Iambic and Trochaic Rhythm in Stress Rules
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1. Introduction

Iambic rhythm is the grouping of successive rhythmic beats into pairs in which the second beat is more prominent; trochaic rhythm is grouping into pairs with the first beat more prominent. In this paper I will discuss a general law that governs iambic and trochaic rhythm, and will show how the law is reflected in linguistic stress patterns. I will also show how my results bear on a current controversy over the proper phonological representation for stress.

The central tenet of the metrical theory of stress (cf. Liberman and Prince 1977, Hayes 1981, Prince 1983, Selkirk 1984, and much other work) is that the stress pattern of an utterance consitutes the utterance's rhythmic structure. There are two reasons for believing this to be so.

First, the alternative view that stress is a segmental feature seems unlikely; since stress, unlike other features, has no phonetic definition. Extensive phonetic research has shown that no physical phenomenon invariably accompanies stress; in particular, loudness and muscular effort are only loosely correlated with stress level. Instead, stress is manifested by phonetic elements that are often controlled by other phonological features as well, for example pitch and duration (Lehiste 1970). Thus stress is best thought of as a phonological "organizing framework" for the prosodic resources of a language rather than as a phonetic feature. This organizing framework is plausibly identified with rhythmic structure.

Second, there appear to be parallels between rhythmic structure and linguistic stress patterns. In particular, a defining characteristic of rhythm is the recurrence of events at regular intervals. Stress systems are likewise "designed" to place stresses at equal intervals. For example, in the English utterance twènty-seven Mìssissippi législators, the stresses on séven and síppi are readily shifted leftward to space them evenly with the main stress on lég (cf. Hayes (1984a) and work cited there).

Rhythmic structure is also characterized by periodicity on several levels at once. Thus 4/4 time in music simultaneously defines periodicities of one beat, two beats, four beats, and often eight beats. Stress patterns typically share this hierarchical property. For example, the utterance noted above, when depicted with the "grid" representation for stress (cf. Liberman and Prince (1977) and below), clearly reveals the multiple periodicities that the English stress rules impart to it:

```
(1)                                 x
        x           x               x           (four syllables)
        x     x     x      x        x    x      (two syllables)
        x  x  x x   x  x   x  x     x x  x x    (one syllable)
      twenty-seven Mississippi legislators
```

If stress is the linguistic manifestation of rhythmic structure, it seems worthwhile to look for further parallels, in the hope of explaining phonological patterning as the result of general laws of rhythm. This is not to say that all aspects of phonological or linguistic structure are reducible to other cognitive domains (cf. Chomsky 1981, Anderson 1981), but the search for links to other domains of the mind seems interesting and worthwhile in its own right.

The strategy of this paper is accordingly as follows. First, I will discuss a general law governing the appearance of iambic and trochaic phrasing. Next, I will outline the typology of alternating stress rules and how they are accounted for in a version of metrical stress theory. I will then show that otherwise mysterious gaps in the typology of alternating stress are directly accounted for by the distinction between iambic and trochaic rhythm. The final section discusses the implications of my results for the general theory of stress.

2. The Iambic-Trochaic Distinction

The general law of rhythm I will invoke is well known to psychologists: prominence contrasts based on duration lend themselves to iambic grouping, while prominence contrasts based on intensity lend themselves to trochaic grouping. To see what this means, consider a psychology experiment in which subjects listen to two extended sequences of "beeps." In one sequence, every other beep is louder; and in the other, every other beep is longer. The two sequences are schematized in (2):

(2)a. Intensity Contrast

... x x́ x x́ x x́ x x́ x x́ x x́ x x́ x x́ x ...

b. Durational Contrast

... --- - --- - --- - --- - --- - --- ...

Numerous experiments have shown that listeners can mentally group such stimuli into pairs. The pairing works as follows: if the prominence contrast is one of intensity, then the groupings are normally trochaic; that is, they take the form [x́ x][x́ x][x́ x] etc. If the prominence contrast is one of duration, then iambic groupings are normally perceived, with the more prominent element occurring last: [- ---][- ---][- ---]. This is apparently a well-established result in psychology; for useful reviews see Woodrow (1951), Bell (1977).

