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The Blackwell Companion to Phonology

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40. The Foot

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Sections

1 Overview

The metrical foot organizes the syllables of words into higher-order units built around stressed syllables.

In this chapter, we review the evidence for, and structure of, the foot. Along the way, we treat some of the major issues that have arisen in the development of this notion.

The organization of this chapter is as follows. First, we review the background against which the foot was proposed: linear generative phonology and then early footless metrical phonology. We then turn to the earliest foot proposals and the arguments advanced at the time, including arguments from stress theory and prosodic morphology. We then go on to consider how the theory of the foot has changed in Optimality Theory (OT). (For a more general discussion of stress, see CHAPTER 39: STRESS: PHONOTACTIC AND PHONETIC EVIDENCE.)

2 Background

In this section, we lay out the necessary background for understanding the earliest proposals about the foot. First and foremost is the background of generative phonology generally and **Chomsky and Halle (1968)** specifically. We then go on to consider the foundation for the foot laid in early metrical theory.

2.1 Generative phonology and *SPE*

Here we discuss **Chomsky and Halle (1968**; henceforth *SPE*) as the foundation for the foot.[1] The main contribution of *SPE* for our purposes is an explicit treatment of the regularities of stress in English. The analysis is comprised of a number of rules written in the specific formalism proposed there. Their full rule for main stress in English is given in (1) (*SPE*: 240).

(1)

$$V \rightarrow [1\ \text{stress}] \ / \ \Big[X \_\_ \ C_0 \left(\left(\begin{bmatrix} -\text{tense} \\ \gamma\text{stress} \\ V \end{bmatrix} C_0^1 \right) \left(\begin{bmatrix} \alpha\text{voc} \\ \alpha\text{cons} \\ -\text{ant} \end{bmatrix} \right) \right)$$

$$/ \ \_\_ \left\langle \left(\begin{Bmatrix} (fik)At \\ [+D]C_0 \end{Bmatrix} \right) \begin{Bmatrix} \langle_1 +C_0 \rangle_1 \begin{bmatrix} -\text{stress} \\ -\text{tense} \\ -\text{cons} \end{bmatrix} [+\text{cons}]_0 \\ \langle_1 \begin{bmatrix} -\text{seg} \\ \langle_2 -\text{FB} \rangle_2 \end{bmatrix} \rangle_1 \ C_0[\beta\text{stress}]C_0 \langle_2 V_0 C_0 \rangle_2 \end{Bmatrix} \right\rangle \Big]_{\langle \text{NSP} \langle_1 \text{VA} \rangle_1 \rangle}$$

Conditions: $\beta = \begin{Bmatrix} 2 \\ 1 \end{Bmatrix}$
$\gamma \leq 2$
X contains no internal #

Setting aside morphological and diacritic variables, and focusing on nouns in particular, the main stress rule assigns main stress and secondary stress to nouns in the following way. First, a [+tense] vowel in a final syllable gets primary or secondary stress, e.g. *kangaroo* [ˌkæŋgəˈru] or *chickadee* [ˈtʃɪkəˌdi]. If the final syllable does not have a stress, and the penultimate vowel is followed by appropriate consonants, then it gets stress, e.g. *agenda* [əˈdʒɛndə]. Likewise, if the penultimate vowel is [+tense], it gets stress as well, e.g. *aroma* [əˈromə]. Finally, in other cases, the antepenult receives stress, e.g. *America* [əˈmɛrəkə] or *remedy* [ˈrɛmədi].

Abstracting away from the formalism of the time, what we see is a restriction of the primary stress to the last three syllables of the word and a pressure to stress syllables of appropriate weight.

The alternating stress rule in (2) (*SPE*: 240) is responsible for stresses further to the left, e.g. the first stress in *kangaroo* [ˌkæŋgəˈru]. Like the main stress rule, it places stress subject to a basically alternating pattern.

(2) $V \rightarrow [1\ \text{stress}] \ / \ \_\_ \ C_0 \ (=) \ C_0 V C_0 [1\ \text{stress}] C_0]_{NAV}$

Both rules alternate in a similar way; both rules assign stress with respect to a following landmark. The fact that both rules exhibit similar patterns and the fact that this kind of alternation is ubiquitous in other languages was a missed generalization in *SPE*, and one that found an explanation in the development of the metrical foot.

A second important aspect of the analysis proposed in *SPE* is that, unlike other phonological features, the feature [stress] exhibited more than two levels in the phonology. Thus, while a feature like [high] could have the values [+high] or [−high] in the phonology, the feature stress could have an *infinite* number of values: [0stress], [1stress], [2stress], [3stress], etc. These different numerical values corresponded to degrees of stress that were held to be contrastive. Moreover, the values had a rather odd interpretation, where [0stress] is the least stressed element and [1stress] has the most stress. Since the values can increase without bound, as the integer value increases, the degree of stress gets smaller, but never quite reaches [0stress].

(3)

Value	*Interpretation*
[0stress]	stressless
[1stress]	primary stress
[2stress]	secondary stress
[3stress]	tertiary stress
[*n*stress]	etc.

What made this interpretation work was the *Stress Subordination Convention* (SSC): “when primary stress is placed in a certain position, then all other stresses in the string under consideration at that point are automatically weakened by one” (**Chomsky and Halle 1968**: 16–17). The SSC governed application of the stress rules through the *cycle* (see **CHAPTER 85**: CYCLICITY). The cycle held that phonological rules were reapplied as morphological and syntactic operations proceeded.

Let us see how this works with the Nuclear Stress Rule (NSR) and Compound Stress Rule (CSR) (**Chomsky and Halle 1968**: 18):

(4)

$$\begin{bmatrix} 1\ \text{stress} \\ V \end{bmatrix} \rightarrow [1\ \text{stress}] \ / \begin{Bmatrix} \_\_ \ldots \overset{1}{V} \ldots]_{NAV} \\ \overset{1}{V} \ldots \_\_ \ldots] \end{Bmatrix} \qquad \begin{array}{ll} \text{a.} & \text{CSR} \\ \text{b.} & \text{NSR} \end{array}$$

The NSR basically re-assigns primary stress to the rightmost stress of a domain. The CSR re-assigns primary stress to the penultimate primary stress of a domain. This re-assignment of stress is vacuous with respect to the particular vowel that is targeted, but has consequences for all other vowels in the domain via the SSC (Chomsky and Halle 1968: 22).

