Stress and Generative Phonology

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The study of stress has occupied a central position in generative grammar since its inception. In this paper we review some of the major results and outstanding problems, concentrating on the developments of the past ten years.*

0. *Introduction.*

Generative grammar has been characterized as the attempt to reach a serious scientific understanding of the formal aspects of human language. As such it has been one of the most important influences in the development of the Cognitive Sciences. The Generative school of linguistics emerged in the mid 1950's at MIT (Cambridge, Massachusetts) through the efforts of Noam Chomsky (b. 1928) and Morris Halle (b. 1923). The major factor distinguishing Generative Grammar from the dominant Structuralist school of the time was the conscious rejection of the assumption that human language is a refinement and distillation of information present in overt speech behavior. Various problems with the structuralist model lead Chomsky and Halle to see things the other way round: that speech is the end product of an internal mental computation (a grammar) whose character may differ radically from its overt manifestation in speech.

These general themes are present in one of the first formal publications in Generative Grammar – Chomsky, Halle & Lukoff's "Accent and juncture in English" (1956). Since the work of Trager & Smith (1951), Newman (1946) and others, it was well-known that English speakers are capable of making quite subtle judgements about degrees of stress that correlate systematically with internal syntactic constituency. For example, the three-morpheme string composing *light+house+keeper* receives different interpre-

* *Editorial note*: this paper was originally conceived of as one of a series of three, which were supposed to defend the respective merits of a certain approach to phonology, as opposed to others. For various reasons, the project did not work out. This explains however the presence of section 10, which addresses dependency phonology. The Editorial board appreciates dr. Jacques Durand's willingness to comment on this particular topic (see further in this issue of the journal).

Rivista di Linguistica 2,2 (1990) *(ricevuto nel febbraio 1990)*

tations depending on the stress contours: 1-3-2-4 is associated with "lighthouse keeper" (i.e. 'someone who keeps a lighthouse') while the 2-1-3-4 contour is interpreted as "a housekeeper who is light in weight").[1] In the structuralist model of the period, these contours were described in terms of a series of four stress phonemes of decreasing strength: [´], [ˆ], [`], [ˇ]. 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 gives rise to a number of anomalies. For one thing, the phonetic correlates of stress prove quite elusive, so much so that even trained phoneticians cannot detect the presence of [´] vs. [`] vs. [ˆ] without knowing the intended meaning.

In their paper Chomsky, Halle & Lukoff show how the distribution of the various stress levels can 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. But this kind of 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 apriori methodological restrictions; that the rules compute representations that may not have straightforward phonetic (material) correlates but which nevertheless constitute psychologically genuine distinctions.

The rules for phrasal prominence sketched by Chomsky, Halle & Lukoff (1956) were elaborated in Chomsky & Halle's landmark study *The Sound Pattern of English* (1968). SPE is the first full-scale exposition of the generative phonological model – illustrated by an indepth 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. This achievement was all the more remarkable because most of the SPE stress rules do not simply translate well-known sound changes but instead constitute genuine empirical discoveries.

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 as the structuralist conception of stress as a phoneme analogous to [p]. It soon became clear that stress – especially when viewed crosslinguistically – displays a suite of properties

[1] In these transcriptions, 1 denotes primary stress, 2 secondary stress, etc. A third meaning "person who does light housekeeping" is associated with the 3-1-3-4 contour.

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.

1. *Some unique properties of stress.*

First, it is well-known that stress is the most phonetically elusive phonological feature. It has no intrinsic 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.

Second, as we mentioned above, [stress] differs from other features like [nasal] in its propensity for greater than binary discriminations. The "lighthouse-keeper" example shows that at least four degrees of stress play a role in the perception of distinct utterances. This example illustrates the rule of English that compounds typically enhance the first member: cf. *the whîte hóuse* vs. *the Whíte Hôuse.* As shown by the examples in (1), when the compounds consistently branch on the left side, the prominence of the first member increases cyclically in proportion to the depth of embedding.[2]

(1) teacher's union
    2 1
(teacher's union) president
    3 1 2
((teacher's union) president) election
    4 1 2 3

With the possible exception of tone, no other feature submits itself so readily to such multivalued scaling.

Another property which sets stress apart from most other phonological features is its ready participation in "long-distance" relations. Most phonetic properties have local phonological determinants: eg. the alternation in the place of articulation of the nasal in co[m]-bat, co[n]-duct, co[ŋ]-gress is determined by the following consonant. And even in such vowel harmony cases as *saki-ttom-uude-sta-nsa-ko* vs. *säki-ttöm-yyde-stä-nsä-kö*, where the Finnish question particle alternates between front vowel [kö] and back vowel [ko] as a function of the root vowel at the other end of the word, the harmony can (and must) be broken down into a chain of local relations between adjacent syllables containing nonneutral vowels.[3] By contrast, for

[2] From now on we depart from the SPE notation by representing higher degrees of stress with larger numbers.

[3] Thanks to Irja Alho for help in constructing these examples. [**sakki* 'group' *säkki* 'sack', *-ttom* adj. 'less', *-uude* nominal 'ness', *-sta* 'out of', *nsa* 'his', *-ko* question clitic; *sulje-skele-va-ise-lla-ko* 'on the one that keeps closing?' vs. *sylje-skele-vä-ise-llä-kö* 'one the one that keeps spitting?' : *sulke* 'close', *sylke* 'spit', *skele* 'freq', *va* participle, *-ise* adj., *lla* 'on', *ko* question].

the down-up pattern of the compound stress in (1), it appears as if the entire syntactic constituent must be taken into account in order to determine the degree of stress of any given syllable.

Another, more striking example of the same kind appears in the Cairene pronunciation of Classical Arabic. Mitchell (1960) showed that in words whose final two syllables are not (super)heavy, the stress alternates between the second-last (penultimate) and third-last (antepenultimate) syllables in the grammar of Cairene Arabic.

(2) šajarátun ʔadwiyatúhu
šajarátuhu
šajaratuhúmaa

In a reanalysis of Mitchell's data, Langendoen (1968) discovered the rule that the stress falls on the penult or the antepenult, depending on which is separated by an even number of syllables from the beginning of the word or from a preceding heavy syllable. Langendoen's rule implies that in order to know whether to stress the penult or the antepenult, we must take into account the entire string of preceding syllables. In other words, the gross syllabic profile of the entire word determines the distribution of stress in Egyptian Arabic. Once again, other features like [nasal] or [labial] never exhibit such nonlocal determinants.

The Cairene data illustrate another characteristic feature of stress in that a given syllable may bear stress not in virtue of its own makeup but simply due to its position in the word or phrase. To take a simpler example, in Polish the primary accent regularly falls on the penultimate syllable of the word: e.g. *nauczýciel* 'teacher' nom.sg. When the gen. sg. suffix is added, the accent jumps from the [czy] syllable to [cie]: *nauczyciél-a*. In the dative singular *nauczyciel-ówi*, the stress has moved off the stem entirely. These "shifts" in stress are motivated solely by the relative positions of the syllables with respect to the right edge of the word. If they are treated merely as a feature change from [+stress] to [-stress], one wonders why we do not find changes from [+nasal] to [-nasal] or from [+coronal] to [-coronal] that are analogously dependent on penultimate position. But a paradigm such as *hamadag*, *habanag-a*, *habadaŋ -owi* with "penultimate nasalization" would be unprecedented.

In many languages stress is implemented through the repetition of a basic pattern or motif. For example, the Australian language Maranungku that has figured prominently in many recent discussions of stress is characterised by Tryon (1970) as having primary stress on the initial syllable of the word and a secondary stress on every other syllable thereafter. The canonical prosodic shape of Maranungku words is thus CV́CV, CV́CVCV̀, CV́CVCV̀CV, CV́CVCV̀CVCV̀. This alternating stress pattern arises from the repetition of a stressed+(unstressed) motif from the beginning to the end of the word. Again, a language in which alternating vowels are nasalized or alternating consonants must be [coronal] is unthinkable.

The various properties reviewed in this section thus suggest that there is something unique about stress that the SPE [±stress] representation fails to capture.

2. *Metrical grid.*

One of generative grammar's most important discoveries (due originally to Mark Liberman 1975) is a perspicuous representation for stress known as the metrical grid. The metrical grid helps us to understand the special properties just enumerated. It assumes that stress is not an inherent property of segments or syllables. Rather, stress is defined in terms of an abstract two-dimensional array that plots metrical positions for levels of prominence. Syllables "bear" a stress simply in virtue of being associated to one of these positions. A six-syllable Maranungku word such as *wélepènemànta* 'kind of duck' receives the analysis of (3).

```
(3) CVCVCVCVCVCV
    |  |  |  |  |  |
    *  *  *  *  *  *   line-0
    *     *     *      line-1
    *                  line-2
```

Line-0 denotes a metrical position—a potentially stressable element. An asterisk on line-1 indicates the presence of a stress, while no asterisk denotes the absence of stress on the corresponding syllable. Similarly, line-2 shows which of the stressed syllables is judged to be the strongest. The relative prominence of a syllable is thus encoded by the number of asterisks in the associated grid column.