There is anecdotal evidence that the relation goes in the opposite direction. If you ask someone to recite the meter of the iambic pentameter and of the trochaic tetrameter, and if your informant had the sort of high school education that provides this knowledge, (s)he will respond with

(3) duh duhhhhh duh duhhhhh duh duhhhhh duh duhhhhh duh duhhhhh

for the iambic pentameter and with

(4) DUH duh DUH duh DUH duh DUH duh

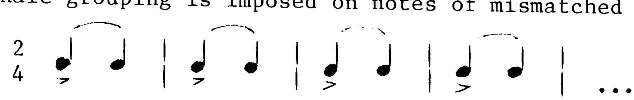
for the trochaic tetrameter. That is, the difference between intensity contrast and durational contrast is conventionally employed to signal the difference between iambic and trochaic bracketing.

The way actual verse is recited also supports the distinction. Typically, verse recitation is "tilted" by distorting the linguistically specified syllable durations to bring them closer to the rhythmic ideal; that is, even spacing for trochaic verse and uneven spacing for iambic. The effect is typically stronger in trochaic verse; for discussion of why, see Attridge (1982), Hayes (1984b).

The iambic-trochaic distinction also determines the relative well-formedness of musical structures. A sequence of alternating half notes and quarter notes in 3/4 time is naturally phrased as in (5):

(5) 

The half note is placed on the strong beat, reflecting its greater prominence within an iambic structure. In contrast, notes of equal length group together more naturally in trochaic pairs; thus (6a), with trochaic grouping, is somewhat more natural than (6b), with iambic grouping. (6a) is certainly far more natural than (6c), in which trochaic grouping is imposed on notes of mismatched duration.

(6)a. 

b. ? 

c. ?? 

It is plausible that the iambic-trochaic bracketing effect is deducible from more fundamental principles. Mark Liberman has pointed out to me that if it is the onsets rather than the terminations of rhythmic events that are more perceptually salient, and if temporally contiguous events are grouped together, then it follows logically that unequal intervals will be grouped iambically. Note that this reasoning cannot account for why intensity-based contrast should favor trochaic bracketings; however, the trochaic effect is somewhat weaker than the iambic one. Whatever its ultimate origin, the iambic-trochaic contrast seems sufficiently well supported in other domains to justify looking for its effects in phonological systems.

3. Alternating Stress Rules

Alternating stress rules assign stress to every other syllable across entire words. They create the stress patterns that most closely resemble the experimental stimuli of (2), and thus are the area of phonology in which we are most likely to find evidence of an iambic-trochaic contrast.

There are two kinds of alternating stress rules; in Hayes (1981) I termed these "quantity sensitive" and "quantity insensitive." Quantity insensitive rules place a stress on every other syllable, irrespective of the syllable's phonological content. Quantity sensitive rules are more complex, and refer to a distinction of syllable weight. For example, syllables with long vowels may be opposed to syllables with short vowels, or heavy syllables may be opposed to light syllables; that is, C_0VV and C_0VC vs. C_0V. These two criteria are by far the most common. In what follows I will use the term "heavy" in a loose sense to refer to the weightier class of syllables in a given language, irrespective of the criterion of syllable weight actually used.

Quantity insensitive stress rules fall into four basic subtypes, determined by two parameters. These parameters are (a) the direction (left-to-right or right-to-left) in which the rule applies; (b) whether the alternation starts off with a stressed or a stressless syllable. To give an example, in Warao (Osborn 1966), alternating stress operates from right to left, beginning with a stressless syllable. Stress is accordingly assigned to the second to last syllable of a word, the fourth to last, the sixth to last, and so on. A later rule designates the rightmost of these stresses as the strongest.

