24) also generate subsidiary stresses, which, according to our sources, are not present in the speech of Selkup speakers. We shall therefore postulate that unlike Koya, Selkup is subject to a special rule of Conflation which eliminates all but the main stress in the word.[5]

Khalkha stresses the first heavy syllable, or, when there are no heavy syllables, the first syllable. Thus Khalkha, like Selkup, must end up eliminating secondary stresses through Conflation. In fact, Khalkha must be the line 1 mirror image of Selkup, placing word stress on the first constituent. However, if the Edge Marking parameter were set to LLL on line 0 this combination would produce uniform initial stress. But we know that the presence of heavy syllables in a word disallows the initial syllable from heading a line 0 constituent. We can achieve this by setting the line 0 Edge parameter to RRR, giving Khalkha the parameter settings in (26).

(26)	Line 0	Project:L	Edge:RRR	Head:L
	Line 1		Edge:LLL	Head:L

By placing a *right* parenthesis to the *right* of the *right*-most element we will get initial stress in words consisting solely of light syllables. However, in words with at least one heavy syllable, the insertion of a right parenthesis at the end of the word will be vacuous, as it will not define a constituent separate from the constituent defined by the right-most heavy syllable. This will prevent the placement of stress on the initial syllable, as illustrated by the derivations in (27).

(27)

Line 0	Project:L	x x x x x L L L L L	x(x x x (x x LH L L H L
	Edge:RRR	x x x x x) L L L L L	x(x x x (x x) LH L L H L
	Head:L	x x x x x x) L L L L L	x x x(x x x (x x) LH L L H L
Line 1	Edge:LLL	(x x x x x x) L L L L L	(x x x(x x x (x x) LH L L H L
	Head:L	x (x x x x x x) L L L L L	x (x x x(x x x (x x) LH L L H L

Khalkha thus differs from Koya in the setting of the Edge parameter on line 0. In words without heavy syllables, this difference has no effect. Either setting yields the same stress contour. In words with heavy syllables, Khalkha will leave the initial string of light syllables unmetrified, but, as shown in (28), in Koya the initial string of light syllables will form a constituent and therefore the initial syllable will receive stress.

(28)

Koya	Khalkha
x (x x x (x (x x x (x x L H L L H L	x x x x (x x x (x x) L H L L H L

Recall that Koya and Khalkha differ in one other respect. The secondary stresses remain in Koya words, but are eliminated in Khalkha by Conflation.

3 Lexical Stress and Syllable Boundary Projection

It has long been known that there are languages where stress is an idiosyncratic property of individual morphemes. A typical example of this is provided by the distinctions in the stress patterns in the nominal inflection of the so-called a-stem nouns in modern Russian, illustrated in (29).

(29)		cow	head
	nominative singular	koróv-a	golov-á
	accusative singular	koróv-u	gólov-u

As was noted first by Kiparsky and Halle (1977), when a word has one or more inherently accented morphemes, stress surfaces on the left-most accented vowel. Otherwise, stress falls on the initial syllable. A comparison of this description with that of Khalkha stress in (21) will readily reveal that these are identical except that in Russian inherently (= idiosyncratically) accented vowels behave like the long vowels in Khalkha. We recall that in Khalkha the left boundary of any syllable with a long vowel was projected onto line 0 by the Syllable Boundary Projection parameter. If we now assume that in Russian the Syllable Boundary Projection parameter is triggered not by a phonetically manifested property of the syllable, but rather by an idiosyncratic property of a morpheme, then we can use the parameter settings, (26), that we used for Khalkha to compute the stress in the Russian words in (29).[6] We illustrate this with the derivations in (30).

(30)						
	Line 0	Project:L	x(x (x korov-a	x(x x korov-u	x x (x golov-a	x x x golov-u
		Edge:RRR	x(x (x) korov-a	x(x x) korov-u	x x (x) golov-a	x x x) golov-u
		Head:L	x x x(x (x) korov-a	x x(x x) korov-u	x x x (x) golov-a	x x x x) golov-u
	Line 1	Edge:LLL	(x x x(x (x) korov-a	(x x(x x) korov-u	(x x x (x) golov-a	(x x x x) golov-u
		Head:L	x (x x x(x (x) korov-a	x (x x(x x) korov-u	x (x x x (x) golov-a	x (x x x x) golov-u

The morphemes, *korov* and *-a*, are lexically marked to trigger Syllable Boundary Projection on one of their syllables. This is the meaning of inherent accent in the present theory. As in Khalkha and Selkup, Conflation also applies to words in Russian, eliminating all but the main stress.

Kiparsky and Halle (1977) argued that the same stress principles found in Russian applied in Lithuanian and in Sanskrit, and that therefore the stress system of the Indo-European protolanguage must have been based on the same principles. This means that Indo-European stress had the parameter settings of (26), with the special proviso that Syllable Boundary Projection was triggered in lexically marked syllables.

Turkish is another language with morphologically and lexically determined stress. Discussions of Turkish stress can be found in Sezer (1983), Poser (1984), Kaisse (1985), Halle and Vergnaud (1987), Barker (1989), Halle and Kenstowicz (1991), and van der Hulst and van de Weijer (1991). In (31) we quote Poser's description of the basic facts of Turkish stress.

(31) In Turkish stress generally falls on the last syllable of the word [cf. 32a] . . . Exceptions are of two kinds. First, there are a number of words with inherent stress on some nonfinal syllable [32b]. In this case, stress does not shift when suffixes are added . . . [Second,] there are a number of suffixes that never bear stress [32c].

Examples are given in (32); (32a) is a normal stem, (32b) is a stem with fixed non-final stress, and (32c) illustrates the prestressing suffix *-dur*.