(5) $[_{NP}$ John's $[_{N} [_{N}$ black board$]_{N}$ eraser $]_{N}]_{NP}$

1	1	1	1	NSR
–	1	2	–	CSR
–	1	3	2	CSR
2	1	4	3	NSR

First, stress is assigned to each word in isolation. Then *blackboard* is assembled, and main stress is assigned to the penultimate/first primary stress, since this is a compound. Next, *eraser* is appended, and compound stress is re-assigned. Notice how, since there are only two primary stresses present at that point, the penultimate primary is actually the third stress from the right. Finally, we add *John's*, and main stress is re-assigned to the rightmost primary, which again is the third stress from the right.

Chomsky and Halle thus contributed four key elements to early stress theory: binary alternation, the cycle, the *n*-ary [stress] feature, and the Stress Subordination Convention (SSC). All of these figured in the development of early metrical theory.

2.2 Early metrical theory

The earliest versions of metrical theory directly addressed the *n*-ary stress feature, the cycle, and the SSC. It was only later that the foot was introduced.

Rischel (1972) was the earliest proposal to replace aspects of the *SPE* stress system with a hierarchical tree. Specifically, Rischel proposes that compound stress in Danish does not require a cycle and that degrees of stress can be easily read off the morphosyntactic tree.

Compare the following two compounds in Danish:

(6)

fædrelandssang	'patriotic song'	[father-land]song
perlehalsbånd	'pearl necklace'	pearl[neck-band]

In the first case, the compound is left-branching and has the stress values 132. In the second case, the compound is right-branching and has the stress pattern 123. The *SPE* rules given for English here would actually accommodate these directly, as shown in the derivations below.

(7) $[_{N} [_{N}$ fædre lands $]_{N}$ sang $]_{N}$

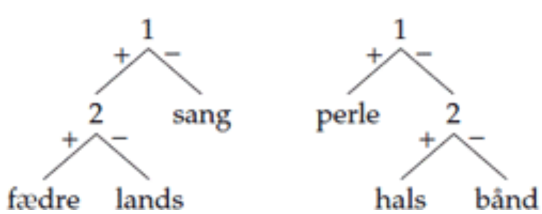
1	1	1	NSR
1	2	–	CSR
1	3	2	CSR

(8) $[_{N}$ perle $[_{N}$ hals bånd $]_{N}]_{N}$

1	1	1	NSR
–	1	2	CSR
1	2	3	CSR

Rischel proposes that cyclic effects can be gotten by reading stress levels directly off of trees. He gives trees like the following for the examples above. The pluses and minuses reflect the relative strength of left and right branches and the numbers on nodes reflect the relative effects of those strengths at different levels of the tree.

(9)



Rischel does not propose a specific algorithm for reading stress values off trees like these, but it is easy to see that various interpretations will produce what appear to be reasonable values. The gist is that reapplication of stress rules per se is not required to get the same kind of cyclic effects cited above from *SPE*.[2]

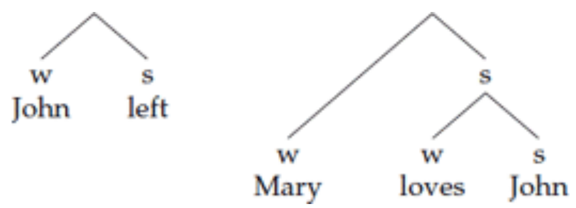
Liberman and Prince (1977) made a similar proposal a few years later, proposing a fairly complete analysis of English stress along similar lines. Basically, they propose that [stress] be treated as a binary feature, with the values [+stress] and [−stress]. Degrees of stress would follow from tree structures erected over the stress values. Trees are binary branching, with each pair of nodes labeled either "strong" (s) or "weak" (w). Liberman and Prince posit the following labeling convention (1977: 257).

(10) In a configuration $[_C \text{ A B }]_C$:

a. NSR: If C is a phrasal category, B is strong.
b. CSR: If C is a lexical category, B is strong *iff* it branches.

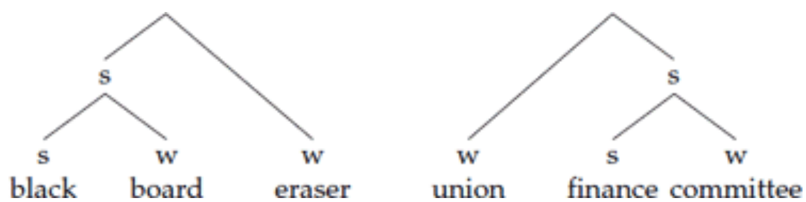
In phrases, clause (a) of the convention places strong nodes uniformly on the right.

(11)



In compounds, labeling depends on branching. In a left-branching compound, left nodes are uniformly strong. When right nodes branch, however, by clause (b), they are strong.

(12)



In the case on the left, all right nodes are non-branching, so the left node of each pair of nodes is labeled strong. In the case on the right, *finance committee* has a non-branching right node, so its left node is labeled strong, but in *union finance committee* the right node is branching, so it is labeled strong.

Like **Rischel (1972)**, Liberman and Prince replace degrees of stress with a tree-based algorithm. However, Liberman and Prince go one step further and propose a similar *word-internal* system.

There are three parts to their system. First, [+stress] values are assigned to vowels in words. They initially propose two separate rules for this, much as in *SPE*. There is the English Stress Rule (ESR (preliminary version); 1977: 272).

(13) $$\mathrm{V} \rightarrow [+\mathrm{stress}] \;/\; \underline{\quad}\; \mathrm{C}_0\, (\breve{\mathrm{V}}(\mathrm{C}))\, (\breve{\mathrm{V}}\mathrm{C}_0)\; \#$$

This rule assigns the rightmost [+stress] in a word. There is also a Stress Retraction Rule (SRR; 1977: 278).

(14) $$\mathrm{V} \rightarrow [+\mathrm{stress}] \;/\; \underline{\quad}\; \mathrm{C}_0\, (\breve{\mathrm{V}}(\mathrm{C}))_a\, (\mathrm{VC}_0)_b \;\; \begin{matrix}\mathrm{V}\\ [+\mathrm{stress}]\end{matrix}$$

Having two separate rules misses a generalization and Liberman and Prince move a major step forward from *SPE* in recognizing this:

> Both rules measure leftward from a fixed point of reference, the ESR from a word boundary, the SRR from a stressed syllable; and the standard of measure is in both cases virtually the same. This parallelism strongly suggests that we are witnessing a single unified process of stress assignment, repeating itself across the word, feeding on its own output. (1977: 278)

To deal with this, Liberman and Prince propose a unified English Stress Rule (ESR (iterative version); 1977: 278).