As I showed in Hayes (1981), all four possible patterns of quantity insensitive alternating stress may be found in the world's languages. The four patterns are schematized below:

(7)a. <u>Left</u> <u>to</u> <u>Right</u>

1. Stress First

x́ x x́ x x́ x ...
------>

2. Stressless First

x x́ x x́ x x́ ...
------>

b. <u>Right</u> <u>to</u> <u>Left</u>

1. Stress First

... x x́ x x́ x x́ #
<------

2. Stressless First

... x́ x x́ x x́ x #
<------

Quantity sensitive stress rules are somewhat more complex. In a quantity sensitive system, every "heavy" syllable receives stress and blocks the alternating count. The alternating pattern is thus confined to sequences of light syllables. Again, there are four logical possibilities, depending on whether the rule applies right-to-left or left-to-right; and on whether the rule starts out with stress or stresslessness. However, it turns out that the latter criterion is only applicable at the beginning of the count, before a rule hits a heavy syllable. Whenever a heavy syllable or sequence of heavy syllables blocks the count, an overriding principle specifies that the count must resume in "stressless first" mode. This principle appears to be valid for all known cases of quantity sensitive alternation. The four logical possibilities for quantity sensitive alternation are shown below with a schematic, impossibly long word. <u>X</u> indicates a heavy syllable, <u>x</u> a light one.

(8)a. <u>Left</u> <u>to</u> <u>Right</u>

1. Stress First

x́ x x́ x x́ X́ X́ X́ x x́ x x́ X́ X́ X́ x x́ x x́ x ...
------>

2. Stressless First

x x́ x x́ x X́ X́ X́ x x́ x x́ X́ X́ X́ x x́ x x́ x ...

b. <u>Right</u> <u>to</u> <u>Left</u>

1. Stress First

... x x́ x x́ x X́ X́ X́ x́ x x́ x X́ X́ X́ x́ x x́ x x́ #
<------

2. Stressless First

... x x́ x x́ x X́ X́ X́ x́ x x́ x X́ X́ X́ x x́ x x́ x #
<------

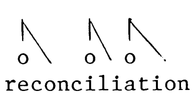
An example of a quantity sensitive alternating stress rule may be found in Munsee, an Algonquian language discussed in Goddard (1982). In Munsee, alternating stress is assigned from left to right, stressless first, with the ordinary heavy/light distinction used as the criterion of syllable weight. The rightmost non-final stress is promoted to main stress by another rule. Some examples are as follows:

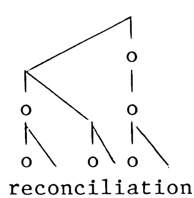
(9)a.	wə là ma lə́ səw	'he is well'
	nò: la má lə sì	'I am well'
b.	a kə̀ ta kə́ kè:w	'he does a fast dance'
	nə kà kə tá kə kà	'I do a fast dance'
c.	sə kə̀h ta kə̀ ní: ka nàl	'reins'
	nə sə̀ kə̀h ta kə̀ nì: ka nə́ mal	'my reins'

4. A Formal Account of Phrasing in Stress Rules

In order to determine how the difference between iambic and trochaic grouping might be detected in stress rules, we need a theory of stress that provides a clear grouping interpretation for surface stress patterns. The metrical theory of stress, in versions that incorporate the "metrical foot," provides such an account. Foot-based metrical theory was originally devised by Prince (1976), and has since been developed by Selkirk (1980), Hayes (1981), Hammond (1984), and other researchers.

The foot-based theory posits that stress assignment begins with the parsing of a word into low-level rhythmic phrases, or "feet." Rules that create feet specify either the first or the last syllable of a foot as its most rhythmically prominent; hence that syllable counts as stressed and all the other syllables of the foot (if any) as stressless. For convenience I will refer to initially-stressed feet as "left dominant" and finally stressed feet as "right dominant." In depicting feet graphically, I will use the notation of Hammond (1984), in which the dominant syllable of a foot is designated with an o. Thus the feet of the English word rèconcìliátion, namely recon, cili, and ation, are depicted as in (10a). In most languages, metrical feet are organized into a higher level structure, which represents prominence relations among stressed syllables. The full metrical structure of reconciliation is thus as in (10b):

(10)a. 

b. 