(32)	(a)	adám	"man"	adam-lár	"men"
		adam-lar-á	"to the men"		
	(b)	mása	"table"	mása-lar	"tables"
		mása-lar-a	"to the tables"		
	(c)	yorgún	"tired"	yorgun-lár	"tired" (pl.)
		yorgún-dur-lar	"they are tired"		

We will now translate the analysis of Halle and Kenstowicz (1991) into the present framework. To do this, we assume that Turkish has the stress parameters shown in (33)

(33)	Line 0	Edge:LLL	Head:R
	Line 1	Edge:LLL	Head:L

For unexceptional words, such as the paradigm for *adam* (32a), final stresses will be correctly generated, as shown in (34).

```
(34) Line 0  Project:L   x x   x
                         adam-lar

             Edge:LLL   (x x   x
                         adam-lar

             Head:R            x
                        (x x   x
                         adam-lar

     Line 1  Edge:LLL         (x
                        (x x   x
                         adam-lar

             Head:L            x
                              (x
                        (x x   x
                         adam-lar
```

The formal problem that arises at this point is how to represent the morphemes that generate the exceptional patterns in (32b, c). We note that these are of two kinds. The stem morpheme, *masa* in (32b) takes stress on the penultimate syllable whereas the exceptional suffix morpheme *-dur* of (32c) places stress on the immediately preceding syllable. We can achieve this by postulating that the Syllable Boundary Projection parameter can be triggered by individual morphemes. Specifically, we shall assume that Turkish contains a set of morphemes that trigger a left Boundary Projection on their final syllable. Under this assumption, we get the derivations in (35), correctly placing main stress in these words.

```
(35) Line 0  Project:L    x(x  x      x   x    (x   x
                         masa-lar     yorgun-dur-lar

             Edge:LLL    (x(x  x     (x   x    (x   x
                         masa-lar     yorgun-dur-lar

             Head:R       x    x      x         x
                         (x(x  x     (x  x     (x   x
                         masa-lar     yorgun-dur-lar
```

Line 1	Edge:LLL	(x x (x(x x masa-lar	(x x (x x (x x yorgun-dur-lar
	Head:L	x (x x (x(x x masa-lar	x (x x (x x (x x yorgun-dur-lar

Turkish words, like those in Selkup, Khalkha, and Russian, are subject to Conflation, which eliminates secondary stresses.[7] Thus, the lexically governed application of Syllable Boundary Projection in Turkish interacts with the general stress parameters of Turkish to derive the stress contours of the exceptional words.

4 Iterative Constituent Construction

Languages are not limited to placing stresses only on elements near an edge or on elements with special properties. Languages also can construct a train of constituents over the sequence of metrical elements. In all known cases these constituents are either binary or ternary. We shall have nothing to say here about ternary constituents other than to note that they are attested in a few languages such as Cayuvava and the Chugach dialect of Yupik Eskimo. We have listed three well-known stress patterns in (36): Warao (Osborn 1966), Weri (Boxwell and Boxwell 1966), and Maranungku (Tyron 1970). We shall discuss each of these in turn.

(36) Warao — Stress falls on even-numbered syllables counting from the end of the word. Main stress is on the penultimate syllable.

Weri — Stress falls on all odd-numbered syllables counting from the end of the word. Main stress is on the last syllable.

Maranungku — Stress falls on all odd-numbered syllables counting from the beginning of the word. Main stress is on the initial syllable.

Languages achieve such binary stress patterns by setting the Iterative Constituent Construction parameter, (37).

(37) *Iterative Constituent Construction parameter*

Insert a {left / right} boundary for each pair of elements.

Iterative Constituent Construction (ICC) constructs constituents by scanning across the form, placing the "far" parenthesis. That is, going left to right, ICC inserts right parentheses; going right to left, ICC inserts left parentheses.[8] We hypothesize that Iterative Constituent Construction is one of a small number of directional rules provided by Universal Grammar.[9] Following the suggestion of Howard (1972) on the directional application of rules, the ICC rules have no "look-ahead." Putting these ideas together thus means that (37) actually governs the application of the two rules in (38).

(38) ICC:L = Ø → (/ ____ x x (right to left)
ICC:R = Ø →) / x x ____ (left to right)

Each of the two rules in (38) will generate a series of binary constituents when applied to a sequence of elements. We assume – in contrast to Halle and Vergnaud – that the ICC rules do not have the option of generating constituents with less than two elements. As a result, in a string with an odd number of syllables the application of a binary ICC rule will leave the furthest element unmetrified. An immediate consequence of this fact is that the ICC can never apply to monosyllabic words. However, in some languages with binary constituents monosyllabic words do bear stress. This fact calls for an explanation. The explanation in the present theory is quite simple: these languages require the setting of the Edge Marking parameter.[10]

Warao places stress on all even-numbered syllables starting from the end of the word, as shown by the examples in (39).

(39) yàpurùkitàneháse "verily to climb"
yiwàranáe "he finished it"

Clearly constituents of two elements are being created from right to left. So the parameters settings for Warao are those in (40).

(40)	Line 0	Edge:RRR	ICC:L	Head:L
	Line 1	Edge:RRR		Head:R

The settings in (40) applied to the words in (39) yield the derivations in (41).

(41)	Line 0	Edge:RRR	x x x x x x x x) yapurukitanehase	x x x xx) yiwaranae
		ICC:L	(x x(x x(x x (x x) yapurukitanehase	x (x x (xx) yiwaranae
		Head:L	x x x x (x x(x x(x x (x x) yapurukitanehase	x x x (x x (xx) yiwaranae

Line 1	Edge:RRR	x x x x) (x x(x x(x x (x x) yapurukitanehase	x x) x (x x (xx) yiwaranae
	Head:R	x x x x x) (x x(x x(x x (x x) yapurukitanehase	x x x) x (x x (xx) yiwaranae

As is evident from the descriptions in (36), Maranungku must assign binary constituents left to right, and Weri must assign them right to left. The line 0 parameter settings for Maranungku and Weri are given in (42).

(42)	Maranungku	Edge:RRR	ICC:R	Head:L
	Weri	Edge:LLL	ICC:L	Head:R

Derivations for two words of Maranungku, one odd and one even, are shown in (43).