Let us now briefly see how the metrical grid explains some of the special properties of stress. First, the phonetically elusive nature of stress is reflected in the fact that there is no longer a feature [±stress]. Rather, stress is manifested by the extent to which other features (principally tonal but also length and vowel quality features) are sensitized to the prominence relations represented in the grid. Second, the propensity of stress for greater than binary distinctions is encoded directly in the height of the grid columns. Third, given this notation, syllables that are quite distant at lower levels of the grid may be adjacent on higher lines of the grid if the intervening syllables fail to register asterisks on these lines. In this way, the thesis that phonological rules state local relations can be preserved.

To appreciate these points, let us briefly review the metrical grid treatment of the SPE phrasal stress rules (see Halle & Vergnaud 1987 for detailed discussion). The Nuclear Stress Rule enhances the second word in a two-word collocation. It can be interpreted as adding a grid mark on line 3 (above the strongest syllable in the word). For example, the *g¹ood k²ing* receives the derivation in (4a).[4]

[4] We assume that the primary stress in a word is marked by an asterisk on line-2 (and hence necessarily on all lower lines). This assumption is necessary because the phrasal rules seek out the major stress of the

```
(4) a. good king          good king
        |    |              |    |
        *    *     →        *    *        line-2
                                 *        line-3

    b. good king died       good king died        good king died
        |    |    |          |    |    |           |    |    |
        *    *    *    →     *    *    *     →     *    *    *    line-2
             *                    *    *                *    *    line-3
                                                             *    line-4
```

To describe the *g*^{1}*ood k*^{2}*ing d*^{3}*ied,* the stress level of the newly added verb is first equalized with respect to the highest stress in its sister constituent (4b); then the NSR applies to enhance the second element. By allowing successive levels of syntactic embedding to be reflected in succeeding lines on the metrical grid, we understand why, of all phonological properties, stress is so readily able to signal differences in constituent structure.

The compound stress in English can now be treated as a rule, applying in X^0 collocations, that retracts the grid mark supplied by the NSR to the left. This rule differentiates the noun phrase *the wh*^{1}*ite h*^{2}*ouse* from the noun *the Wh*^{2}*ite H*^{1}*ouse.*

```
(5) white house          white house          White House
      |     |              |     |              |     |
      *     *     →        *     *     →        *     *     line-2
                 NSR             *     CR       *           line-3
```

Phonological locality predicts that the asterisk will be attracted to the closest available position, where "closest" means relative to the grid. We can now account for the down-up modulation of left-branching compounds noted earlier by simply allowing the rules to mirror the constituent structure. For instance, the left-branching compound *t*^{3}*eacher's* ^{1}*union pr*^{2}*esident* is derived as follows. The innermost constituent undergoes the NSR and then the CR (6a). At the next level of structure (6b), the major stress of the constituent [president] is equalized to the highest stress of its sister constituent. The NSR then enhances the second element. Finally the CR retracts the asterisk. (6c) sketches the derivation of the additional layer of embedding in t^{4}eacher's ^{1}union pr^{2}esident el^{3}ection.

```
(6) a. teacher's union       teacher's union       teacher's union
           |       |             |       |             |       |
           *       *     →       *       *     →       *       *    line-2
                                         *             *            line-3

    b. T U P          T U P           T U P           T U P
       | | |          | | |           | | |           | | |
       * * *    →     * * *     →     * * *     →     * * *    line-2
       *        EQ    *   *     NSR   *   *     CR    *   *    line-3
                                          *           *        line-4

    c. T U P E        T U P E        T U P E        T U P E
       | | | |        | | | |        | | | |        | | | |
       * * * *   →    * * * *   →    * * * *   →    * * * *    line-2
       *   *          *   * *        *   * *        *   * *    line-3
       *              *     *        *     *        *     *    line-4
                                           *        *          line-5
```

Note that in the last step of (6b) the grid mark is retracted four syllables to the left, skipping entirely the intervening *union.* With successively greater levels of embedding, the asterisk is retracted over a gulf of ever increasing size. While quite distant on the lower lines of the grid, these two syllables are adjacent at the higher grid levels computed by the EQ, NSR, and CR rules.

3. *Alternating stress and extrametricality.*

Let us now return to the problem of alternating stress patterns and the metrical grid. Building on the results of Hayes' (1981) extensive survey of the primary literature, Prince (1983) shows how they can be generated from a primitive rhythmic alternation of stressed and unstressed positions at the base of the metrical grid (7).

```
(7) .... * * * * * ....     line-0
           *   *            line-1
```

Words receive different stress contours depending on whether the mapping initiates with a stressed (peak) or unstressed (trough) position and whether we start with the first or the last syllable of the word. We list these parameters in (8).

(8) position: peak, trough
direction: left-to-right, right-to-left

The Maranungku pattern CV́CVCV̀CV... that is characteristic of many native languages of Australia arises from choosing {peak, left-to-right}, as shown in (9).

```
(9) CVCVCVCV.....
     ↘
    ...* * * * *...       line-0
       *   *              line-1
```

Once the initial syllable is mapped, the rest of the stress contour is obtained by simply matching syllables with line-0 asterisks, one after the other. A subsequent rule enhancing the first stress by adding a line-2 asterisk completes the analysis.

In many American Indian languages of the Algonquian family, the direction of mapping to the grid also is left-to-right. But the initial syllable is assigned to an unstressed (trough) position. In these languages the words present prominence paradigms of the form in (10).[5]

word, be this the single stress of *kíng*, the final stress of *bùccanéer,* or the initial stress of *crócodìle*: it is these syllables that are enhanced by the nuclear stress rule: *the g*^{1}*ood k*^{2}*ing, the br*^{2}*ave b*^{1}*uccan*^{3}*eer, the b*^{2}*ig cr*^{3}*ocod*^{1}*ile.*

[5] Monosyllabic words represent a special case: CV́(C). It has generally been assumed that a word cannot fail to receive some stress and hence this condition overrides the initial mapping to an unstressed position.

```
(10) b. CVCV́            CVCVCVCV.....
        CVCV́CV             ↓
        CVCV́CVCV̀        ...* * * * *...     line-0
        CVCV́CVCV̀CV          *   *          line-1
```

While the location of the major stressed syllable is considerably more complex in English, the secondary stresses of many monomorphemic words distribute themselves in an alternating pattern similar to the one in Maranungku. For example, the place name *Àpalàchicóla* has the grid in (11). Primary stress falls on the <co> syllable and secondary accents on the <la> and <A>. No stress appears on <pa> and <chi>, allowing the vowels in these syllables to reduce to schwa: [æpəlæčəkʰolə]

```
(11) Apalachicola
     | || | | |
     * **  * * *
     *  *    *
             *
```

Before continuing, let us mention one additional source of variation. Languages with alternating stresses frequently tolerate a deviation from the strictly binary modulation at the word edges. For instance, the American Indian language Winnebago (Hale and White Eagle 1980) has the alternating unstressed+stressed motif of Algonquian, except that the Winnebago word may start with two unstressed syllables: CVCVCV́CVCV̀. We can account for this deviation if we invoke the option of shielding the first syllable from the mapping. This done, then Winnebago receives the same analysis as Algonquian: {trough, left-to-right}. The technical term for this option is "extrametricality" of a syllable at the edge of the domain. A syllable assigned the feature [extrametrical] becomes invisible to the metrical parsing rules.

To briefly summarize, we have three degrees of freedom in constructing stress patterns: whether the initial mapping is to a stressed or to an unstressed position, whether it goes from left-to-right or from right-to-left, and whether the syllable at the left or right edge is extrametrical. This system allows eight possible metrical grammars. Given such parametrized systems, an important research objective is to see whether each possible combination can be attested. Systematic gaps should be explained.