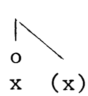
Note that if the /o/'s of the tree are vertically aligned with the stressed syllables, they form a representation of the rhythmic beats of an utterance, while the vertical and diagonal lines represent its phrasing. Hammond's notation thus obviates the need for separate representations of these two aspects of rhythm. This seems conceptually superior to the proposals of Liberman and Prince (1977) and Hayes (1984a), in which rhythmic beats and phrasing have entirely separate representations.

Consider next the phonological rules that create metrical structure. Under most accounts, the basis of such rules is a template defining well-formed metrical feet. This template specifies (a) the maximum number of syllables a foot may contain; (b) whether the dominant syllable of the foot is its leftmost or rightmost; (c) which positions within the foot are optional; and (d) restrictions on what kind of syllable may appear in certain positions of the foot. A complete stress rule specifies a template, the direction in which parsing is to take place, and (on some accounts), whether parsing applies iteratively to the whole word or applies just once. In the course of parsing, stress rules create the largest well-formed foot possible. If conditions on syllable weight prevent this, or not enough syllables are available, then a smaller foot is created.

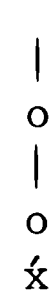
In Hayes (1981) I argued that the inventory of possible foot templates can be sharply restricted with no loss of descriptive adequacy. The following restrictions appear to be tenable: (1) If a template places a limit on foot size, that limit must be exactly two syllables. In other words, foot templates come only in binary and unbounded varieties. (2) All positions within a template are optional except the dominant position. (3) If the template requires any of its positions to be filled by light syllables, these must be recessive (i.e. non-dominant) positions. Together, these restrictions limit to eight the basic inventory of foot templates, defined by the parameters (binary/unbounded), (quantity sensitive/quantity insensitive), and (left dominant/right dominant). A further possibility not relevant here brings the actual total to twelve.

Consider now how this theory describes the patterns of alternating stress discussed above. In the case of quantity-insensitive stress patterns, no restrictions are placed on the terminal nodes of the foot template, but the template itself is restricted to two syllables. For example, to derive a pattern that optionally appears in Polish (Hayes and Puppel (forthcoming)), we set the template as left dominant and parse from right to left. The higher level structure is right dominant. This procedure derives the following stress patterns for words of one to six syllables:

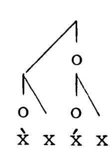
(11)a. Template:



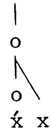
b. One syllable:



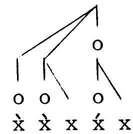
Four syllables:



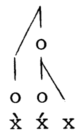
Two syllables:



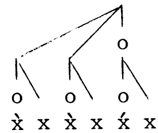
Five syllables:



Three syllables:



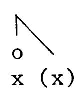
Six syllables:



The forms shown for one, two, four, and six syllables are in fact correct for Polish. The remaining cases require some discussion. Observe that when a word has an odd number of syllables, the template assigns the leftover syllable to a monosyllabic foot, since the recessive side of the template need not be filled. In the case of three and five syllable words, this leads to adjacent stresses. As quantity insensitive languages rarely permit adjacent stresses within a word, these configurations are usually resolved by destressing rules. In Polish, destressing works as follows. In trisyllabic words, the rightmost clashing stress is the main stress. Following the general principle that stronger stresses dominate over weaker, the stress on the left is removed, giving x x́ x as the output. In pentasyllabic words, the stress rules create two clashing stresses that are "tied," so that no general principle dictates the output. As it happens, either both stresses are retained (in very slow speech) or the second stress is selected for removal, resulting in x̀ x x x́ x on the surface. Other languages (e.g. Warao, Osborne 1966) delete the first stress, with x x̀ x x́ x resulting. In any event, the existence of the x̀ x x x́ x stress pattern for pentasyllabic words in Polish (as well as English, Spanish, Hawaiian, and Modern Hebrew; cf. Prince 1983, 49) strongly supports the decision to create nonbranching feet at an intermediate stage of the derivation; a straightforward requirement for alternating stress would be unable to explain this common aberration.