(43)	Odd	Even
Edge:RRR	x x x x x) langkarateti	x x x x x x) welepenemanta
ICC:R	x x)x x)x) langkarateti	x x)x x) x x) welepenemanta
Head:L	x x x x x)x x)x) langkarateti	x x x x x)x x) x x) welepenemanta
	"prawn"	"kind of duck"

And derivations for two similar Weri words are given in (44).

(44)

	Odd	Even
Edge:LLL	(x x x x x akunetepal	(x xx x uluamit
ICC:L	(x (x x(x x akunetepal	(x x(x x ulu amit
Head:R	x x x (x (x x(x x akunetepal	x x x (x x(x x ulu amit
	"times"	"mist"

Notice that the two different parameter settings in (43) produce the same stress contours for words with an odd number of syllables, just as Koya, Selkup, and Khalkha have different parameter settings, but all produce initial stress in words with only light syllables. Furthermore, it is again possible for other parameter settings to achieve the same patterns for both even and odd words. For example, the Weri stress patterns can also be generated with the line 0 parameter settings given in (45).

(45) Edge:LLR ICC:L Head:L

The settings in (45) yield the derivations in (46).

(46)

Edge:LLR	x x xx(x akunetepal	x x x (x ulu amit
ICC:L	(x x (x x(x akunetepal	x(x x (x ulu amit
Head:L	x x x (x x (x x(x akunetepal	x x x(x x (x ulu amit

Parameter homogeneity will not decide between the settings in (42) and (45). Each of these two possibilities for Weri stress contains one R specification. However, there are differences in the metrical structure assigned to the Weri words. The structure for *uluamit* shown in (44) has two-element constituents exclusively. In contrast, the structure for *uluamit* shown in (46) has a constituent with two elements, a constituent with one element, and one unmetrified element. Thus, the metrical structures assigned to Weri even words by (42) are more homogeneous than those assigned by (45). It has also been suggested (see Hayes 1991, for example) that unary constituents and unmetrified elements are disfavored in constructing metrical constituents. For these reasons, we conjecture that the settings in (42) are preferred over those in (45).

5 Avoidance Constraints

The stress patterns of Garawa are similar to those of Warao, but not identical. According to Furby (1974), stress falls on even-numbered syllables counting from the end of the word, and on the first syllable, but never on the second. Main stress is on the first syllable. Examples are given in (47).

(47) wátjimpàŋu "armpit"
nářiŋinmùkunjìnamìřa "at your own many"

If we modify the Warao settings by adding Edge:LLL we will ensure that the first syllable is stressed. So the first approximation to the Garawa parameters is the parameter settings shown in (48).

(48)	Line 0	Edge:LLL	ICC:L	Head:L
	Line 1	Edge:LLL		Head:L

The settings in (46) yield stresses on all even-numbered syllables counting right to left and also on the first syllable. However, something must still be added to prevent stress from occurring on the second syllable. We can accomplish this by preventing the creation of certain grid configurations. Specifically, we want to prevent orphans – constituents with only one element – from being created. The constraint in (49) specifies the metrical configuration that Garawa does not tolerate.

(49) Avoid (x(

Avoid (x(prevents what is called "stress clash." If Garawa did not have this constraint, sometimes two adjacent syllables would both be heads of line 0 constituents, and thus would both be stressed. Some languages, including Garawa, do not tolerate such a situation. Other languages, for example Tubatulabal (Hayes 1980), do allow adjacent stressed syllables. The addition of Avoidance Constraints provides us with sufficient tools to correctly locate Garawa stress; the derivations are given in (50).

(50)	Line 0	Edge:LLL	(x x x x x x x x x nařiŋinmukunjinamiřa	(x x x x watjimpaŋu
		ICC:L	(x x x (x x (x x (x x nařiŋinmukunjinamiřa (x (avoided	(x x (x x watjimpaŋu
		Head:L	x x x x (x x x (x x (x x (x x nařiŋinmukunjinamiřa	x x (x x (x x watjimpaŋu
	Line 1	Edge:LLL	(x x x x (x x x (x x (x x (x x nařiŋinmukunjinamiřa	(x x (x x (x x watjimpaŋu
		Head:L	x (x x x x (x x x (x x (x x (x x nařiŋinmukunjinamiřa	x (x x (x x (x x watjimpaŋu

Thus, the effect of Avoid (x(is to give words with an odd number of syllables a constituent with three elements at the left edge.

The blocking of the application of a rule in this fashion is the same as the "active" formulation of the OCP of McCarthy (1986), quoted in (51), in which the OCP *prevents* the application of rules which would produce unacceptable configurations.

(51) . . . the OCP operates not only in a passive way, on the lexical listing of morphemes, but also actively in the course of the phonological derivation. Its function in the derivation, I claim, is not that sporadically assumed in the tonal literature (a process that fuses adjacent identical tones into a single one), but rather is more typical of other principles of grammar, accounting for a hitherto unnoticed constraint, called antigemination, which prohibits syncope rules from creating clusters of identical consonants.

We adopt this view of constraints: that they prevent the creation of disfavored structures. However our Avoidance Constraints are different from McCarthy's formulation of the OCP in one respect: some Avoidance Constraints are active only in particular languages. Thus, the constraints act as output conditions on the rules. The rules are the only means of creating metrical structures, and the function of the constraints is to limit the application of these rules. As such, the Avoidance Constaints cannot be violated. Thus, a child acquiring a language must learn which rules are operative in the language and which constraints are utilized.

This analysis of clash avoidance must be contrasted with clash resolution accounts. In Halle and Vergnaud (1987), the full metrical constituency was constructed, and at the end disfavored configurations were eliminated by the application of a rule. Under such a view, the origin of the constituent structure plays no role in the resolution of clash. Parentheses are parentheses, no matter what parameter licensed their occurence. With Avoidance Constraints, the function of the derivation is extremely important. Since disfavored configurations are not allowed to arise, the origin of each parenthesis is very much at issue. Simply put, parentheses that get placed first preclude the introduction of later parentheses that would result in a disfavored configuration. As a result, in avoiding a configuration such as (x(, the presence of a parenthesis will prevent the introduction of a parenthesis both to the left and to the right. By contrast, in a rule-based account like that of Halle and Vergnaud (1987), clash is always resolved in a particular direction.