(15) $$V \rightarrow [+\text{stress}] \,/\, \_\_\; C_0\, (V(C))_a\, (\underset{\langle -\text{long}\rangle_d}{V}\; C_0)_b\, (\underset{[+\text{stress}]}{V}\; X)_c\#$$

Conditions: $\neg c \supset d$; $\neg a$, $\neg b$ under certain morphological and lexical circumstances.

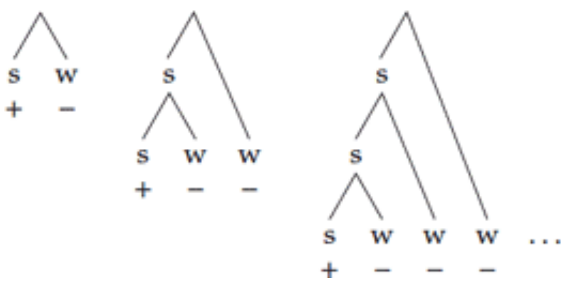
A variety of conditions must be imposed on the rule, much as on the *SPE* equivalents. That said, the rule captures the intuition that there is a similar pattern of iteration.

The second part of Liberman and Prince's algorithm is a key step in the development of the metrical foot. Once values of stress have been assigned to a string by the rule(s) above, syllables are gathered into trees. Above the word level, these trees correspond to syntactic and morphological structures. Below the word level, there are two essential components. First:

> every sequence of syllables + −, + − −, + − − −, etc., forms a metrical tree. Because of the condition limiting [−stress] to weak positions, and because of the bivalent (binary branching) character of metrical trees, the structure and labeling of the sequences is uniquely determined. (1977: 266)

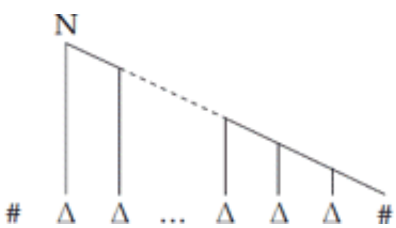
By this algorithm, we get trees like the following:

(16)



These trees are then gathered into larger right-branching trees:

(17)



As noted above, the labeling of the lower-level trees is unambiguous, because of a general constraint against [+stress] in weak position. The higher-level trees are labeled in accord with the Lexical Category Prominence Rule (LCPR; 1977: 270).

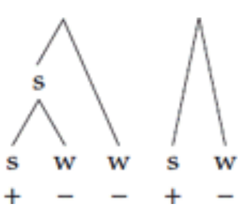
(18) In the configuration [$N_1 N_2$], N_2 is strong *iff* it branches.

Let us take a look at an example: *Winnepesaukee* [ˌwinəpə'sɔki]. First, [+stress] values are assigned by the ESR, producing:

(19)
\+ − − + −
Winnepesaukee

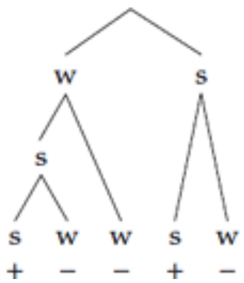
Syllables are gathered into feet as below:

(20)



Finally, the feet are gathered into a tree, the right node of which is labeled strong, since it is branching.

(21)



What is important about this entire tree-construction and tree-labeling procedure is that it explicitly recognizes two levels: a *foot* level and a higher *word* level. This is the first step toward an explicit theory of the foot. Liberman and Prince showed how the foot could be employed in a reanalysis of the basic stress facts of English that *SPE* introduced.

3 Why we need feet

The next step was the parametric elaboration of the foot. At around the same time as **Liberman and Prince (1977)**, **Hyman (1977)** offered the first typological treatment of stress. While he was not able to go very far in terms of the technical analysis offered, this paper was an important catalyst in forcing phonologists interested in stress to look at the broader typological implications of their work.

The first parametric approaches to the metrical foot showed up in **Halle and Vergnaud (1978)** and **McCarthy (1979)**, but the most influential early proposal was that of **Hayes (1980)**. Let us look at the Hayes proposal in some depth.

Hayes offered a theory of the foot based on the trees proposed in Liberman and Prince. In particular, feet were parameterized for the following:

(22) a. *Headedness*

Is the designated terminal element – the strongest element of the foot – on the left edge or the right?

b. *Boundedness*

Are feet binary or unbounded? Do feet contain only two syllables or as many as possible?

c. *Directionality*

Are feet built left-to-right or right-to-left?

d. *Iterativity*

Are feet constructed iteratively or not? That is, is only a single foot built on some edge or are as many feet built as possible?

e. *Quantity-sensitivity*

There are three choices here. First, feet can be quantity-sensitive (QS): weak nodes cannot dominate heavy syllables. Second, feet can be quantity-insensitive (QI): syllable weight is irrelevant. Last, feet can be obligatory-branching (OB): in OB feet, strong nodes must dominate heavy syllables and weak nodes may not.

f. *Syllable weight*

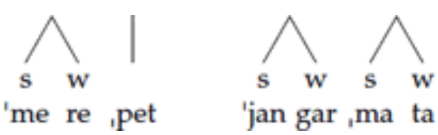
If feet are sensitive to syllable weight, are they sensitive to the weight of the syllable nucleus or the syllable rhyme?

Let us go through some of the examples Hayes cites in support of this theory. Maranungku (**Tryon 1970**) is cited as an example of left-headed binary left-to-right QI feet. Here, main stress falls on the first syllable of the word and secondary stresses fall on alternating syllables to the right.

(23)	'tiralk	'saliva'
	'mere,pet	'beard'
	'jangar,mata	'the Pleiades'
	'langka,rate,ti	'prawn'
	'wele,pene,manta	'kind of duck'

Here are two examples:

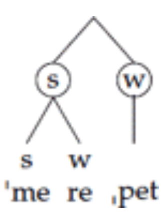
(24)



Notice how the left-to-right construction of feet is apparent from the fact that in words with an odd number of syllables, a monosyllabic, or *degenerate*, foot is built on the right.

The difference between primary and secondary stress is captured by positing a higher level of structure: the *word tree*. These are left- or right-headed unbounded trees built on the roots of feet (see CHAPTER 41: THE REPRESENTATION OF WORD STRESS). In Maranungku, the word tree is left headed.