4. *Metrical constituents.*

As we have sketched the theory so far, a stressed syllable is equally related to unstressed syllables on either side. That is to say, in *Àpalàchicóla* <la> is no more or less related to the preceding <pa> than it is to the following <chi>. A competing interpretation of alternating motifs, dating back to classical metrics, constructs them from binary constituents of the form "stressed plus unstressed" (trochaic) or "unstressed plus stressed" (iambic). On this view, also developed in Dependency Phonology, a stres-

sed and adjacent unstressed syllable are organized into a metrical constituent in which the stressed syllable has special status as the "head" of the construction that "governs" the adjacent unstressed syllable which acts as its "dependent". The notion of "government" has been a popular one in the phonological theory of the past ten years and has been applied to a variety of circumstances in which asymmetric relations have been detected. The study of stress and its effects on phonological rules has furnished us with some of the strongest empirical evidence for introducing the notion of constituency into phonology.

Maintaining the assumption that the grid encodes levels of stress prominence, we may indicate the metrical constituency by parenthesization of the asterisks on any given line in the grid. On this view, *Apalachicola* has the representation of (12).

```
(12) Apa  lachi  cola
     | |  |  |   | |
    (* *) (*  *) (* *)
     *     *      *
                  *
```

It claims that <la> <co> are more closely related to the syllables that follow on their right than to the ones that precede on their left. It turns out that there is substantial evidence to justify this postulated asymmetry. A number of rules in English assign a phoneme different allophones depending on the location of stress (see Borowsky 1983). Each rule consistently treats a stressed plus unstressed syllable sequence differently from an unstressed plus stressed one. For example, in many regions of North America the dental stops [t] and [d] are sonorized to a flap (a variety of [r]) when they stand between vowels. In virtue of this rule, the final consonants in the verbs *write* [rayt] and *ride* [ra·yd] merge in the gerundives *writing* [ráyDiŋ] and *riding* [rá·yDiŋ]. However, application of the flapping rule is inhibited when the second vowel is stressed (i.e. is associated with a line-1 asterisk). Compare *átom* (á[D]om) but *atómic* (a[tʰ]ómic).

```
(13) atom          atomic
     | |           | | |
    (* *)         *(* *)
     *              *
```

Given that the metrical feet of English are left-headed, we may say that flapping applies when the two flanking vowels belong to the same line-0 constituent. Phrased somewhat differently, the left parenthesis in *atomic* forms a barrier inhibiting application of the intervocalic weakening process.

To take another example, medial [h] sometimes deletes, depending on the position of the stress: [h]aráss, vé[ ]icle, but ve[h]ícular. Once again, this rule applies in the context V́__V̊ but is blocked in the context V̊__V́. Given the postulated metrical constituency, we can say that [h] deletes when medial in the line-0 constituent. The important points are that both flapping and the h-deletion rule single out the same asymmetry (v́__v̊ vs. v̊__v́) and that this asymmetry is expressed naturally by the idea that the metrical constituent boundary blocks application of the rules.

If this view is right, then we expect to find parallel cases in which an unstressed plus stressed vowel share a special relationship in those systems like Algonquian where the alternating stress pattern begins with an unstressed syllable. A spectacular example of this kind was discovered by Hale & White Eagle (1980) in their analysis of Winnebago.

5. *Winnebago.*

Recall that in Winnebago the first syllable is extrametrical and following syllables alternate in an unstressed-stressed pattern. Some examples appear in (14).

(14) hipirák 'belt' hočį́čį́nį̨k 'boy' hokiwárokè 'swing'
hakirújikš̨ą̨ną̨ 'he pulls it taut'

If alternating stresses are assigned through a parsing into metrical constituents, the parameters in (15a) are required.

(15) a. i. initial syllable is extrametrical
ii. parse line-0 asterisks into binary right-headed constituents from left to right
iii. enhance the initial line-1 asterisk

b.
```
hokiwaroke
| | | | |
<*>(* *)(* *)    line-0
   (  *    *)    line-1
      *          line-2
```

A form such as *hokiwárokè* receives the analysis in (15b).[6]

Hale & White Eagle (1980) develop a striking argument for the postulated metrical constituents. Winnebago has a rule known as Dorsey's Law which copies a vowel into a preceding consonant plus sonorant cluster. We state this rule in (16a). It is most easily illustrated by adding the second person prefix [š-] to a stem beginning with a sonorant: e.g. underlying [š-wažok] 'mash' is realized as *šawažók*. In some cases the vowel inserted by Dorsey's Law fails to disrupt the accent pattern (16b). But in other cases (16c), the location of the stresses changes in response to the inserted vowel.

(16) a. CRV_i – CV_iRV_i (Dorsey's Law)
b. [ho-š-wažá] → hošawažá 'be sick'
[ha-ra-kí-š-rujìk-šą̨ną̨] → harakíšurujikšą̨ną̀ 'pull taut'
cf. ha-ki-rújik-šą̨ną̨ 'pulls taut'

[6] We show here the Halle-Vergnaud (1987) interpretation of extrametricality as the angled brackets around the relevant asterisk. In their theory, metrification arises from parsing the asterisks of a given line in the grid into either binary or unbounded constituents; a separate rule then marks the head (right or leftmost asterisk) by assigning an asterisk on the superior line of the grid. In the Winnebago example, the line-0 asterisks are metrified as binary right-headed feet. The line-1 asterisks are then grouped into an unbounded left-headed constituent, expressing the fact that the major stress occurs at the beginning of the word.

c. mą̨ą̨-rác̆ 'promises'
[mą̨ą̨-š-rác̆] → mą̨ą̨-šárač 'you promise'
[hi-ra-kró-ho] → hirakórohò 'prepare'
cf. [hi-kro-hó] → hikorohó 'prepares'
[wakriprás] → wakiripáras
[hirakróhonìrà] → hirakórohònirà

Note for example that in *hŏsawažá* from [hŏswažá], the first accent is located on the fourth syllable of the word instead of the third; and in *harakíšurujìkšanà* two unaccented syllables intervene between the primary stress and the first secondary stress – a deviation from the otherwise strictly alternating pattern of secondary accents. Both of these aberrations are explained if stress is assigned before the vowel insertion rule applies. But in the forms of (16c) such as *hirakórohò* (from [hirakroho]) a stress falls on the inserted vowel. In these cases it appears that the stress must be assigned after Dorsey's Law.

The Winnebago data thus present two problems—first to distinguish the two groups of words and second to explain why one group preserves the underlying accent and the other does not. As Hale & White Eagle observe, a noteworthy generalization emerges when the representations prior to the application of Dorsey's Law are parsed into metrical feet. For the forms in (16b), the inserted vowel falls in the gap between the postulated metrical constituents (17a); for those in (16c) the vowel is inserted within the metrical constituent (17b).

(17)
```
      ↓                     ↓
a. hoš waža          harakiš rujikšana
   |   | |           | | |    | | | |
  <*> (* *)         <*>(* *) (* *)(* *)
          *               *     *    *

      ↓              ↓               ↓                   ↓
b. hirak roho      mą ąš rač      hi rak ro honira     wakrip ras
   | |   | |       |  |  |        |   |  |  | | |      |  |   |
  <*>(*  *)(*)    <*>(*  *)      <*> (*  *) (* *)(*)   <*> (*  *)
           * *           *            *     *               *
```

This consistent difference demonstrates that the metrical relation between a stressed and adjacent unstressed syllable is not symmetric—a result that is expected if stresses are assigned in terms of metrical constituents. Furthermore, the postulated iambic (unstressed+stressed) grouping helps to explain why it is the separation of an unstressed plus stressed syllable sequence (rather than a stressed plus unstressed one) by Dorsey's Law that leads to a stress shift. We need merely assume that the vowel inserted by Dorsey's Law projects a metrical position on line-0. This new position disrupts the binary foot and hence leads to deformation of the disturbed constituent, whose freed asterisks are then reparsed according to the parameters of (15a). In this analysis, a form such as *hirakórohò* is derived as in (18).

```
(18) hirakroho    →   hi rakoroho   →   hirakoroho   →   hirako roho
     | | | |          |  | | | |        | | | | |        | | |  | |
   <*<(* *)(*)      <*>(* **)(*)      <*>* * *(*)      <*<(**) (* *)
        * *               * *             *                *    *
```

In the first step, Dorsey's Law inserts a new metrical position within the foot; this leads to a deformation of the constituent, which is then remetrified from left-to-right as an iambic foot. It's an open question what treatment is to be given the asterisk associated with the [ro] syllable. See Halle & Vergnaud (1987) for discussion.

6. *Arabic.*

With its dialectally diversified stress patterns and stress-sensitive rules of syncope and epenthesis, Arabic offers a rich testing ground for any theory of stress. Not surprisingly, Arabic has figured prominently in the recent metrical literature. In this section we survey three dialects to illustrate some additional concepts and findings in metrical phonology. (See Halle & Kenstowicz 1989 for more detailed discussion.)