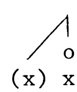
To complete the picture, the four basic varieties of quantity insensitive alternating stress are derived under this theory as follows:

(12)a. Left-to-right, stress first:

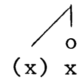


Parse left to right.

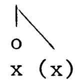
b. Left-to-right, stressless first:



Parse left to right.

c. Right-to-left, stress first: 

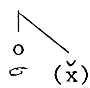
Parse right to left.

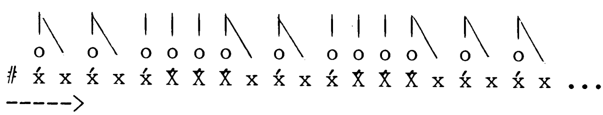
d. Right-to-left, stressless first: 

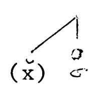
Parse right to left.

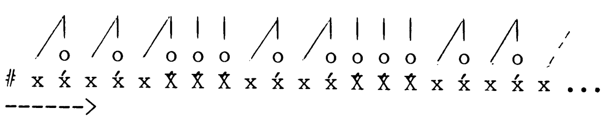
Quantity sensitive alternating stress is derived in much the same way. The difference is that quantity sensitive rules require the recessive side of the foot to dominate only light syllables (whatever the specific criterion of syllable weight happens to be). If, in the course of parsing, a disyllabic foot cannot be created without placing a heavy syllable in the recessive position of a foot, then a monosyllabic foot is created instead. Abstracting away from the effects of destressing, this procedure derives the four logically possible quantity sensitive patterns described under (8) by using the four available combinations for dominance and directionality:

(13)a. Left to Right

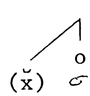
1. Stress First = 

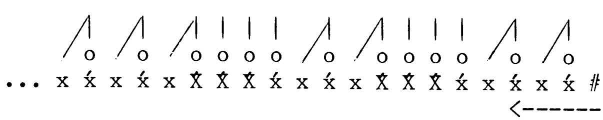


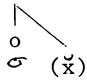
2. Stressless First = 

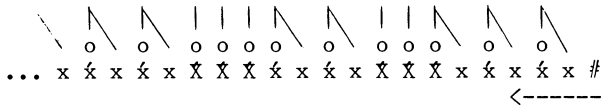


b. Right to Left

1. Stress First = 



2. Stressless First = 



The foot based theory can also account for an observation made earlier: recall that in a quantity sensitive alternation, the light syllable that follows a heavy is always skipped over, regardless of whether the rule in question assigns stress first or stresslessness first at the edge of a word. Inspection of the examples above will show that this is an automatic consequence of the parsing procedure: the syllable after a heavy will be skipped no matter how the parsing parameters are set.

5. Iambic and Trochaic Stress Rules

We are now ready to link the formal theory of stress assignment to the difference between iambic and trochaic rhythm. Recall that in general, durational prominence contrasts are associated with iambic rhythm, intensity contrasts with trochaic. It is clear that if quantity sensitive and quantity insensitive stress rules behave differently, then the quantity sensitive rules should be associated with durational contrast, and the quantity insensitive rules with intensity contrast. The quantity sensitive rules are inherently designed to produce feet whose syllables will contrast in duration if possible, while the quantity insensitive rules are not. My assumption is that a normal, unmarked alternating stress rule will group the syllables of a word in the most rhythmically natural way, in accord with the law of iambic and trochaic groupings. This assumption leads to a number of predictions.

First, in the normal case quantity sensitive alternating stress rules should impose foot templates with iambic prominence. Expressed more directly, this means that they should impose a stress-first alternation when they apply from right to left and a stressless-first alternation when they apply from left to right.