(25)



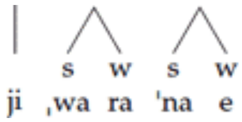
Note that in this and in subsequent diagrams we circle the roots of feet when the word tree is represented.[3]

Warao (**Osborn 1966**) provides an example of right-to-left footing with left-headed binary feet.

(26)	,japu,ruki,tane'hase	'verily to climb'
	,naho,roa,haku'tai	'the one who ate'
	ji,wara'nae	'he finished it'
	e,naho,roa,haku'tai	'the one who caused him to eat'

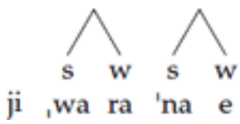
Warao differs from Maranungku in that, in words with an odd number of syllables, there is no initial degenerate foot; rather that foot is removed by an additional *destressing rule*. For example, [ji, wara'nae] is first footed as follows:

(27)



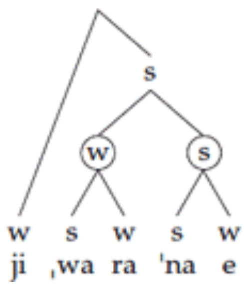
This intermediate representation is then converted to:

(28)



The word tree in Warao is right headed. Hayes assumes that unfooted syllables are adjoined as weak nodes to the word tree. For example:

(29)

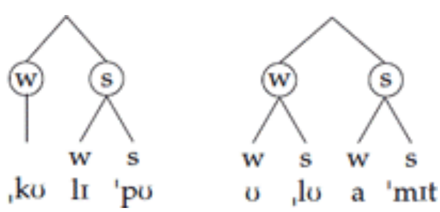


Hayes cites Weri (**Boxwell and Boxwell 1966**) as an example of binary right-headed feet constructed from right to left with a right-headed word tree.

(30)	ŋɪnˈtɪp	'bee'
	ˌkʊlɪˈpʊ	'hair of arm'
	ʊˌlʊaˈmɪt	'mist'
	ˌakʊˌneteˈpɛl	'times'

And again, a couple of examples:

(31)

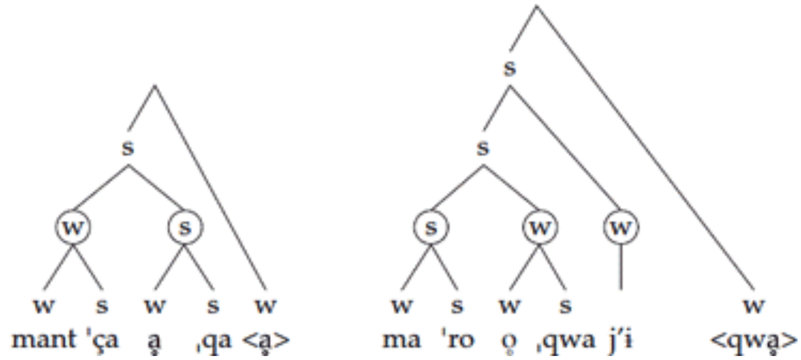


Completing the set of binary QI systems, Hayes cites Southern Paiute (**Sapir 1930**) as an example of binary right-headed feet built left to right. Main stress is assigned with a left-headed word tree.

(32)	mantˈçaạˌqaạ	'to hold out one's hands'
	maˈroọˌqwajˈiqẉạ	'(I) stretch it'

There are several complications to the Southern Paiute system, both noted by Hayes. First, it appears as if there are elements that might be analyzed as long vowels, but that must be treated as adjacent short vowels. (Hayes cites additional evidence for this claim.) In addition, there is an another mechanism that prevents footing of the final syllable: *extrametricality* (see CHAPTER 43: EXTRAMETRICALITY AND NON-FINALITY). With these provisos, and marking extrametricality with angled brackets, we get structures like these:

(33)



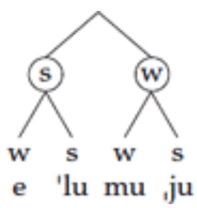
Southern Paiute is a rather complex case. A simpler example is Araucanian, as described by **Echeverría and Contreras (1965)**. There are some complications here too, but stress in Araucanian basically falls on even-numbered syllables counting from the left.[4]

(34)

wu'le	'tomorrow'
ṭi'panto	'year'
e'lumuˌju	'give us'
e'luaˌenew	'he will give me'
ki'mufaˌluwuˌlaj	'he pretended not to know'

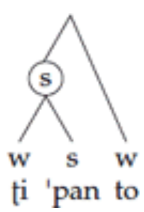
The analysis here is binary right-headed feet built left to right.

(35)



Monosyllabic feet are generally disallowed (or removed) in odd-syllabled cases:

(36)



Let us now consider quantity-sensitivity (QS; see CHAPTER **57**: QUANTITY-SENSITIVITY). This parameter allows heavy syllables to attract stress. Hayes cites Tübatulabal (**Voegelin 1935**) as an example of right-to-left right-headed QS bounded feet. The generalization is that stress falls on (a) the final syllable, (b) any long vowel, and (c) any vowel that is two syllables to the left of a stress. Since stresses are unranked, there is no word tree.

(37)

'taa'hawi'laap	'in the summer'
pi'tipi'tiidi'nat	'he is turning it over repeatedly'
'ii'ˀiii'ˀaani'ʃa	'he will meat-fast'
'pɔnih'win	'of his own skunk'

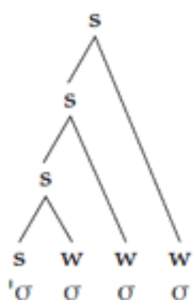
Here are two examples of the footings produced by these parameter settings.

(38)

Notice that long vowels count as heavy in Tübatulabal; thus QS refers to the nucleus, not the rhyme.[5]

Hayes' theory of feet also allows for unbounded feet. When these are quantity-insensitive, they simply position stress on the first or last syllable of the word. No actual examples are cited, but we would expect trees like the following for a language with initial stress and QI left-headed unbounded feet:

(39)



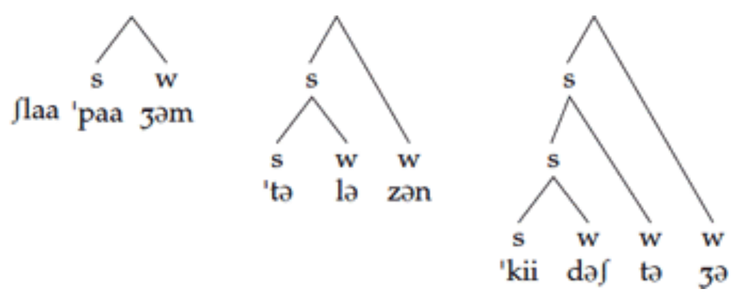
Notice how, since the foot expands to fill the domain, no more than a single foot will ever be built. A language like Czech, with regular initial stress, might qualify as such a system.