The Cairene dialect is undoubtedly the most widely discussed. The location of word stress in Cairene is summarized in three successively more inclusive statements. First, a final superheavy (CVVC, CVCC) syllable is stressed (19a). Otherwise, stress falls on a heavy (CVV,CVC) penult (19b). Finally, in all other words the stress varies between the penult and the antepenult (19c). For these Langendoen (1968) discovered the rule that the stress falls on the penult or the antepenult, depending on which is separated from a preceding heavy syllable or the beginning of the word by an even number of light syllables.

(19) a. darábt, yusallúun, yatahaddáwn
b. mustášfaa, muʕállim, muqáatil, šaabáatun
c. kaatába, qattálat, maktábah, kátab, ráʔaa, híya
kátaba, šájarah, ʔinkásara, bulahníyatun, ʔadwiyatúhu,
murtabitátun, šajarátun, katabátaa,

These data are significant in several respects. First, as we mentioned earlier, the choice between penult and antepenult in (19c) can only be resolved by scanning the entire string of preceding syllables. This implies, however, that the stress location effectively depends on the gross syllabic profile of the entire word – another violation of locality. However, note that Langendoen's rule scans the pretonic string for a very restricted type of information – the number of syllables and their weight. Furthermore, the scansion equates two light syllables with one heavy syllable. But this is exactly the kind of information computed in the analysis of alternating stress patterns.

We can capture the elusive Cairene pattern into our theoretical net as follows. We assume that the mora (syllable-rimal element) is the stress-bearing unit which projects a line-0 asterisk. We then parse these elements

into binary, left-headed constituents from left-to-right—just as in the Australian example. The systematic exclusion of final syllables that are not superheavy is handled by extrametricality. Finally, instead of making the initial stress primary, the last one is enhanced. We state these rules and parameter settings in (20) and illustrate their operation in (21).

(20) i. the mora is stress-bearing unit
ii. final syllables that are not extraheavy are extrametrical
iii. parse line-0 asterisks into binary, left-headed feet from left to right
iv. enhance the rightmost stress by constructing an unbounded right-headed constituent on line-1

```
(21) šajaratuhu       šaja ratuhu        šaja ratuhu         šaja ratuhu
     | | | | |    →   | | | | |     →    | | | | |      →   | | | | |
     * * * *<*>      (* *)(* *)<*>      (**)(**)<*>         (* *)(* *)<*>
                      *    *            (*   *)                  *
                                             *

   ʔadwiyatuhu     ʔadwiya tu hu       ʔadwiya tu hu        ʔadwiya tu hu
   ||  | | | |  →  ||  || |  |    →    ||  | | |  |    →    ||  || |  |
   **  * * *<*>    (**) (**)(*)<*>     (**) (* *)(*)<*>     (**) (**)(*)<*>
                    *    *   *         (*    *    *)                  *
                                                  *
```

In our derivations, the first step parses the line-0 asterisks and the second enhances the final stress. Most sources agree that Cairene has no surface secondary stresses. Thus a rule is needed to suppress the nonprimary stresses. We follow Halle and Vergnaud and suppose that there is a rule conflating lines 1 and 2 by cancelling line-1. The result is a single stress at the right end of the word – but one whose location is crucially determined by a left-to-right parse of the entire word.

Beyond the technical details, the important theoretical point is that our system captures the superficially quite different Cairene stress pattern by simply combining in new ways the various descriptive options that we have already motivated – in particular, extrametricality and stress enhancement – but at the opposite edge of the word from which the metrical parse begins. Another feature worthy of note is the decision to allow the mora to count as the stress bearing unit.

With this combinatoric theme in mind, let us now look at two Bedouin dialects discussed in Irshied & Kenstowicz (1984). In the Bani-Hassan dialect of Jordan, stems of the shape CaCaC reduce to CCaC when followed by a vowel.

(22) sáhab	'he pulled'	báǧal	'mule'
saḥáb-na	'we pulled'	baǧál-na	'our mule'
sḥáb-at	'she pulled'	bǧál-i	'my mule'

Since elision fails in stems such as *ʕasáah* 'cane', *máktab* 'office' or *ʕállam-at* 'she taught', *báarak-at* 'she blessed', it would appear that we must characterize the context for the rule as __CVCV. This formulation violates phonological locality since it furnishes information outside the immediately adjacent syllable. However, if light syllables are organized into binary metrical feet from left to right, then the rule receives a simple expression: elide the short low vowel [a] when it occupies the head of a disyllabic trochaic foot.

```
(23) [a]   →   Ø / ___
                   |
                 (* *)     line-0
                   *       line-1
```

We account for the absence of elision in CaCaC words by assuming that final syllables are extrametrical, just as in Cairene. The form *sḥáb-at* receives the derivation of (24).

```
(24) sahab-at          shab-at          shab-at
     | |   |            |   |            |   |
    (* *)<*>     →     (*)<*>     →     (*)<*>
     *                  *                *
```

When the elision rule deletes the stressed vowel, the line-0 asterisk associated with [sa] loses its licensor and hence disappears. Just as the deletion of a tone-bearing unit typically leads to the shift of tone to an adjacent tone-bearing unit, so the stress in (24) is preserved. Given our hypothesis that stress indexes the head of a metrical constituent, it is natural to construe the shift of stress (the line-1 asterisk) as reflecting the conservation of metrical constituency – in the second step of (24) headship is transferred from the deleted vowel to the following one, which now becomes the leftmost element in the foot.

While this chain of reasoning may seem excessively recondite, it has empirical consequences when the eliding stressed vowel is located in the middle of the word. The conservation of constituency principle predicts that the stress will shift to the left or right as a function of whether the constituent is right or left-headed. As we shall see, the Bedouin elision rule confirms this hypothesis in striking fashion.

The brief paradigms in (25) suggest that a heavy plus light syllable constitute a metrical constituent in the Bani-Hassan dialect.

(25) ʕállam	'he taught'	sáhab	'he pulled'
ʕállam-at	'she taught'	sháb-at	'she pulled'
ʕàllam-át#uh	'she taught him'	shàb-át#uh	'she pulled him'
sáaʕad	'he helped'		
sáaʕad-at	'she helped'		
sáaʕad-át#uh	'she helped him'		

This assumption simultaneously explains the primary stress on the [-at] suffix when it is nonfinal (not extrametrical) as well as the fact that the second syllable of CaCCaC stems such as [ʕallam] does not elide. As the representations in (26) show, this syllable does not satisfy rule (23).


```
(26) ʕallam-at-uh        sahab-at-uh
     | |   |  |          | |   |  |
    (* *) (*)<*>        (* *) (*)<*>
    (*     *)           (*     *)
           *                   *
```

Let us now compare the Bani-Hassan paradigms of (25) with the cognate ones in (27) from the Riyadh dialect.

(27) ʕállam	sáaʕad	sáhab
ʕíllim-at	sáaʕad-at	sháb-at
ʕallm-ít#ah	saaʕd-ít#ah	sháb-it#ah

The first two entries are virtually the same as those found in Bani-Hassan, except for a rule that raises the low vowel of a short open syllable when not adjacent to a guttural consonant. The two dialects diverge before the clitic object suffix. First, in CaCaC-at#V structures, Riyadh has the word stress on the root while Bani-Hassan places the accent on the suffix: compare Riyadh *sháb-it#ah* vs. BH *shàb-át#uh*. Second, in Riyadh the second vowel of CaCCaC and CaaCaC stems elides before the [-at] suffix when the latter is in turn followed by a vowel; no such elision occurs in Bani-Hassan.

We can account for both of these differences if we assume that Riyadh agrees with Cairene in designating the mora as the stress-bearing unit. On this analysis, Riyadh *ʕallm-ít#ah* and *sháb-it#ah* receive the underlying metrical representations of (28a,b).

```
(28) a. ʕal lam-at#ah          b. sahab-at#ah
        ||  |   |                 | |  |  |
       (**)(*   *)<*>            (*  *)(*)<*>
        *   *                     *    *

     c. ʕal lm-at#ah           d. s/hab-at#ah
        ||     |  |                 |  |  |
       (**)   (*)<*>               (*) (*)<*>
        *      *                    *   *
```

If the mora is the stress-bearing unit, then the initial heavy syllable of [ʕallam] constitutes a foot by itself. The result is that the following [la] heads a new metrical foot. When [la] joins with the following syllable in a foot, elision may now apply leading to a shift of stress to the [at] suffix to preserve metrical constituency. The result is the representation in (28c). The segmental rule raising the low vowel of an open syllable derives *ʕallm-ít#ah*. Elision also converts (28b) into (28d).[7]

Finally, to account for the fact that underlying /sáhab-át#ah/ surfaces as /sháb-it#ah/ in Riyadh, we must postulate a rule that deletes stress from a final nonbranching foot. We state this rule in (29a); it converts (29b) into (29c).