To test this prediction and others, I have located as many alternating stress rules as I could find, analyzing them with iambic or trochaic feet as the data required. Obviously, in a number of cases my analyses are tentative and possibly incorrect; however, I believe that corrections to individual analyses and data are not likely to alter the overall picture.

My survey found fifteen quantity-sensitive alternating stress rules, encompassing fourteen languages and eight language families. Remarkably, in all fifteen rules, the foot template is iambic. The rules are listed in the following chart by direction of application. I include the criterion of syllable weight and reference sources.

(14) <u>Quantity Sensitive Alternating Stress Rules</u>

a. <u>Left to Right</u>

Eastern Ojibwa (Algonquian, Bloomfield 1957), long vs. short V
Menomini (Algonquian, Bloomfield 1962), long vs. short V
Passamaquoddy (Algonquian, Stowell 1979), long vs. short V
Munsee (Algonquian, Goddard 1982), heavy vs. light syllable
Creek (Muskogean, Haas 1977), heavy vs. light syllable
Choctaw (Muskogean, Munro and Ulrich 1984), heavy vs. light syl.
Chickasaw (Muskogean, Munro and Ulrich 1984), heavy vs. light syllable
Yup'ik Eskimo (Eskimo-Aleut, Alaska, Woodbury 1981), long vs. short V
St. Lawrence Island Eskimo (Eskimo-Aleut, Alaska, Anderson 1974), long vs. short V
Cayuga (Iroquoian, Foster 1982), long vs. short V
Macushi (Carib, Brazil, Hawkins 1950) heavy vs. light syl.
Tübatulabal (Uto-Aztecan, Voegelin 1935), long vs. short V

b. <u>Right to Left</u>

Aklan (Austronesian, Philippines, Hayes 1981), heavy vs. light syllable
Tiberian Hebrew (Semitic, McCarthy 1979b), heavy vs. light syl.
Tübatulabal (Uto-Aztecan, Voegelin 1935), long vs. short V

The appearance of Tübatulabal twice on the list deserves explanation. The left-to-right case represents the reconstructed stress rule of an earlier stage of the language, whose effects persist as a synchronic vowel lengthening rule. The right-to-left rule represents stress in Modern Tübatulabal. For discussion, see Prince (1983).

Although further research may uncover contrary cases, the unanimity of the examples found so far is encouraging, and suggests we may be justified in referring to quantity sensitive alternating stress as an "iambic" stress pattern.

Among quantity insensitive stress rules, we should expect to find at least a preference for trochaic feet; recall that the grouping effect for trochaic units is not as strong as that for iambic. The prediction would be reflected in the data by a preference for stress-first alternation going from left to right and stressless-first alternation going from right to left. I have collected 37 examples, which are listed below. The annotation <u>2ary</u> means that the rule in question assigns only secondary stress, with primary stress either determined lexically or by an earlier rule.

(15) Quantity Insensitive Alternating Stress Rules

a. Trochaic

i. Left to Right

Auca (unclassified, Ecuador, Pike 1964)
Piro (Arawakan, Peru, Matteson 1965), 2ary
Livonian (Uralic, Latvia, Sjögren 1861)
Vogul (Uralic, Siberia, Kálmán 1965)
Central Norwegian Lappish (Uralic, Itkonen 1958)
Votic (Uralic, env. Leningrad, Ariste 1968)
Selepet (Papuan, New Guinea, McElhanon 1970)
Ningil (New Guinea, Manning and Jaggers 1977)
Dehu (Austronesian, Loyalty Islands, Tryon 1968)
Lenakel (Austronesian, Vanuatu, Hammond (forthcoming)), 2ary
Southwest Tanna (Austronesian, Vanuatu, Lynch 1982), 2ary
Pitjantjatjara (Pama-Nyungan, Australia, Douglas 1959)
Pintupi (Pama-Nyungan, Australia, Hansen and Hansen 1969)
Maranungku (Daly, Australia, Tryon 1970)
Bidyara-Gungubula (Australia, Breen 1973)
Mayi (Australia, Breen 1981)
Modern Greek (Malikouti-Drachmann and Drachmann 1981), 2ary
Czech (Slavic, Jakobson 1962)
German (Giegerich 1983), 2ary