Hayes cites Eastern Cheremis (**Sebeok and Ingemann 1961**) as an example of unbounded left-headed QS footing: a single such foot is built on the right edge of the word; a word tree is not needed. The generalization is that the rightmost long vowel bears stress. If there is no such vowel, the initial vowel bears stress.

(40)	ʃiin'ʧaam	'I sit'
	ʃlaa'paaʒəm	'his hat (ACC)'
	'pyygəlmə	'cone'
	'kiidəʃtəʒə	'in his hand'
	'tələzən	'moon's'

This footing produces examples like the following. Notice how the foot starts at the right edge, expands as far as possible subject to the QS restriction that its weak nodes cannot dominate a long vowel. Notice that QS here is sensitive to only vowel length.

(41)

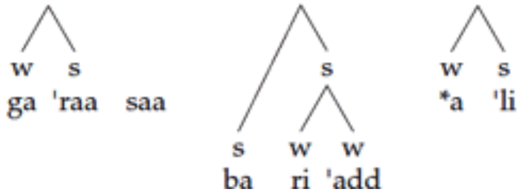


The OB parameter is required for languages that exhibit a curious parallelism to languages like Eastern Cheremis. Khalkha Mongolian (**Street 1963**) is an example of this sort. Stress in Khalkha falls on the leftmost long vowel in the word; in the absence of a long vowel, stress falls on the *initial* vowel.[6]

(42)	bos'guul	'fugitive'
	bari'aad	'after holding'
	xojərdu'gaar	'second'
	ga'raasaa	'from one's own hand'
	'ali	'which'
	'xøtəbərə	'leadership'

When there are long vowels in the word, the pattern could be treated with a single right-headed unbounded QS foot built on the left edge of the word. The problem with this is that it produces an incorrect result in the case of words with no long vowels:

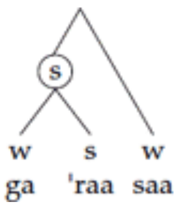
(43)



To treat such systems, Hayes proposes a new parameter and makes interesting use of word trees. Specifically, he proposes that QS feet can be further restricted so that the strong/dominant node must dominate a heavy syllable: *obligatory-branching* (OB). If no such syllable is available, no foot is built.

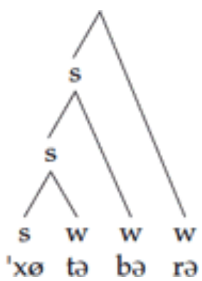
In the case of Khalkha, a single right-headed unbounded OB foot is built on the left edge of the word and a left-headed word tree is constructed. If there is at least one long vowel in the word, the OB foot will be built over the leftmost one, assigning stress to it, and the word tree is vacuous.

(44)



If there are no long vowels, then the OB foot fails to be constructed. In that case, the word tree is still built, taking syllables as terminals. Since, the word tree is left headed, this results in initial stress.

(45)



Obligatory-branching allows for a treatment of systems where stress is assigned to the first or last of the available heavy syllables and in the absence of heavy syllables, the *same* end of the word gets primary stress. This is in contrast to systems like Eastern Cheremis where the *opposite* edge of the word gets the default stress. These latter systems are treated with unbounded QS feet.[7]

We have only exemplified some of the combinations of parameter settings that this theory allows. The claim of the theory is that all settings can be freely combined and that the set of possible stress languages is fully defined by these settings.

The argument for feet per se comes from their role in this parametric system. If the set of possible stress languages is best defined in terms of a theory that adopts the foot as a central descriptive device, then the typology of stress is an argument for the foot.

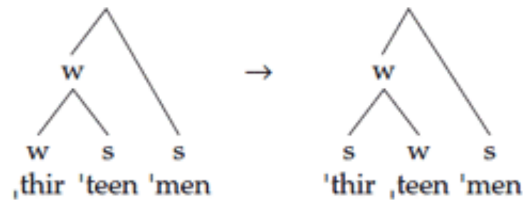
4 Do we need constituency?

One could argue that while the foot is a central computational device in the system Hayes develops, the full predictive power of the foot in that system is not exploited; specifically, while the foot is a *constituent* in metrical trees, its constituency plays no specific role in the system.

Prince (1983) takes this observation to its logical conclusion, proposing an alternative metrical theory without constituency and without feet. To understand this proposal, let us return to **Liberman and Prince (1977)** and their theory of the *metrical grid*.

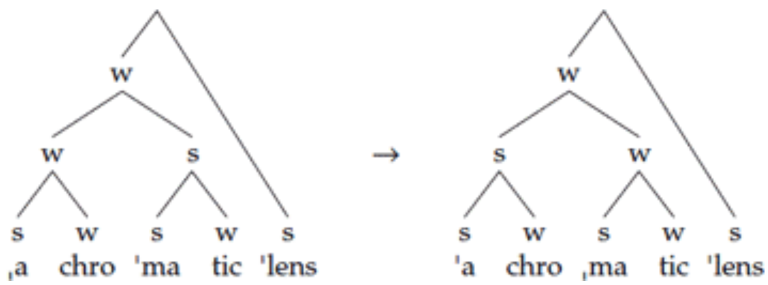
Liberman and Prince propose the metrical grid as a mechanism for identifying the environment for the *rhythm rule*, the phenomenon whereby stress is shifted in certain contexts. Thus, when a word like ˌ*thir*ˈ*teen* is combined with ˈ*men*, we get a shift of stress in the former: ˈ*thir*ˌ*teen* ˈ*men*. The effect of this shift can be diagrammed as follows:

(46)

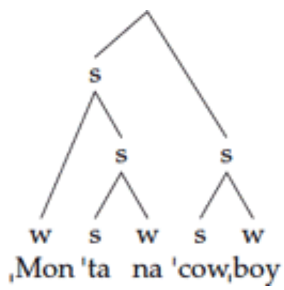


Interestingly, the shift also happens with phrases like ˈ*achroˌmatic* ˈ*lens*, but not with phrases like ˌ*Mon*ˈ*tana* ˈ*cowˌboy*. Why this should be the case is not apparent from the metrical trees.