[7] Irshied & Kenstowicz (1984) report that their Riyadh informant can suppress the elision rule in order to give a more "standard" flavor to his speech. When he does, the stress appears on the elidable vowel – just as predicted by the representation in (28a).

```
(29) a. line-0          (*)  <*>
        line-1     * → . / __
     b. shab-at#ah        c. shab-at#ah
        | | |                | | |
        (*)(*)<*>            (*) * <*>
         *  *                 *
```

Rule (29a) also accounts for the retraction of stress in Riyadh *ʕíllim-at* and *sáaʕad-at* vs. Cairene *ʕallám-at* and *saaʕád-at*.

To briefly summarize the discussion, the fact that the shift of stress under the Bedouin elision rule systematically correlates with left-headed feet is a surprising and significant result since the postulated metrical constituency is independently motivated within our system in order to describe the distribution of stress. Also, the fact that both the scope of elision and the distribution of stress covary between the two dialects suggests that whether the mora or the syllable is the stress-bearing unit is a significant parameter of difference. And more generally, since such a rich network of parameter settings is required in order to delimit the scope of elision, the evidence encourages us to believe that the overall framework is on the right track.

7. *Enclitic stress.*

In addition to stress shifts induced by epenthesis and elision, accentual displacements occasioned by the attachment of enclitics have proved a useful probe of metrical structure. Steriade (1988) inaugurated this line of inquiry in a study of enclitic accent in Ancient Greek and Latin. Halle & Kenstowicz (1989) discuss a number of additional examples. We briefly review these results here.

As is well-known, Latin stresses the antepenult unless the penult is heavy, in which case it takes the stress: *réficit*, *refé:cit*, *reféctus*. In our parametrized system, there is just one way to obtain antepenultimate stress. The final syllable must be extrametrical and a binary left-headed foot must be assigned from the right word-edge. We state these rules in (30a) and show the associated grid in (30b).

(30) a. i. final syllable is extrametrical
ii. parse line-0 into binary, left-headed feet from right to left.

```
     b. refe cit
        | |   |
        (* *)<*>
         *
```

Steriade (1988) shows that enclitic stress corroborates this postulated metrical constituency. Latin has both monosyllabic and disyllabic clitics. Examples appear in (31).

(31) a. úbi 'where' — ubí#libet 'wherever'
b. lí:mina 'thresholds' — li:miná#que 'and thresholds'
c. Mú:sa 'the Muse' — Mu:sá#que 'and the Muse'

Addition of the clitic displaces the stress of the base. But there is a systematic and intriguing difference between *ubí#libet* and *li:miná#que*. In both cases we have a four-syllable string. But they are stressed differently. *ubí#libet* suggests that stress assigned under enclisis can reach back to the antepenult. But when the base is trisyllabic and the clitic monosyllabic, antepenultimate stress is shunned in favor of penultimate stress.

As Steriade observes, if we assume that enclitic stress is assigned to a representation which already has the metrical structure of the base word imposed, then a simple and elegant explanation emerges for the contrasting behavior of *li:mina* and *ubi* when they host enclitics. The second syllables in the quadrisyllabic *ubí#libet* and *li:miná#que* have a different status. In the latter the [mi] syllable is metrified as a dependent of the stressed syllable [li:], while in the former the [bi] syllable is unmetrified, because it is extrametrical (32).

```
(32)  li:mina      ubi
      |  |  |      | |
      (*  *)<*>   (*)<*>
       *           *
```

To explain the contrast, all we need say is that stress assignment under enclisis respects the previously established structure and is constrained to erect metrical constituents only on free, unparsed asterisks. Under this assumption, the inputs to enclitic metrification are the representations in (33a) (we show extrametricality already assigned).

```
(33) a. li:mina#que       ubi#libet
        |  |  |   |       | | | |
        (*  *)*   <*>     (*)* *<*>
         *                 *

     b. li:mina#que       ubi#libet
        |  |  |   |       | || |
        (*  *)(*) <*>     (*)(**)<*>
         *     *           *  *
```

ubí#libet contains two free positions; consequently, when rule (30aii) applies, a disyllabic left-headed foot is assigned (33b). But *li:miná#que* contains just a single free position and hence the enclitic stress is planted there. Enhancement of the rightmost stress then yields the correct surface forms.

The important theoretical point is that this result crucially depends on the second syllables in *ubi* and *li:mina* having a different status even though they presumably receive identical phonetic implementations as simple, unstressed syllables. They differ only in terms of the hidden (inaudible) metrical structure imputed by the rules in (30).

There is a second way in which metrical constituency is respected under enclitic stress assigment. Consider *Mu:sá#que* (31c). The rules of (30) assign the representation of (34a). (34b) ensues from addition of the clitic.

```
(34) a. Mu:sa        b. Mu:sa#que      c. Mu:sa#que
        |  |            |  |  |           |  |  |
        (*)<*>          (*) *  <*>        (*)(*) <*>
         *                   *             *   *
```

Recall that Latin metrical constituents are trochaic (left-headed). (34b) contains one free asterisk preceded by a degenerate (monosyllabic) foot. A priori, there are two possible responses the theory might make in this situation. First, the boundary of the degenerate foot could expand to take in the [sa]. But if we take seriously the ideas that previously established metrical structure is inviolate and that metrical constituents are built by taking unmetrified asterisks in a right-to-left scan of the word, then we predict that the degenerate foot will not expand. Rather, the single free element will parse into a degenerate foot, as in (34c). Steriade reports that *Musá#que* in fact has penultimate stress. This illustrates a second respect in which the invisible metrical structure makes its presence felt.

The Latin result raises the question of what to say about the well-known paradigms in (35).

(35) a. comp [ə]nsation vs. cond [ɛ]nsation
b. órigin, oríginal, orìginálity vs. Wìnnepesáukee

SPE noted that some English dialects contrast the phonemically nearly-identical four-syllable strings in (35a) in terms of whether or not the second syllable is unaccented and hence may reduce to schwa. The SPE analysis explains the difference in terms of the morphological bases on which the words are built: the second syllable is unstressed in *cómpensàte* (in virtue of a regular rule of English phonology) while it bears a stress in *còndénse*. In order to explain how the stress pattern of one word can determine the stress of a related but nevertheless different word, SPE proposes to embed the phonological derivation of the shorter word inside the derivation of the longer one. Specifically, the stress contours of *compensation* and *condensation* are computed cyclically. First, the stress of the bases *compensate* and *condense* are derived. The resultant representations then serve as the inputs [cómpensát+ion] and [cóndén+sation] for the derivations of *compensat+ion* and *condens+ation*.

Kiparsky (1979) uncovered additional evidence for the cyclic analysis of English stress. He noted a consistent difference in the behavior of trisyllabic strings of pretonic light syllables in underived words such as *Winnepesáukee* versus in such morphologically complex words as *orìginálity*. In the former class, the first syllable is typically stressed and the following two unstressed: *Wìnnepesáukee*. But in the latter class, a secondary stress can fall in the middle of the trisyllabic string: *orìginálity*. Clearly, this difference is a function of the existence of the related word *oríginal*. If the stress is assigned cyclically, then it is easy to see how the primary stress in *oríginal*

may emerge as a secondary stress in *orìginálity*. Kiparsky (1982) noted that the suffixes which shift the stress in the base may also shorten its vowel. For example, *-ity* shifts the stress in *lócal, locál-ity* and shortens the vowel in *divīne, divĭnity*. To explain this correlation, Kiparsky proposed that the rules of English phonology fall into two major blocks (levels or strata). Primary suffixes such as *-al*, *-ity* activate rules of the first level, while secondary suffixes such as *-less*, *-ness* trigger rules of the second. If we accept this line of reasoning then a word such as *original* is cyclically derived from the base *origin*. But by the logic of the metrical interpretation of the Latin stress rule sketched above, the latter must have the metrical structure of (36a). It then appears as if the input to the derivation of *original* must be the representation of (36b). But if metrification is restricted to free elements, as the Latin enclitic accent suggests, then the [ri] syllable should be inaccessible.

```
(36) a. ori gin       b. ori gin al
        ||  |            ||  |   |
        (**)<*>          (**) *<*>
         *                *
```

A couple of solutions to this problem have been proposed. Inkelas (1989) suggests that underived roots may be lexically marked to skip the cyclic rules. This allows the base [origin] to bypass the first cycle. The stress assigned in [origin]al then operates on a metrically clean slate. An alternative tack taken by Halle & Vergnaud (1987) postulates a special stress erasure convention operating at the beginning of each cycle that effectively cancels the metrical structure erected on the preceding cycle. On this approach, the [ri] syllable in (36a) is now accessible to the stress rules operating on the [origin]al cycle. Cases like the Latin enclitic stress, where the metrical structure of the base is respected and hence must be present at the point the enclitic accent is assigned are treated by Halle & Kenstowicz (1989) as noncyclic effects. The Latin enclitics are [-cyclic] and thus fail to activate the rules of the cyclic block – in particular, the stress erasure convention. Their host must have passed through the cyclic block and thus have obtained a metrification. It is this metrical structure which is respected by the enlitic accents. Clearly, more cases of this form must be uncovered in order to strengthen the hypothesis that respecting metrical structure is a diagnostic of the noncyclic block.