2. Right to Left

Warao (unclassified, Venezuela, Osborn 1966)
Cavineña (Tacanan, Peru, Key 1968)
Auca (unclassified, Ecuador, Pike 1964)
Bikol (Austronesian, Philippines, Mintz 1971), 2ary
Nengone (Austronesian, Loyalty Islands, Tryon and Dubois 1969)
Lenakel (Austronesian, Vanuatu, Hammond (forthcoming)), 2ary
Southwest Tanna (Austronesian, Vanuatu, Lynch 1982), 2ary
Djingili (Tjingiluan, Australia, Chadwick 1975)
Malakmalak (Daly, Australia, Birk 1975)
Garawa (Karwan, Australia, Furby 1974), 2ary
Modern Hebrew (Bolozky 1982), 2ary
Modern Greek (Malikouti-Drachmann and Drachmann 1981), 2ary
Spanish (Harris 1983), 2ary

b. Iambic

1. Left to Right

Southern Paiute (Uto-Aztecan, Sapir 1930-31)
Winnebago (Siouan, Hale and White Eagle 1980)
Seneca (Iroquoian, Chafe 1977)
Onondaga (Iroquoian, Chafe 1977)

2. Right to Left

Weri (Papuan, New Guinea, Boxwell and Boxwell 1966)

The totals are 32 "trochaic" stress rules, five "iambic." Given the number and diversity of languages involved, I believe that the size of the disparity supports the hypothesis. As before, some languages appear twice in the chart because they have two stress rules. In Auca, trochaic feet are assigned from left to right up to the right edge of the stem and from right to left within a sequence of suffixes. Lenakel and Southwest Tanna assign trochaic alternating stress from right to left in nouns and from left to right in verbs. In Modern Greek, secondary stress is assigned freely, but trochaically, in either direction.

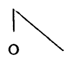
The law of iambic and trochaic grouping makes a third prediction. Note that while the mode of parsing for iambic feet is optimal for the creation of feet having an actual iambic durational contour, the actual phonological shape of a word does not always cooperate. For example, when an iambic stress rule parses two light syllables in a row, the result will be a foot with phonologically even duration. One thus might expect that iambic stress languages would contain later segmental rules that could impart a proper durational contour to such feet. In fact, such rules appear quite frequently among these languages. In Choctaw, Chickasaw, Yup'ik Eskimo, Cayuga, Onondaga, and reconstructed Tübatulabal, short stressed vowels are lengthened, thus converting feet of the form [CV CV́] to the more properly iambic [CV CV́V]. In Menomini and some dialects of Yup'ik, consonants following a short stressed vowel are geminated, again producing durationally iambic feet via the mechanism [CV CV́] C --> [CV CV́C] C. Finally, in Tiberian Hebrew, Macushi, Eastern Ojibwa, Munsee, and Menomini, stressless vowels are reduced. Here, the iambic durational contour of a rising foot is enhanced by decreasing the duration of its first syllable.

These effects are surprisingly absent among the trochaic alternating-stress languages: none phonologically lengthens stressed vowels, geminates consonants after stressed vowels, or even reduces stressless vowels. This sharp typological difference further argues that the iambic-trochaic distinction is a fundamental one.

To make this argument more solid, we must rule out an alternative explanation: that rules emphasizing durational contrast are simply a characteristic of quantity-sensitive languages, rather than of iambic languages per se. There are two reasons why this alternative is unlikely. First, it is possible for a quantity insensitive language to lengthen stressed vowels, provided that it has iambic stress: such a language is Onondaga, with two such lengthening rules. The second argument is somewhat less direct. Note first that a language may have vowel reduction together with non-alternating, quantity insensitive stress, as in Russian (Jones and Ward 1969), Catalan (Mascaró 1976), or Tiwi (Osborne 1974). These languages reduce any vowel of the appropriate quality that fails to bear primary stress. Clearly, this form of reduction has nothing to do with reinforcing an iambic or trochaic timing pattern. If it is possible for a quantity insensitive language to have vowel reduction, then it seems all the more significant that no quantity-insensitive alternating stress language uses vowel reduction to reduce alternating vowels. This gap strongly supports the notion of a trochaic stress rule: to reduce stressless vowels that appear in an alternating trochaic pattern would destroy the even timing that is inherent to trochaic rhythm.