(47)



(48)



To identify cases where rhythm is applicable, Liberman and Prince propose an alternative representation of stress: the metrical grid. The grid represents relative stress as columns of elements where the heights of those columns are projected from metrical trees. Specifically, Liberman and Prince propose the Relative Prominence Projection Rule (1977: 316).

(49) *Relative Prominence Projection Rule* (RPPR)

> In any constituent on which the strong—weak relation is defined, the designated terminal element of its strong subconstituent is metrically stronger than the designated terminal element of its weak subconstituent.

The way this is interpreted is that the column for any element must be tall enough so that the RPPR is satisfied for all node pairings defined by its metrical tree. For the phrases we have discussed we then have grids as below.

(50)

							11					
		6			*9		*10				8	
	*4	*5	6		7		8		6		7	
1	2	3	1	2	3	4	5	1	2	3	4	5
thir	teen	men	a	chro	ma	tic	lens	Mon	ta	na	cow	boy

Each syllable is marked with a grid element. We then go through the tree, making sure that the RPPR is satisfied for each branching node. If it is not, we add a grid element to the relevant column. For example, the second syllable of *Montana* gets a grid element because of the lowest-level pairing with the syllable *na*. This same element is sufficient to satisfy the RPPR when we come to the pairing of *tana* with *Mon*. On the other hand, in *achromatic*, the third syllable gets a second-level grid mark because of its pairing with the fourth syllable. It must get an additional grid mark because of the pairing with the first two syllables.

We have marked certain grid elements with asterisks. The rhythm rule applies when two columns are too big and too close, i.e. when stresses clash. These properties are formalized in terms of two adjacent elements at two adjacent levels of the grid. For example, in *thirteen men*, elements 2 and 3, and elements 4 and 5 are adjacent and we therefore mark elements 4 and 5. Likewise, in *achromatic lens*, elements 7 and 8 and elements 9 and 10 are adjacent, so again we mark this as a clash.

The Rhythm Rule applies on the metrical tree to eliminate these clashes.[8] The following grids show the results of the relabeling we have already shown for the relevant metrical grids.

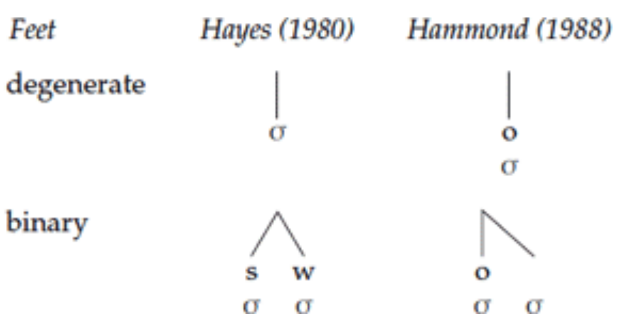
(51)

								11
			6	9				10
	4		5	6		7		8
	1	2	3	1	2	3	4	5
	thir	teen	men	a	chro	ma	tic	lens

Notice how there are no longer clashes in these grids. The metrical grid thus correctly distinguishes cases like *thirteen men* and *achromatic lens* from cases like *Montana cowboy*.

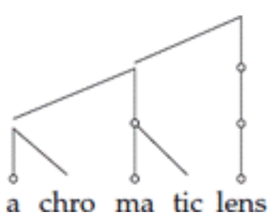
It is, of course, unfortunate that a single representation for stress was not available. There were two broad responses. One response was a proposal by **Hammond (1988)** for a blended representation.[9] The key insight in this proposal was that the designated element of a constituent should be marked the same way regardless of whether the constituent branches or not. This gives us equivalences as below for degenerate and binary left-headed feet. Notice how the heads of the feet have the same representation in Hammond's approach, but not in Hayes's approach.

(52)



Here is what a phrase like *achromatic lens* would look like after application of the rhythm rule.

(53)



While this particular formalism did not survive, this general proposal – that heads of constituents should be marked uniformly – did. **Halle and Vergnaud (1987)** and **Hayes (1995)** adopt the following equivalent notations that exhibit the same uniformity.[10] These are referred to as “bracketed grids.”

(54)

Feet	Halle and Vergnaud (1987)	Hayes (1995)
degenerate	x (x) σ	(x) σ
binary	x (x x) σ σ	(x .) σ σ

The other proposal in response to parallel tree and grid representations of stress was that of **Prince (1983)**. Specifically, Prince proposed a grid-only theory of stress *without* the foot. The basic idea behind the proposal as far as feet are concerned is that binary patterns of iteration are replaced by appeal to the *perfect grid*. This device allows for a binary pattern of stress to be assigned in one of four ways, depending on whether the assignment is from left to right or from right to left and on whether one begins with a stressed syllable or a stressless syllable.

```
(55) Feet          Left-to-right (LR)     Right-to-left (RL)
     peak first    x   x   x                  x   x   x
                   x x x x x                  x x x x x
                   σ σ σ σ σ . . .      . . . σ σ σ σ σ

     trough first    x   x                      x   x
                   x x x x x                  x x x x x
                   σ σ σ σ σ . . .      . . . σ σ σ σ σ
```

Notice how this pattern is achieved with no appeal to binary constituents.

To get the effect of word trees and unbounded foot construction, Prince proposes the *End Rule*. This device assigns a grid mark to the leftmost or rightmost element of the highest level of the grid present. If no stresses have already been assigned, the effect of the End Rule is to assign a stress to the first or last syllable of the word.

```
(56) End Rule Left
                               x
                   x x x x     x x x x
                   σ σ σ σ  →  σ σ σ σ

     End Rule Right
                                     x
                   x x x x     x x x x
                   σ σ σ σ  →  σ σ σ σ
```

If stresses are already present, however, then the effect of the End Rule is to promote the leftmost or rightmost stress to primary stress:

```
(57) End Rule Left
                               x
                   x   x       x   x
                   x x x x     x x x x
                   σ σ σ σ  →  σ σ σ σ

         End Rule Right
                                     x
                   x   x       x   x
                   x x x x     x x x x
                   σ σ σ σ  →  σ σ σ σ
```

Again, no constituents per se are required.