Latin exemplifies a common stress pattern in which main stress is restricted to the last three syllables of the word. Stress is assigned to the penultimate syllable if it is heavy, otherwise to the antepenultimate. We propose the parameters in (52) for Latin.

(52)	Line 0	Project: L	Edge: RLR	ICC:L	Head: L
	Line 1		Edge: RRR		Head: R
	Conflation				

In Latin final syllables are not stressed, even when they are heavy. That means that they must not be subject to Project:L. To capture this fact we propose that Latin avoids creating final orphans; that is, Latin has the constraint Avoid (x#. In Garawa certain applications of ICC rules were blocked in avoiding orphans, while in Latin, certain applications of Syllable Boundary Projection are blocked in avoiding orphans. Derivations for two Latin words are shown in (53).

(53) Line 0	Project:L	x x x x reprimitur	x x (x x reprimuntur	(x# avoided
	Edge:RLR	x x x)x reprimitur	x x (x)x reprimuntur	
	ICC:L	x (x x)x reprimitur	(x x (x)x reprimuntur	
	Head:L	x x (x x)x reprimitur	x x (x x (x)x reprimuntur	

Line 1	Edge:RRR	x) x (x x)x reprimitur	x x) (x x (x)x reprimuntur
	Head:R	x x) x (x x)x reprimitur	x x x) (x x (x)x reprimuntur

Notice that as a consequence of the fact that the Iterative Constituent Construction cannot construct constituents with less than two marks, the last element is systematically precluded from being part of a constituent because of the effect of the Edge parameter. Since the last mark will effectively be "frozen out," it acts as if it is not there. Previous metrical theories had to invoke a special device of extrametricality to skip these elements. We are able to capture the extrametricality effect as a specific manifestion of the general Edge Marking.

There is a problem with the parameters in (52), however. This system incorrectly predicts that monosyllabic words should not be stressed, as shown in (54).

(54)	Line 0	Project:L	x muːs	(x# avoided
		Edge:RLR	)x muːs	
		ICC:L		
		Head:L		
	Line 1	Edge:RRR		
		Head:R		

Mester (1991) notes that Latin has a minimal word constraint (see McCarthy and Prince 1986): #CV# words are systematically excluded in Latin. Thus all Latin monosyllabic words must consist of a heavy syllable. Then all that is required is to exempt monosyllabic words from the constraint against final orphans. This can be accomplished by embellishing Avoid (x# to Avoid x(x#, making specific reference to two grid marks. Because all monosyllabic words consist of a heavy syllable, Syllable Boundary Projection will apply to them, as shown by the derivation in (55).

(55)

(55)	Line 0	Project:L	x muːs	x(x# avoided
		Edge:RLR		
		ICC:L		
		Head:L	x (x muːs	
	Line 1	Edge:RRR	x) (x muːs	
		Head:R	x x) (x muːs	

This account of Latin stress is also compatible with the accounts of Latin enclitic stress in Steriade (1988) and Halle and Kenstowicz (1991). When enclitics are added to a word, stress shifts onto the last syllable of the host word regardless of the length of the host or the clitic, as shown in (56).

(56)	(a)	líːmina	"thresholds"	liːminá#que	"and the thresholds"
	(b)	úbi	"where"	ubí#libet	"wherever"
	(c)	quáː	"which"	quáː#propter	"because of which"

Words with bisyllabic enclitics (56b, c) have antepenultimate stress, as do words without enclitics. However, the enclitic stress is not attracted to a heavy penultimate syllable, as shown by (56c). Words such as (56a) show an unexpected pattern of penultimate stress. Steriade's insight into this unexpected pattern was to apply metrification rules both before and after cliticization, with the second round of metrification respecting the constituent structure built during the first.

We can translate the analyses of Steriade (1988) and Halle and Kenstowicz (1991) into the present theory. We will assume, following Halle and Vergnaud (1987), that phonological rules are assigned to two distinct blocks. The first of these is the cyclic block, and the second is the noncyclic block. The morphemes that make up a word are each labeled for the feature [± cyclic]. Only morphological constituents whose heads are [+ cyclic] are subject to the rules in the cyclic block. After the cyclic rules have applied to the largest [+ cyclic] constituent in the word, the entire word is subjected to the rules of the noncyclic block. We assume that in Latin the line 0 parameters are part of both the cyclic and the noncyclic block, with the exception of Syllable Boundary Projection, which applies only in the cyclic block.[11] Since the enclitics are all noncyclic affixes, this correctly captures the fact that syllable quantity is not relevant in the calculation of enclitic stress. Words without enclitics will nevertheless still be subject to all of the metrical parameters, and the two applications of Edge Marking in such words is equivalent to a single application. Derivations for words with bisyllabic enclitics are shown in (57).

(57)	Cyclic	Line 0	Project:L	x x ubi	xx eaː	x(x# avoided
			Edge:RLR	x) x ubi	x) x e aː	
			ICC:L			
			Head:L	x x)x ubi	x x) x e aː	
	Noncyclic	Line 0	Edge:RLR	x x) x x)x ubi#libet	x x) x x) x e aː#propter	
			ICC:L	x x) (x x) x ub i#libet	x x) (x x) x e aː#propter	
			Head:L	x x x) (x x) x ub i#libet	x x x) (x x) x e aː#propter	
		Line 1	Edge:RRR	x x) x) (x x) x ub i#libet	x x) x) (x x) x e aː#propter	
			Head:R	x x x) x) (x x) x ub i#libet	x x x) x) (x x) x e aː#propter	

The procedure also correctly yields penultimate stress in words with monosyllabic enclitics, as shown in (58).