Some idiosyncratic stress patterns in other languages may also be explainable using the iambic-trochaic distinction. Alan Prince has pointed out one such case to me. The unusual stress pattern of Cairene Arabic is described by McCarthy (1979a) with a left-to-right rule that is both quantity sensitive and trochaic. This sounds like a counterexample to our generalization, except that the foot template McCarthy proposes requires a light syllable in both of its positions, as in (16):

(16)



CV (CV)

In other words, although the Cairene rule is quantity sensitive, it nonetheless preserves the even timing required by trochaic rhythm in all the disyllabic feet it creates.

The rather unusual foot labeling rule required in Yidiny, an Australian language (Dixon 1977, Hayes 1982), also falls into place in light of the iambic-trochaic principle. Briefly, in Yidiny the word is parsed left-to-right into disyllabic feet. If any foot within the word contains a long vowel in its final syllable, then all the feet in the word are made right dominant. If all the feet contain short vowels in their final syllables, then every foot is made left dominant. Further, when right dominant feet occur, any long vowel occurring on the left side of a foot is shortened. It is clear that the iambic/trochaic distinction plays a central role in this system: it assigns iambic prominence when there is a foot suited to it, and trochaic prominence otherwise. Further, the shortening rule corrects rhythmically ill-formed feet of the type [V: V́] and [V: V́:] to the more appropriate [V V́] and [V V́:].

6. Comparison with Other Theories

I think that the above arguments constitute a good preliminary case for the claim that the law of iambic and trochaic phrasing is applicable to stress patterns. The crucial mechanism that links phrasing with stress is foot-based metrical theory, which postulates grouping as the basic operation of stress rules.

In this connection, it is worthwhile to compare the foot-based theory with other metrical theories of stress that do not invoke grouping, in particular the grid-based theories of Prince (1983) and Selkirk (1984). In these theories, the representation for stress depicts only the hierarchical arrangement of rhythmic beats, using x's arrayed in a grid. (For an example of grid representation, see (1) above.) Phonological stress rules in grid theory directly place rhythmic beats in the appropriate positions. For example, the alternating pattern of Polish stress described above could be accounted for with a rule saying "going from right to left, place a beat on every other syllable, starting out with stresslessness."

Both Prince's and Selkirk's grid theories are well thought-out, and are serious candidates for a valid general theory of stress. In describing "stress clashes" and destressing rules, they are clearly superior to the purely tree-based account I proposed in Hayes (1981). Note, however, that the advantages of grids in this area also accrue to the modified tree theory of Hammond (1984), which incorporates grid-like information within tree structure.

One area where grid theories appear to be lacking, however, is in providing an account of the iambic/trochaic distinction in stress rules. The basic mechanisms available to grid theory for assigning alternating stress (cf. Prince 1983) are inherently neutral with respect to direction. Thus grid theory can provide no explanation for why quantity sensitive alternation should always begin with a stressed syllable when going from right to left but with a stressless syllable when going from left to right. By the same token, grid theory cannot explain why quantity insensitive alternation should show precisely the opposite pattern. In addition, grid theory lacks a perspicuous means of characterizing what we have called "iambic" stress, and cannot explain why rules that reinforce durational contrast should occur only in the iambic class of alternating stress systems. All three observations fall out straightforwardly from the law of iambic and trochaic grouping, as I have shown. But a theory that denies the existence of grouping in stress rules has no access to this law. In general, grid-based stress theory is conceptually simpler than tree theory, but in this instance, simplicity is bought with a loss of explanatory power.

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