Finally, the effect of heavy syllables is achieved by allowing heavy syllables to project their own grid marks. Such marks are placed before assignment of the perfect grid.

The perfect grid is interrupted by heavy syllable marks or End Rule marks in different ways. One possibility – the default – is that marked heavy syllables are treated as if they were assigned by the perfect grid itself; such syllables may not have a stress assigned to an adjacent syllable. The other possibility – *Forward Clash Override* (FCO) – is that iteration by the perfect grid continues right up to the marked syllable.

The following schematic examples show how FCO works with (left-to-right trough-first) iteration toward a syllable marked by the End Rule Right.

```
(58) [–FCO]
                                        x             x     x
                 x x x x x      x x x x x       x x x x x
                 σ σ σ σ σ  →   σ σ σ σ σ   →   σ σ σ σ σ

     [+FCO]
                                        x             x   x x
                 x x x x x      x x x x x       x x x x x
                 σ σ σ σ σ  →   σ σ σ σ σ   →   σ σ σ σ σ
```

Similar effects obtain when a syllable has been marked as a heavy syllable. In the following example, heavy syllables are marked with H; light syllables with an L.

```
(59) [–FCO]
                                 x                 x     x   x
       x x x x x x x     x x x x x x x     x x x x x x x
       L L L L H L L  →  L L L L H L L  →  L L L L H L L

     [+FCO]
                                 x                 x   x x   x
       x x x x x x x     x x x x x x x     x x x x x x x
       L L L L H L L  →  L L L L H L L  →  L L L L H L L
```

Forward Clash Override, in conjunction with the End Rule, does the work of degenerate footing and destressing. There is an additional complication involved in whether heavy syllables occupy a single grid position or two positions in sequence. Recall that **Hayes (1980)** had to make a similar move in the case of Southern Paiute.

The central result of **Prince (1983)** for our purposes is that it established that, on purely stress-based arguments, there is no argument for the foot as a constituent.

5 Other arguments for feet

There were three broad classes of additional arguments for feet: phonological processes, poetic meter, and prosodic morphology. Some of these arguments persevere and some do not.

5.1 Flapping

One of the earliest arguments for feet outside of stress per se comes from **Kiparsky (1979)**, who argues that flapping in English is best described in terms of feet (see CHAPTER 113: FLAPPING IN AMERICAN ENGLISH).

The basic environment for flapping is as follows. Coronal stops in English ([t d]) are pronounced as flaps before a stressless vowel and after a [−consonantal] element. Thus, word initially we have stops whether the following vowel is stressed or stressless, e.g. *toe* ['tʰo] or *doe* ['do] and *tonight* [tʰə'nait] or *deny* [də'nai]. Medially, before a stressed vowel, we also have stops, e.g. *attack* [ə'tʰæk] or *adult* [ə'dʌlt]. However, medially before a stressless vowel, we get flaps, e.g. *caddy* ['kʰæɾi] or *pity* ['pʰɪɾi].

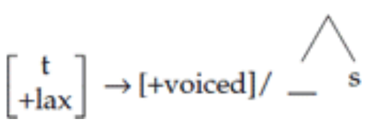
Kiparsky describes this with two rules. The first is a cyclic rule of laxing that makes a consonant lax when it follows a [−consonantal] element within a foot (denoted with Φ here).

(60) *Laxing* (cyclic)

$$C \rightarrow [+\text{lax}] \; / \; {}_{\Phi}[\ldots\ [-\text{cons}]\ \_\_\ \ldots]_{\Phi}$$

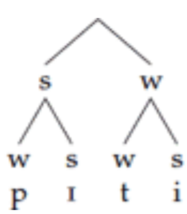
The second rule converts some of these lax consonants into voiced ones when they are initial in a syllable. Kiparsky uses strong—weak labeling for syllable structure as well. The tree structure in the environment of this rule encodes the syllable-initial restriction.

(61) *Voicing* (postcyclic)



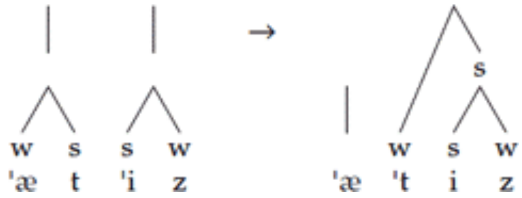
A form like *pity* ['pʰɪɾi] would be syllabified and footed as follows.

(62)



First, the /t/ undergoes Laxing because it is medial in the foot and follows a [−consonantal] element. Then it can undergo Voicing because the /t/ is syllable-initial. The approach nicely accommodates examples like *at ease* [ˌæ'ɾiz], where flapping applies across word boundaries, and examples like *a tease* [ə'tʰiz], where it does not. For *at ease*, we get a derivation as follows:

(63)



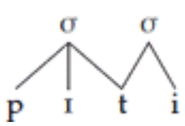
Each word is syllabified separately as a separate syllable and foot. Since the /t/ follows a [−consonantal] element in a foot, it undergoes Laxing. Postcyclically, the words are combined and syllable structure is readjusted so that the /t/ is resyllabified as an onset, reflecting a general preference for onsets over codas. At this stage, Voicing is applicable and we get a flap.

For *a tease*, the /t/ begins in the second syllable. Hence at the cyclic stage of the derivation, there is no opportunity for Laxing to apply. Postcyclically, there is no pressure to resyllabify the onset /t/ as a coda. Even if the /t/ had undergone Laxing, Voicing would still be inapplicable.

(64)

The main virtue of this approach is that it does not require ambisyllabicity. **Kahn (1980)** had proposed that flapping occurred when a consonant occurred in two syllables simultaneously:

(65)



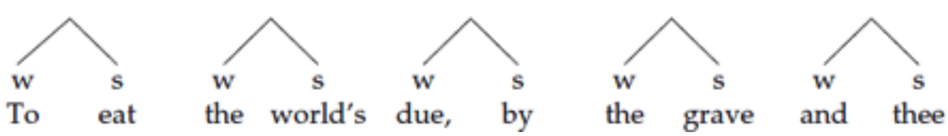
This argument has not survived the test of time. **Hammond (1982)** showed that the ambisyllabicity approach of **Kahn (1980)** extended to phrasal instances of flapping, while the foot-based approach did not, citing examples like *go tomorrow* [ˌgoɾə'maro] *vs. buy tomatoes* [ˌbajt^{h}ə'meroz]. Under appropriate phrasal conditions, flapping can apply to examples where the /t/ begins the second word. There is also substantial psycholinguistic evidence for ambisyllabicity (**Treiman and Zukowski 1990**; **Kessler and Treiman 1997**; **Treiman and Danis 1988**), so eliminating it from linguistic representations is not an obvious desideratum.