(58)	Cyclic	Line 0	Project:L	x x x li:mina	(x x mu:sa	x(x# avoided
			Edge:RLR	x x) x li:mina	(x)x mu:sa	
			ICC:L	(x x) x li:mina	(x)x mu:sa	
			Head:L	x (x x) x li:mina	x (x)x mu:sa	
	Noncyclic	Line 0	Edge:RLR	x (x x)x)x li:mina#que	x (x)x)x mu:sa#que	
			ICC:L			
			Head:L	x x (x x)x)x li:mina#que	x x (x)x)x mu:sa#que	
		Line 1	Edge:RRR	x x) (x x)x)x li:mina#que	x x) (x)x)x mu:sa#que	
			Head:R	x x x) (x x)x)x li:mina#que	x x x) (x)x)x mu:sa#que	

Finally, this analysis correctly predicts the position of stress in the enclitic forms with monosyllabic stems, as shown in (59).

(59)	Cyclic	Line 0	Project:L	(x qua:	x(x# avoided
			Edge:RLR		
			ICC:L		
			Head:L	x (x qua:	
	Noncyclic	Line 0	Edge:RLR	x (x x)x qua:#propter	
			ICC:L		
			Head:L		
		Line 1	Edge:RRR	x) (x x)x qua:#propter	
			Head:R	x x) (x x)x qua:#propter	

Notice that the structure built by the cyclic rules for monosyllabic hosts differs from that for polysyllabic ones. A monosyllabic host gains a metrical constituent that is open at the right edge. A polysyllabic host instead gains a metrical constituent that is closed at the right edge (and also a following grid element). Thus, the metrical constituent in a monosyllabic host can accomodate new material that is added to the right edge, in particular, enclitic elements.[12] Additional material cannot be incorporated in this way into the final metrical constituent of a polysyllabic host. This behavior is subtly different from that predicted by the Free Element Condidition of Prince (1985). The analyses of Steriade (1988) and Halle and Kenstowicz (1991) both restrict the enclitic metrification to free elements – elements not belonging to metrical constituents – and thus incorrectly predict stress on the first syllable of a bisyllabic enclitic following a monosyllabic host: **qua:#própter*. In the present theory, a single parenthesis suffices to define a constituent, thus it is possible for constituents to be "open-ended." Such representations were not possible in previous metrical theories, where all constituents had both a left parenthesis and a right parenthesis, leading to incorrect predictions regarding free elements.

6 Winnebago

The accentual system of Winnebago has been very important in the development of metrical theory. Metrical analyses of Winnebago have been presented by Hale and White Eagle (1980), Halle and Vergnaud (1987), Miner (1989), and Hayes (1991). In particular, Winnebago was the source of the Domino Condition of Halle and Vergnaud (1987). The present theory allows for a simpler characterization of the Winnebago stress system, which renders the Domino Condition unnecessary. The source of the complications in Winnebago stress is the rule known as Dorsey's Law, informally stated in (60), which inserts an echo vowel between a consonant and a sonorant in the onset of a syllable.

(60) $\varnothing \rightarrow V_i / C$——$RV_i$

Halle and Vergnaud (1987) note that rules adding new stressable elements (such as Dorsey's Law) could take place either before or after metrical constituent assignment. If such rules apply before metrification, then the epenthetic vowels will bear stress if they appear in an appropriate location in the string. If the epenthesis follows metrical constituent construction, then no epenthetic vowel should ever bear stress. Winnebago words, however, seem to act both ways: epenthetic vowels can sometimes bear stress, but at other times they seem to be completely ignored.

Hale and White Eagle (1980) observe that in words (with light syllables) not subject to Dorsey's Law, stress is assigned to every odd mora except the first one. Winnebago is a language where all vowels can bear stress, not just syllable heads, and therefore all vowels are projected. To get stress on every odd mora except the first one, we will employ the parameter settings in (61).

(61)	Line 0	Edge:LRL	ICC:R	Head:R
	Line 1	Edge:LLL		Head:L

Derivations for two words not subject to Dorsey's Law are given in (62).

(62)

Line 0	Edge:LRL	x(x x x na anaʔa	x(x x xx ha akitujik
	ICC:R	x(x x)x na anaʔa	x(x x)xx) ha akitujik
	Head:R	x x(x x)x na anaʔa	x x x(x x)xx) ha akitujik
Line 1	Head:L	(x x(x x)x na anaʔa	(x x x(x x)xx) ha akitujik
	Head:L	x (x x(x x)x na anaʔa	x (x x x(x x)xx) ha akitujik
		"you weigh"	"I pull it taut"

From this point on we will ignore the line 1 parameters. Hayes (1991) points out that syllables with long vowels or diphthongs behave differently depending on their position in the word. Those in initial position behave as described so far, those in noninitial position attract stress. In order to capture this fact we will analyze these as Halle (1990) analyzes Cairene Arabic and Chugach Alutiiq – in addition to projecting two marks, long vowels and diphthongs will also receive a left bracket. In order to correctly characterize initial cases, we will also include the constraint Avoid #(, which prevents left parentheses from being projected in initial syllables.[13]

Some words with epenthetic vowels (capitalized in the following examples) seem to ignore the epenthesized vowels in stress assignment, as shown in (63).

(63) hoshAwazhá "you are ill"

In other words the epenthetic vowels bear stress, as in (64).

(64) maashÁrach "you promise"

And in still other words the epenthetic vowels do not bear stress, but do count in determining pairs, as in (65).

(65) xOrojíke "hollow"

Under the Halle and Vergnaud (1987) analysis there are two places an epenthesized vowel in a Winnebago word can occur: between two elements belonging to the same constituent or between two elements belonging to different constituents. As noted by Hale and White Eagle (1980), when the echo vowel occurs between two elements belonging to different constituents, it has no effect. When it occurs between two elements in the same constituent, the effect is to re-metrify all subsequent elements. It is this fact that the Domino Condidition, (66), was designed to capture.