8. *Tone and word structure.*

We close by discussing two unexpected places in which metrical structure has been recently detected – in the realization of tonal patterns in some Bantu languages and in the reduplicative morphology of Lardil.

In most Bantu languages verb roots fall into one of two tonal classes. The first is typically realized by a high tone on the initial syllable of the root, from which it may spread to succeeding or (more rarely) to preceding syllables. Roots in the other class are low-toned or toneless. Inflectional prefixes also contrast as high versus low tone. Recent research by Kisseberth, Goldsmith, and others has uncovered a class of languages in which the proto-Bantu high vs. low tonal opposition is maintained but the high tones are radically displaced from their diachronic and underlying synchronic point of origin. The positions to which the high tones gravitate seem best characterized in metrical terms. We briefly illustrate the phenomenon here with material from Chizigula, a language of Tanzania. (For more discussion see Kenstowicz 1988, Kenstowicz & Kisseberth 1989)

In (37a) we display infinitives from the two tonal classes. The high tone (marked by the acute) is consistently realized on the final syllable of the root.

(37) a. ku-lombéz-a 'to ask' — ku-lagaz-a 'to drop'
ku-bindilíz-a 'to finish' — ku-songelez-a 'to aggravate'
b. ku-lombez-íl-a 'to ask for' — ku-lagaz-il-a 'to drop for'
ku-lombez-il-án-a 'to ask for one another' — ku-lagaz-il-an-a 'to drop for one another'

The paradigms in (37b) suggest that "penultimate syllable of the word" rather than "final syllable of the root or stem" more accurately describes the landing site. Bantu verbs inflect freely for suffixes marking argument structure changes (eg. passive, reciprocal, benefactive). In these cases the high tone shifts off the root, migrating to the penultimate syllable of the word.[8]

In (38) we see that the 3 sg. [a-] and the 3pl. [wa-] present tense prefixes contribute a high tone; once again, this tone is realized on the penultimate syllable of the word.

(38) ku-lagaz-a 'to drop' — ku-lagaz-il-an-a 'to drop for one another'
na-lagaz-a 'I drop' — cha-lagaz-il-an-a 'we drop for one another'
a-lagáz-a 'he drops' — wa-lagaz-il-án-a 'they drop for one another'

As the reduplicated *wa-lagaz-lagaz-il-án-a* 'they repeatedly drop for one another' shows, the high tone may traverse a considerable distance in its journey from the prefix to the penultimate syllable.

We complete our sketch of Chizigula tonology with verbs whose prefix and root are each drawn from the high-tone categories.

(39) ku-bindilíz-a 'to finish' — ku-hangalasány-a 'to carry many things at once'
na-bindilíz-a 'I finish' — na-hangalasány-a 'I carry ...'
a-bíndilíz-a 'he finishes' — a-hángálasány-a 'he carries...'
a-hángálásany-íz-a 'he is causing to carry..

[8] Since most verbs end in a suffix -a, one might conclude that the high tone is attracted to the right edge of the stem. The nominal tonology proves this interpretation to be spurious. Since their inflection is largely prefixal in nature, nouns and adjectives typically terminate with the bare root. In a number of constructions, a nominal attracts a high tone from the preceding word. As long as no other high tone intervenes, the tone regularly shifts to the second-last syllable. For example, the final three syllables of *mi-tunguja* 'tomato plants' belong to the root; the copular form is *ni mi-tungúja*.

In the third-person forms of these verbs we find the following tonal pattern: a string of high-toned syllables starts at the beginning of the stem and runs up to antepenult, which is low, and followed by a high-toned penult. Descriptively, this pattern is easily resolved into a HLH sequence. As the paradigm in (40) shows, the phrasal phonology of Chizigula has a rule that spreads a high tone to the right. We state this rule in (40b). It is blocked by another tone or by the penultimate syllable of the phrase. (See Kenstowicz & Kisseberth 1989 for further discussion of this rule and its domain).

(40) a. ku-guh-a 'to take' — mi-tunguja 'tomato plants'
a-gúh-a 'he takes' — a-gúh-á mí-túnguja 'he takes tomato plants'

```
b. V  V
   | /
   H
```

A prepausal syllable (as in the citation form *a-gúh-a* 'he takes') is also exempt from the rule – presumably because a boundary low tone has already occupied this position.

Given the tone-spreading rule (40b), a form such as *a-hángálásany-íz-a* derives from the representation in (41a). Here the high tone spreads to the right but is separated from a following high by a buffering low tone—a so-called OCP effect.

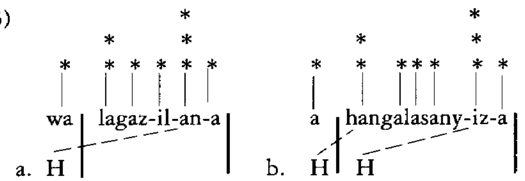
```
(41) a. a-hangalasany-iz-a      →     b. a-hangalasany-iz-a
          |          |                  |//     |   | |
          H          H                  H       L   H L
```

Having peeled back the structure of *a-hángálásany-íz-a* to (41a), we return to the landing sites which the tones display in their rightward displacement. The following generalizations emerge. A single high tone – either from the root or from the prefix – is attracted to the penult. If the representation contains two high tones, then one is assigned to the penult and the other to the initial syllable of the stem. The important point is that these two positions – penult and initial – have no particularly special status in tonal theory. Rather, they figure in many stress languages and are thus more properly the province of metrical theory. For example, Rubach & Booij (1985) describe Polish as having the major stress on the penult and a minor stress on the initial syllable. In the metrical theory of accent this implies a grid such as that in (42) for a five-syllable word. (We suppress the constituent structure for expository purposes).

```
(42)          *
      *       *
      * * * * *
      | | | | |
      CVCVCVCVCV
```

If we postulate that Chizigula imposes the same metrical organization on its words, then the displacement of the high tones is easy to state: the tones shift rightward to the most prominent syllable in the grid that is not already occupied. The derivations of *wa-lagaz-il-án-a* and *a-hángálásany-íz-a* proceed straightforwardly if we make the additional assumption that the tones are assigned cyclically, as illustrated in (43).

(43)



On the internal cycle in (43b) the H of the root is attracted to the penult, since it is most prominent. The internal cycle of (43a) has no H to contribute. On the outer cycle the prefixal H is again attracted to the most prominent free syllable – the penult in (43a) and the initial syllable in (43b).

It is important to note that Chizigula speakers do not perceive the penultimate syllable as stressed or in any way more prominent than the other syllables. The metrical structure only manifests itself in attracting the tones.

To summarize, our argument that metrical structure controls the realization of the Chizigula tonal pattern is based on two assumptions: first, that notions like "initial" and "penultimate" syllable are the special province of metrical theory; and second, that the choice of the more distant penult over the closer initial syllable in (43a) reflects a prominence discrimination – again a metrical phenomenon. The range of landing sites so far discovered in the study of Bantu tonal displacement also supports the metrical interpretation. Goldsmith et. al. (1986) show that high tones in Xhosa and Zulu are attracted to the antepenult and Sietsema (1989) argues that they are attracted to the final syllable in Digo. Such a three-syllable window (final, penult, antepenult) is exactly what we expect if the landing sites are determined metrically.

9. *Minimal word.*

A second unexpected place where metrical structure has been detected is the phenomenon of the minimal word. In many languages a free-standing lexical item is required to have a minimal prosodic weight. The system may sometimes go through tortuous means to achieve this result. It is the hypothesis of McCarthy & Prince (1986, 1989), who first drew attention to the phenomenon, that the minimal word reflects the imposition of metrical structure. The concept also figures in morphology. An affixation process

may require its base to be a minimal word. This requirement also is often imposed in reduplication. Another hypothesis of McCarthy & Prince is that when morphological processes refer to the phonological shape of a base, they examine its prosodic structure, looking for the minimal word.