(66) The introduction of an additional position inside a bounded constituent destroys the constituent and all constituents to its right if the Constistuent Construction rule applied left to right, and all constituents to its left if the Constituent Construction rule applied from right to left. Constituent structure is reimposed on the affected substring by a subsequent re-application of the Constituent Construction rule. (Halle and Vergnaud 1987)

Notice that in a left to right system the structure to the right is deleted, and that in a right to left system the structure to the left is deleted. This ensures that the effect of the Domino Condition is to restart the metrical count from the location of the epenthesis in a constituent. That is, new positions inserted inside existing constituents act like heavy syllables in restarting the metrical count. Obviously, it is preferable to have a theory that captures these facts without such a special stipulation. We believe that the theory sketched above accomplishes this. The invariant effect is that the echo vowels must coincide with a metrical constituent boundary. Thus, the appearance of an epenthetic vowel correlates with stress two syllables later. If a constituent boundary would have been placed there anyway, then it will appear as though stress is assigned before Dorsey's Law. If a boundary would not have been placed there, the apparent effect of Dorsey's Law is to provide a constituent boundary.

To capture the stress effect of these epenthetic vowels we will also project a left parenthesis for CRV syllables – those syllables that will be subject to Dorsey's Law. Thus, Dorsey's Law syllables behave like long vowels in projecting a left parentheses. To begin with, however, they project only a single grid mark. Another grid mark will be supplied by the operation of Dorsey's Law. The new grid mark is added to the left (outside) of the left parenthesis. Thus, the net effect of Projection and Dorsey's Law is to provide Dorsey's Law sequences with the metrical pattern x(x Since line 0 constituents are right-headed, Dorsey's Law syllables have a post-accenting effect. After Dorsey's Law has applied, the rest of the metrical parameters will apply. Derivations for three such words are shown in (67).[14]

(67)

Project:L	xx x xrojike	xx (x x x hirakrohoni	xx (x xxx hirakrohonira
DL	x xxx xOrojike	xx x(x x x hirakOrohoni	xx x(x xxx hirakOrohonira
Edge:LRL		x(x x(x x x hirakOrohoni	x(x x(x xxx hirakOrohonira
ICC:R	x (xx)x xOrojike	x(x x)(x x)x hirakO rohoni	x(x x) (x x)x x) hirakO rohonira
Head:R	x x (xx)x xOrojike	x x x(x x)(x x)x hirakO rohoni	x x x x(x x) (x x)x x) hirakO rohonira
	"hollow"	"you do not dress"	"the fact that you do not dress"

As Miner (1989) notes, there is one case where epenthetic vowels do not always correlate with a following stress: when the Dorsey's Law syllable is final in the word, as shown by the words in (68).

(68) hojisÁna "recently" boopÉres "to sober up" kerepÁna "unit of ten"

To account for such words we will constrain Syllable Boundary Projection as we did in Latin, with Avoid (x#. This prevents final Dorsey's Law syllables from projecting parentheses and forming orphans, and yields the derivations in (69).

(69)

Project:L	xx x hojisna	xx x boopres	(x x krepna
DL	xx x x hojisAna	x x x x bo opEres	x(x x x kErepAna
Edge:LRL	x(x x x hojisAna	x(x x x bo opEres	
ICC:R	x(x x) x hojisAna	x(x x)x bo opEres	x(x x) x kErepAna
Head:R	x x(x x) x hojisAna	x x(x x)x bo opEres	x x(x x) x kErepAna
	"recently"	"to sober up"	"unit of ten"

Notice, however, that the ICC does pick up a final pair formed from a Dorsey's Law syllable when the preceding material coincides with the end of a constituent, as shown in (70).

(70)	
Project:L	x x x (x x x harakishrujikshna
DL	x x x x(x x x x harakishUrujikshAna
Edge:LRL	x(x x x(x x x x harakishUrujikshAna
ICC:R	x(x x) x(x x) x x) harakishUrujikshAna
Head:R	x x x x(x x) x(x x) x x) harakishUrujikshAna
	"you pull taut"

The derivation in (70) also illustrates a case where Dorsey's Law would have inserted a vowel between constituents in the Halle and Vergnaud (1987) analysis. Because the ICC cannot create constituents with only one element, the epenthetic vowel remains unmetrified, yielding a surface stress lapse of two syllables.

Of special interest are the cases where main stress falls on the fourth surface vowel of form, such as the examples in (71)

(71) hikOrohó "to prepare" wakIripÁras "flat bug"
wakIripÓropÓro "spherical bug"

Notice that the last two examples have final Dorsey's Law syllables, which will not project parentheses because of Avoid (x#. Thus far our account of Winnebago predicts that stress will occur on the second syllable of such forms, because of Edge Marking, as shown in (72).

(72)

Project:L	x (x x hikroho
DL	x x(x x hikOroho
Edge:LRL	x (x(x x hikOroho
ICC:R	x (x(x x) hikOroho
Head:R	x x x (x(x x) *hikOroho
	"to prepare"

There are two possible ways to address this problem: order Dorsey's Law after Edge Marking, or prevent Edge Marking from applying in these forms. However, reordering Dorsey's Law and Edge Marking will not work with other words, as the derivation in (73) demonstrates.

(73)

Project:L	x x hip res
Edge:LRL	
DL	x x x hipEres
ICC:R	x x)x hipEres
Head:R	x x x)x *hipEres
	"to know"

Rather, the correct derivation has Dorsey's Law preceding Edge Marking, as shown in (74).

(74)

Project:L	x x hipres
DL	x x x hipEres
Edge:LRL	x (x x hipEres
ICC:R	x (x x) hipEres
Head:R	x x (x x) hipEres
	"to know"

Therefore, we need to prevent Edge Marking from applying to these forms. The same constraint as in Garawa, Avoid (x(will accomplish this. Recall that Winnebago has a constraint against final orphans, Avoid (x#. That is, Winnebago has a general constraint against orphans, incorporating both Avoid (x(, as in Garawa, and Avoid (x#, as in Latin.[15] However, this system is still not sufficient, as the ICC can also create a constituent from the initial pair of marks, again yielding stress on the second syllable, as shown in (75).

(75)

Project:L	x (x x hikroho
DL	x x (x x hikOroho
Edge:LRL	
ICC:R	x x) (x x) hikO roho
Head:R	x x x x) (x x) *hikO roho
	"to prepare"

The correct constraint to add is somewhat surprising – Avoid)(. This constraint will prevent the ICC from creating constituents that abut projected parentheses. Thus, Winnebago has the constraints Avoid #(, (x#, (x(and)(. After adding this constraint, we get the derivations in (76).

(76)

Project:L	x (x x hikroho	x (x x wakripras	x (x x x wakripropro
DL	x x(x x hikOroho	x x(x x x wakIripAras	x x(x x x x x wakIripOropOro
Edge:LRL			
ICCC:R	x x(x x) hikOroho	x x(x x) x wakIripAras	x x(x x) x x) x wakIripOropOro
Head:R	x x x(x x) hikOroho	x x x(x x) x wakIripAras	x x x x(x x) x x) x wakIripOropOro
	"to prepare"	"flat bug"	"spherical bug"

The ICC is prevented from creating a constituent out of the initial pair of elements by Avoid)(. Because the initial pair of elements does not form a constituent, the main stress falls on the fourth mora of the word. Futhermore, Avoid)(also predicts the location of stress in more complicated forms, correctly modeling the curious three-syllable lapses observed by Hale (1985), as shown in (77).

(77)

Project:L	x x x x (x x hirat'at'ashnakshna
DL	x x x x x (x x x hirat'at'ashAnaksAhna
Edge:LRL	x(x x x x (x x x hirat'at'ashAnaksAhna
ICC:R	x(x x) x x (x x) x hirat'at'ashAnaksAhna
Head:R	x x x(x x) x x (x x) x hirat'at'ashAnaksAhna
	"you are talking"

This form exhibits an interior lapse of three syllables, as the preceding cases exhibited in initial position. Miner (1989) and Hayes (1991) also cite further cases of lapses, involving long vowels, as shown in (78).

(78)			
	Project:L	x x x x x(xx x x waGiGigishgapuizhere	x x(xx x x(xx x x hizhakiichashgunianaga
	DL		
	Edge:LRL	x (x x x x(xx x x waGiGigishgapuizhere	
	ICC:R	x (x x)x x(xx) x x) waGiGigishgapuizhere	x x(xx) x x(xx)x x) hizhakiichashgunianaga
	Head:R	x x x x (x x)x x(xx) x x) waGiGigishgapuizhere	x x x x x(xx) x x(xx)x x) hizhakiichashgunianaga
		"baseball player"	"nine and"

Perhaps somewhat anticlimactically, this analysis also correctly predicts the stress placement in monosyllables subject to Dorsey's Law, as shown in (79).

(79)		
	Project:L	x kre
	DL	x x kEre
	Edge:LRL	
	ICC:R	x x) kEre
	Head:R	x x x) kEre
		"to leave returning"

The analysis of Winnebago presented above has several important characteristics which we want to emphasize. By allowing boundaries to be projected it is possible to account for the effect of Dorsey's Law syllables on the stress patterns of Winnebago words without resorting to mechanisms such as the Domino Condition of Halle and Vergnaud (1987). Winnebago also employs both Avoid (x# and Avoid (x(, showing that languages can have very general prohibitions against orphans. Perhaps most interestingly, Winnebago shows that the parameters for Syllable Boundary Projection and Head Location do not need to be homogeneous. By projecting left parentheses for CRV syllables while line 0 constituents are right headed we achieve the post-stressing effect of syllables subject to Dorsey's Law.

7 Summary

The discrete calculus presented above formally captures Liberman's insight that stress in language is a reflection of the groupings that speakers impose on sequences of linguistic elements. Once these groupings have been established, greater prominence is supplied to certain elements in the group than to the others. The prominence is thus a by-product of the grouping of the elements into constituents.

We suggested that for purposes of notating these groupings Universal Grammar provides a special plane on which the metrical grid is constructed. The grid consists of a number of parallel lines composed of marks and parentheses. The various parameter settings then interact with universal and language particular constraints to produce the stress systems found in different languages. Thus, metrical constituents are not composed of sequences of phonemes, or (as in Kager 1992) moras or syllables. Rather metrical constituents group projections of particular units in the phoneme sequences, specifically, those that are capable of bearing stress. In this way, the framework captures the fact that not all elements in the sequence have a bearing on stress assignment. In particular there are languages in which certain syllable heads (usually schwa) are metrically inert while behaving as normal syllable heads in every other respect. Thus, we deny the hypothesis that units of prosody are strictly layered in a hierarchy (McCarthy and Prince 1986; Selkirk 1986). In particular, stress and syllable structure are represented on different planes.

For the purposes of constructing metrical grids, the theoretical framework proposed here has available only two mechanisms. One of these generates a line on the metrical grid by the Projection of marks and boundaries from the next lower line. The other mechanism constructs constituents by the placement of appropriate boundaries. The functioning of these two mechanisms is constrained by universal restrictions so that only a narrow range of options is available for the placement of boundaries and marks. Because of the parameterized nature of the framework, the addition of parameters to the set utilized in characterizing a body of data causes a geometric increase in the number of patterns characterized. Since learners of such a characterization need to look only for cues to set the individual parameters (Dresher and Kaye 1990; Dresher to appear), they need to make only a relatively small number of decisions to be able to generate a large number of distinct stress patterns. This explains the well-known fact that speakers of different languages master their stress patterns with great facility and speed.

The most significant innovation of the present theory is in the representations of bracketed grids. By eliminating superfluous parentheses, we change the meaning of the parentheses themselves. A single parenthesis is now sufficient to define a metrical constituent. This has the important consequence that metrical constituents can be open-ended. This, in turn, means that constituency can be modified while still respecting the already assigned structure in the sense of Halle (1990). The addition of new elements can augment constituents and the (re)application of parameter settings can subdivide constituents. Operations that must destroy previously built structure in tree theory can be formulated in the present theory so that they only add structure. Thus this theory gives a whole new meaning to constituent structure and Free Elements.

We also deviate from previous metrical theories by not requiring exhaustive parsing of the sequence of elements, that is we do not require that every element belong to some constituent, thus also denying the fundamental basis of Prosodic Licensing (Itô 1989; see also Bagemihl 1991).