Let us illustrate with a brief example from the Australian language Lardil (drawn from the discussion of McCarthy & Prince 1986). Lardil has a general rule (44a) truncating the final vowel of a word, evident in the uninflected forms of the stems [mayara] and [yiliyili] in (44b).

(44) a. → Ø / __ #

	uninflected	nonfuture	future	
b.	mayar	mayara-n	mayara-ṛ	'rainbow'
	yiliyil	yiliyili-n	yiliyili-wuṛ	'oyster'
c.	mela	mela-n	mela-ṛ	'sea'
	wanka	wanka-n	wanka-ṛ	'arm'

However, as the forms in (44c) demonstrate, disyllabic stems systematically fail to apocopate. The rule must be restricted to bases of at least three syllables. The system scrupulously avoids monosyllabic words (unless they contain a long vowel – see below).

The Lardil aversion to monosyllabism is also revealed by an augmentation process. Lardil stems may end in consonants as well as vowels. The consonant-final stems take a slightly different inflection, as shown in (45a).

(45)	uninflected	nonfuture	future	
a.	kentapal	kentapal-in	kentapal-uṛ	'dugong'
	kethar	kethar-in	kethar-uṛ	'river'
b.	tera	ter-in	ter-uṛ	'thigh'
	yaka	yak-in	yak-uṛ	'fish'
c.	peer	peer-in		'tree' sp.
	maan	maan-in		'spear'

The inflected forms in (45b) have suffixes indicating that the base terminates in a consonant even though the surface form of the uninflected word ends in a vowel. These bases are special in two senses. First, they are monosyllabic; second, they surface with an additional vowel – always [a] – when unsuffixed. Hale (1973) sets them up as underlying CVC monosyllables and postulates an augmentation process adding a final [a] to unaffixed monosyllables: ##CVC## → ##CVCa##. The forms in (45c), taken from McCarthy & Prince (1986) add a further twist to the story. Monosyllabic bases are possible – but just in case they contain a long vowel. The data thus suggest that the minimal prosodic word in Lardil contains two moras and that coda consonants do not contribute prosodic weight.

To summarize, there are two respects in which Lardil aborts the generation of monomoraic words: restricting apocope to trisyllabic or longer stems and augmenting monomoraic stems. Stated differently, all independent words in Lardil must contain at least two moras. If we recall the discussion of Maranungku, it was stated that the metrical foot in most Australian languages is a dimoraic one: necessarily bisyllabic in languages which do not contrast syllable weight and with the option of a single long syllable in those that do. Accordingly, we may subsume the Lardil ban on monomoraism under the requirement that each word fill out the dimoraic foot template so that a minimal prosodic word is achieved.

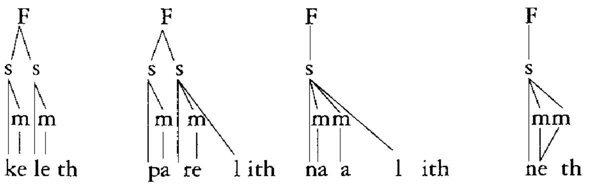
The minimal prosodic word also figures in the morphology of the language by helping us to understand the ways in which the base is transformed under reduplication. To see this point, consider the verbal paradigms in (46).

(46) underlying	simple	reduplicated	
[keleth]	kele	kelekele	'cut'
[parelith]	pareli	parelpareli	'gather'
[ŋaalith]	ŋaali	ŋaalŋaali	'thirst'
[neth]	netha	neene	'strike'

Lardil has a general constraint barring nonapical consonants from the coda of the syllable (Ito 1986). Underlying verbal bases terminate in a nonapical, laminal stop, transcribed here as *-th*. This consonant protects their final vowel from apocope. But being nonapical, the *-th* itself does not generally reach the phonetic surface – unless the augmentation process places it in the syllable onset, as in *netha* 'strike'.

Consider now the various shapes the reduplicated prefix takes. In [keleth] we find the entire base reduplicated except for the final consonant. But in [parelith] just the initial CVCVC sequence is copied. Both cases may be subsumed under the dimoraic template constructed from the minimal prosodic word in Lardil. In [keleth], the template encompases the whole base except for the final *-th*, which being nonapical is barred from entering the coda and hence cannot be admitted to the template. In [parelith] the template spans the initial CVCVC substring since this disyllabic sequence satisfies the two-mora requirement. In [ŋaalith] the reduplication stops with the first syllable since it contains a long vowel and hence is dimoraic. Finally, in [neth] the base contains just a single mora. The dimoraic template is satisfied this time by lengthening the root vowel. As a result, the augment *-a* that appears in the simple form is no longer needed and so does not surface.

In (47) we sketch the various manifestations of the reduplicative template.

(47)


Lardil reduplication transforms the phonemic shape of the verbal base in a variety of ways. But we may detect an underlying prosodic invariant – a dimoraic sequence of syllables – the language's minimal prosodic word and, if McCarthy & Prince are right, thus necessarily its metrical foot.

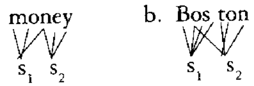
10. *Dependency Phonology.*

In this section we briefly contrast the Dependency and Generative models of phonology. The similarities between the two are much greater than their differences. Our principle references are Anderson & Ewen (1988) (hereafter PDP) and Durand (1990). DP is primarily a theory of phonological representation - rules, sound changes, phonotactic constraints, etc. are tools to probe the representational aspects of language. PDP takes as its point of departure a critique of the SPE conception of phonological representation (largely inherited from Structuralism) as a string of Jakobsonian feature matrices. PDP enriches this representation both syntagmatically as well segment-internally; our discussion touches on each of these two areas.

10.1. *Syntagmatic structure*

In its conception of the phonological string, DP parallels many of the developments in generative phonology over the past fifteen years. Both models impute a prosodic hierarchy organizing phonemes into syllables and syllables into higher-level metrical and prosodic constituents. As we have seen, many phonotactic constraints and otherwise mysterious conditions on sound change can be explained in terms of this prosodic organization. While one is struck by the overall similarity of the dependency and generative models of prosodic structure, let us briefly discuss two points of difference: ambisyllabicity and the location of heads.

GP organizes segments into syllables autosegmentally. An important principle of autosegmental representation is the ban on crossing association lines. While a single onset consonant may simultaneously belong to the preceding coda (48a), this constraint bars assignment of ambisyllabicity to a string (48b). PDP (64-66) explicitly rejects such a constraint and allows syllable brackets to overlap (48c).

(48) a. b.


c. [Bo [st]on]

We suspect that this treatment of ambisyllabicity is an anachronism in the DP model. Elsewhere dependency structures are subject to a strict "no tangling" condition that prohibits the crossing branches seen in graphs such as (48b); PDP is forced to weaken the constraint solely in order to allow ambisyllabic sequences (p. 97). Moreover, Anderson & Ewen only hint at the phonological evidence that allegedly supports the analysis of (48c), making evaluation and comparison of alternatives difficult. In general, ambisyllabicity seems to introduce more problems than it solves. Since many rules assign a consonant different properties depending on whether it occupies the syllable onset or coda, we expect an ambisyllabic segment to be subject to both rule types. But largely this does not appear to be so and would be impossible in cases where the properties conflict (eg. clear versus dark [ɫ] in English). To the extent that we must supplement the onset-coda distinction with a third parameter (exclusively in the onset/coda vs. ambisyllabic), appeal to ambisyllabicity complicates rather than simplifies the theory.

Another point distinguishing the two models is PDP's interesting hypothesis (p.100) that the left-right orientation of the head and modifiers in prosodic constituents reverses as we move from one level of the prosodic hierarchy to another. For example, syllable rimes have the nuclear head on the left and the modifying coda on the right. At the succeeding, higher level of the syllable, the modifying onset precedes the obligatory rime. If this reversal constraint holds in general then individual constituents need not be labeled since their type (rime, syllable, foot, etc.) can be reconstructed from the direction of government and their position in the hierarchy.

This hypothesis has two implications worth noting. First, as the next step up the hierarchy from the syllable, stress feet must be trochaic (head-initial). But, as we have seen, the generative model recognizes iambic (right-headed) feet as well (though see the asymmetry reported in Hayes 1985). Anderson & Ewen do not say how they would account for alternating unstressed+stressed patterns that have been amply documented in the literature. Since at various points PDP cites Abercrombie's (1965) idea of silent stresses, perhaps a #CVC'VCV... sequence would be parsed (' #CV)(C'VCV)... But even if this move is made, Hale & White Eagle's Winnebago example discussed earlier remains problematic.