Another innovation of the present theory is the Edge Marking Parameter, which, among other things, captures the effects ascribed to Extrametricality and the End Rule in Prince (1983). This simple device solves a number of puzzles in generative stress theory. For example, as we showed in our discussion of the stress patterns of Koya, Selkup, and Khalkha, these very different patterns are elegantly characterized by different settings of the Edge Marking parameter. This represents an advance over previous theories since they were able to characterize the stress pattern of languages like Khalkha only with the help of special ad hoc devices. This is important because Khalkha-type stress patterns show up in languages the world over. Salish languages, certain Northwest Caucasian languages, and Indo-European languages such as Russian, Lithuanian, and Sanskrit all show this kind of stress pattern.

In constructing iterative constituents we deviated from the procedure in Halle and Vergnaud (1987) and restricted this operation to construct only full constituents, agreeing in this respect with Hayes (1991). However, the theory of binary constituent construction through the operation of the ICC is to be contrasted with Hayes (1991) and other recent work in stress theory, which claim that binary constituents are universal, and that there is a taxonomy of foot types. In such theories each foot type encodes both constituency and prominence simultaneously, so that parsing a word into feet assigns prominence at the same time. In our framework the foot is not a theoretical primitive. Rather, metrical boundaries are placed among the stress-bearing elements.

In this way the sequence of stress-bearing elements is subdivided into constituents of various kinds, including iambs and trochees, although iambs and trochees have no privileged status. In fact, the ICC, like Syllable Boundary Projection and Edge Marking can be present or absent in a language's parameter settings. If there is a setting for the ICC, then a sequence of constituents is generated. If there is no setting for ICC then the constituents that arise are only those defined by either Syllable Boundary Projection or Edge Marking. This also means that there are no parameters that directly control the size of the metrical constituents, as the parameters of [±Bounded] and [±Head Terminal] did in Halle and Vergnaud (1987). Unbounded constituents result from the absence of the application of the ICC.

For example, the projection of elements onto the higher lines in the grid is limited to the operation of the Head Location parameter. The framework therefore lacks the capability of increasing an element's prominence directly. As a consequence, any element with increased prominence must always be first or last within its constituent. Furthermore, in the present theory constituent construction precedes the assignment of heads. By separating the construction of constituents from the marking of heads we predict that the constituents of a word will all have the same headedness. For instance, words parsed into a combination of trochees and iambs are forbidden within this framework. Likewise, we also predict that syllables which project boundaries will not necessarily receive more prominence. The post-accenting effect of Dorsey's Law syllables in Winnebago is an example of just such a system.

Finally, the new representations and rules are subject to various constraints on well-formedness – the Avoidance Constraints. These constraints act in concert with the application of specific parameterized rules of element and parenthesis insertion to yield a derivation. This means that parentheses that are inserted by earlier parameters have priority over those inserted by later parameters. Taken together, these innovations in representations, rules and constraints yield a novel and more accurate conception of the meaning of metrical structure and operations.

NOTES

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1 We will introduce some departures from Idsardi (1992), which we will indicate in footnotes.

2 We depart from previous work in

bracketed grid theory (Halle & Vergnaud (1987), Hayes (1991), etc.) in proposing that a single parenthesis serves to define a metrical constituent. Thus, where the former representation of a three element constituent is (xxx), the present theory can also have (xxx or xxx), depending on other factors within the language.

3 In (7) and subsequent examples the links between elements on different lines of the grid have been suppressed.

4 Notice that settings which employ only one kind of parenthesis will be more homogeneous than those employing both. Other kinds of preferences could also play a role, such as dispreferences for unmetrified elements and orphans. See below for one method of encoding such dispreferences.

5 See Halle & Kenstowicz (1991) and Idsardi (1992) for formulations of Conflation

6 In Idsardi (1992), idiosyncratic stress is analyzed as morphologically triggered applications of Edge Marking. We have chosen in this paper to outline how morphologically triggered Syllable Boundary Projection can be used to the same ends. At the present time there seems to be insufficient evidence for a definitive conclusion as to which theory of lexical stress is preferable, or if both views are required. For discussion see Idsardi (1992).

7 See van der Hulst and van de Weijer (1991) for a discussion of cases of final secondary stress in Turkish words.

8 In Idsardi (1992) Iterative Constituent Construction settings are described from the starting element. We have chosen to describe them here in terms of the parenthesis inserted. By doing this we gain a better match between observed iterative stress systems and the principle of homogeneity preference discussed above.

9 The syllabification rules also seem to be directional, for some arguments to this effect see Sloan (1991)

10 See also the analysis of Latin, below for a related point.

11 We have chosen here to maximize the similarity between the line 0 parameters in the cyclic and noncyclic blocks. Note that other allocations of line 0 parameters to the two blocks will yield the same results. Edge Marking must apply in both blocks, and Syllable Boundary Projection must apply only in the cyclic block. Head Location must apply in the noncyclic block. Finally, ICC must apply in at least one of the blocks.

12 Notice that subsequent application of other rules can, in effect, steal elements from constituents, for example, ICC:L applied to (xxx + x yields (xx(x + x.

13 Miner (1989) notes that there are separate principles of accent placement on long vowels and diphthongs following the initial metrical calculations. He also notes that similar proposals can be found in Vance (1987) for Japanese and Steriade (1988) for Greek. Hayes (1991) gives an analysis in terms of the sonority hierarchy, with the more sonorous mora receiving the accent. This can be handled in the present theory by deleting the second line 0 mark of a long vowel or diphthong with nonrising sonority.

14 The derivations for the second and third words will change slightly with the addition of Avoid)(, discussed below. This change will

not affect the stress patterns in these words.

15 Since Avoid (x(is operative in Winnebago, in a sequence of Dorsey's Law syllables not all syllables will be able to project a boundary. Instead, an alternating pattern of projected left brackets will be created, going from left to right. This effect is exactly the same as the alternating heavy syllable stresses of Wolof, discussed in Idsardi (1992), and it indicates that Projection is also a directional rule.