The conjecture of an alternating direction of government raises questions at the lower levels of the prosodic hierarchy as well. The syllable rime is uniformly left-headed. In many languages with rising diphthongs, one can show that the onglide is a constituent of the rime rather than the onset. But in their phonology such onglides typically act as modifiers rather than as heads (see for example the case of Slovak discussed in Kenstowicz & Rubach 1987). An obvious solution is to recognize a distinct prosodic category "nucleus" lying between the left-headed rime and the individual segment. Anderson & Ewen's conjecture then locates the nuclear head on the right. But now something must be said about falling diphthongs, whose off-glides also typically act as dependents. The implication that nuclei are right-headed appears to require analyzing the off-glides as part of the coda. But this seems wrong for English, where they partake of the vowel-shift and are predictable off-shoots of the nuclear vowel.

10.2. *Segment-internal structure*

Two leading ideas characterize Dependency Phonology's conception of the internal structure of a speech sound: gesture and monovalency. Early DP can legitimately take credit for recognizing that the features composing phonological segments are partitioned in some fashion and that the determination of this organization should be an important research objective of any linguistic theory. It was only with the publication of Clement's (1985) seminal paper that generative phonologists realized the significance of this issue. The nature of the feature organization has now become one of the most active research areas in contemporary phonological theory. Given what has been learned so far, there does not appear to be much that separates the DP and GP models in this area.

The same cannot be said for the idea of monovalency, however. To see this point, let us briefly review the SPE conception of the speech sound. In Generative Phonology the speech sound is analysed into a matrix of features. Each feature designates a well-defined articulatory dimension (typically binary). The relatively small number of features cross-classify the entire universal phonetic alphabet into a densely packed network. Individual grammars select particular features to encode their vocabulary; the remaining feature specifications are assigned by language-particular rules and UG defaults. At the phonetic level each segment is specified for each UG feature. The resultant matrix can be considered a description of the linguistically significant states of the vocal apparatus.

Given this overall model, the vowels [i], [ü], [u], [ɨ] receive the representations of (49). Phonological rules can change one sound into another by modifying the appropriate feature coefficients. The model imputes an implicit measure of phonological distance in terms of the number of shared feature specifications.

(49)			
+high	+high	+high	+high
-back	-back	+back	+back
-round	+round	+round	-round
[i]	[ü]	[u]	[ɨ]

PDP's argument for monovalency begins with the observation that the [back] and [round] specifications in the vowels [i] and [u] do not have the same status. For [i], [-back] is phonologically more prominent than [-round]; but in [u], [+round] is more prominent than [+back]. These asymmetries are reflected in the sound changes the vowels characteristically activate. In many languages [i] fronts [u] to [ü]. But [u] → [ɨ] in the environment of [i] (assimilation of the [-round]) is unheard of in Germanic and unlikely in general. Similarly, [u] labializes [i] to [ü] but seldom (according to PDP) retracts [i] to [ɨ]. And in cases where [u] assimilates [i] to [u], we typically find that the back vowel [ɑ] also changes to [ɔ], suggesting that [+round] is the active or "hot" feature for [u] and that the realization of the labialized [i] as [ü] or [u] is a matter of "phonetic detail".

PDP proposes to explain these asymmetries by making reference to the nonsalient features impossible. [i] is represented as pure palatality and [u] as pure labiality. Sound changes in which [i] causes derounding or [u] causes retraction (instead of simple rounding) are now impossible to state. More generally, PDP raises this monovalency to a general theoretical postulate: each phonological dimension (renamed "component" in place of "feature") has just a single value.

With this kind of representation, sound change can no longer be a matter of transforming feature coefficients but rather arises from the suppression, addition, and combination of components. For example, [ü] combines the palatality of [i] with the labiality of [u]. Equations such as [e] = [i] + [a] and [o] = [u] + [a], familiar to students of phonology since Panini, are now formally recognized in the theory. For PDP the mid vowels [e] and [o] only arise from combining [a] with [i] or [u], respectively, as if the tongue were pulled by two opposing forces and the tension is resolved somewhere in between.

This combinatorial approach has a number of advantages. First, the fact that the presence of a given sound in a phonological inventory often implies the presence of others can now be formally reflected. For example, if [ü] is really the combination of [i] and [u], then we cannot have an [ü] unless the system also licenses its components. Such phonological antecedence can be stipulated (eg. in theory of markedness) but here it follows naturally from the representation. Secondly, given that sounds can now be ranked for complexity in terms of the number of components, we begin to understand why certain segments tend to be barred from particular positions: eg. the inventory of stressed vowels usually properly includes the unstressed ones, the latter typically being drawn from {i,u,a,ə} rather than {o,e,ü}. We may now say that the complex vowels {o,e,ü} tend to be restricted to stressed or otherwise prominent positions. Third, this notation is tailor made to express processes of coalescence and breaking. For example, in the Genovese dialect of Italian *bianco* is realized as *džanko* where the [dž] blends the palatal point of articulation of [i] with the manner features of [b]. Or Catalan *añ* 'year' is transformed in *aym pasat* 'last year', where the palatality of [ñ] is left as residue glide [y] after the nasal has assimilated the labiality of the following consonant.

While this conception of phonological representation lends a natural interpretation to certain sound changes, there are others which it seems incapable of handling. Consider for example the metaphony found in many Italian dialects, where high vowel suffixes raise the root vowel.[9] Calabrese (1984) discusses the following examples from Northern Salentino, a southern Apulian dialect.

(50)					
	fr'edda	l'ɛnta	r'ossa	b'ɔna	fem.sg.
	fr'iddu	l'iɛntu	r'ussu	b'uɔnu	masc.sg.
	fr'iddi	l'iɛnti	r'ussi	b'uɔni	masc.pl
	'cold'	'slow'	'red'	'good'	

In the generative model this metaphony can be described quite simply as the assimilation (autosegmental spreading) of [+high] from the suffix to a preceding mid vowel. On the assumption that [e,o] vs. [ɛ,ɔ] contrast as

[9] The implications of Italian metaphony for monovalency have also been noted in Kaze (1989).

[±tense], spread of [+high] transforms [e,o] to [i,u] directly. As Calabrese shows, since lax high vowels are missing from the Italian vocalic inventory, the incompatible [+high] and [-tense] feature combination that results from spreading [+high] to an [ɛ,ɔ] vowel is subject to various repair strategies in the different dialects. Salentino linearizes the incompatible features as [+high] [-tense] [iɛ], [uɔ] sequences, much the way in which Italian or English students of German tend to diphthongize as [iu] the unfamiliar combination of labiality and palatality presented by [ü]. Finally, a later rule of Salentino dissimilates [uɔ] to [uɛ].

As we have seen, a central claim of Dependency Phonology is that [i] and [u] are primitive elements. Consequently, there is no feature they share in common which can be transmitted to the root vowel in order to describe the metaphony. In an effort to duplicate some of the natural classes that follow straightforwardly from the Jakobsonian framework, both PDP and Durand introduce a negation operator. For example, high vowels are characterized as primitive elements that lack an [a] component: ~{a}. We thus might interpret the metaphony as a rule that transmits ~{a} to {a,~a} vowels – the latter formula designating the class of vowels having two components one of which is {a} and the other which is not (i.e. the mid vowels). While this "works", introduction of the negator diminishes the explanatory force of the overall model since it denies the basic postulate of monovalency. For example, nothing prevents us from writing ~{u} to designate [-round].

From a generative perspective, assimilation to ~{a} vowels has another odd property. In autosegmental phonology, many sound changes can be expressed as spreading a feature from an adjacent position. This view of assimilation allows the representation to constrain the class of rules since a segment cannot spread a feature it does not have: [np] → [mp] is thus possible. while [nt] → [mt] is now impossible. However, this appears to be precisely the position we are driven to in order to express the Italian metaphony with the DP conception of vowels. It raises the broader question whether DP has not generalized too far. Just because some features are monovalent, it does not follow that all are. Anderson & Ewen are certainly correct that the [-round] of [i] never seems to count phonologically. The Salentino dialect provides another example of this insight. Calabrese proposes a rule whereby a vowel in the metrically weak position of a trochaic foot assimilates the features of a following vowel. While underlying [ančel] assimilates the rounding of the suffixal vowel in *'ančulu* 'angel', the comparable vowel of [sɛkol] does not lose its rounding in *si'ɛkuli* 'centuries'. This asymmetry follows directly from the hypothesis that [round] only has the value plus. Strident is another feature that functions in this univocal fashion. An alternative hypothesis worth exploring is that monovalency is restricted to a certain subset of features that includes strident and round – features which according to Stevens & Keyser (1989) enhance the saliency of more central features such as [back], [high], [continuant], which are binary.

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