5.2 Poetic meter

Another initial argument for the foot came from poetic meter. **Kiparsky (1977)** argued that constraints on meter occasionally require reference to foot constituency. Subsequently, **Hayes (1983)** showed that this foot constituency was not necessary, arguing for a purely grid-based theory of meter.

Let us look at this argument a little more closely. Iambic pentameter in English is characterized by lines with 10 syllables, where even-numbered syllables are "strong" and odd-numbered syllables are "weak." Traditionally, such a line is seen as a sequence of five iambic feet. For example (Shakespeare, Sonnet 1):

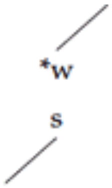
(66)



The effect of the division of syllables into strong and weak is that poets can restrict the distribution of stresses in these positions. In English, poets restrict stressed syllables in weak positions; strong positions are unrestricted.[11]

Kiparsky argues that constraints on the distribution of stresses in weak position refer to constituency, including foot constituency. For example, he argues that Milton's verse is subject to the following constraint, which he labels "Milton I."

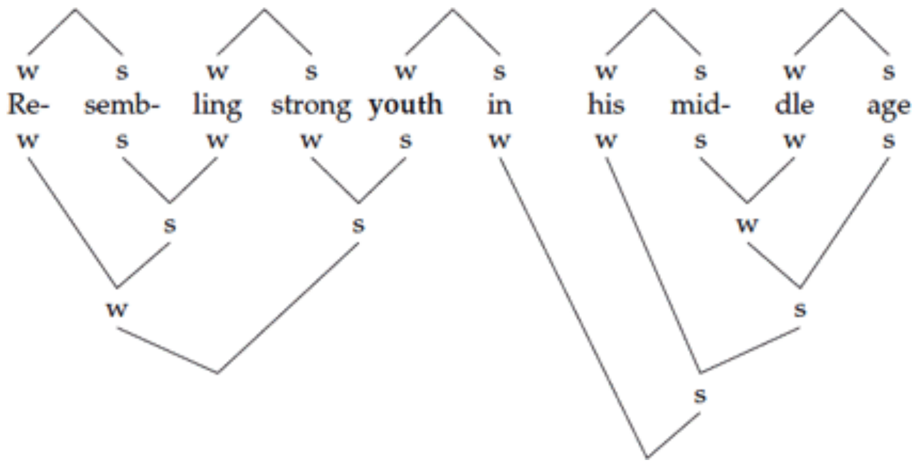
(67)



where *s* is the strongest syllable of its phrase.

Here, the tree above is the line structure and the tree below is the actual prosodic structure of the line. A constraint like this rules out a line like the following for Milton (though it is well formed for Shakespeare, Sonnet 7).

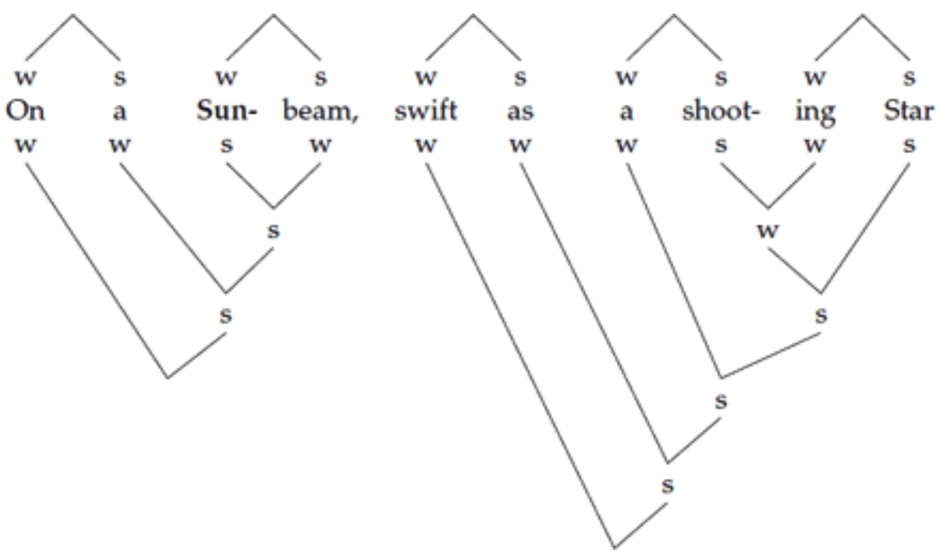
(68)



Here the word *youth* is strongest in its phrase, labeled *s*, and a right branch. On the upper side, this word occurs as the weak left branch of a foot.

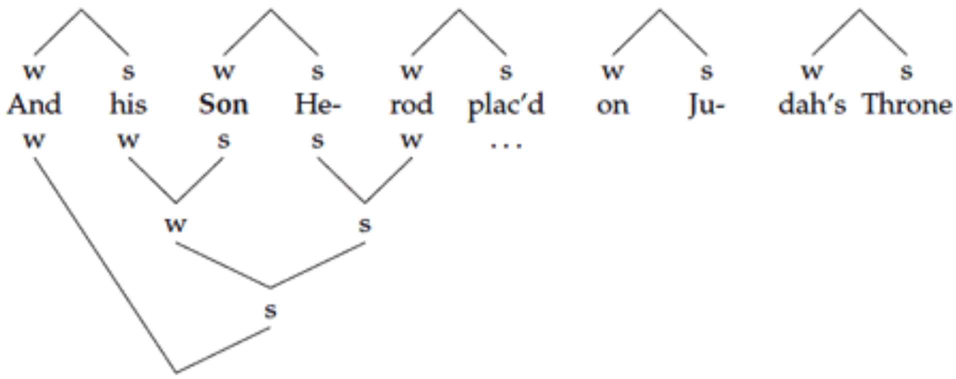
If the bracketing agrees, however, such a line is acceptable for Milton (Paradise Lost 4.556).

(69)



Finally, examples like the following show that the element must be the strongest element of the phrase, and that the bracketing restrictions do not suffice of themselves (Paradise Regained 2.424).

(70)



Hayes (1983) argues that references to foot constituency can be done away with if we define stress peaks over metrical grids and refer to higher-level prosodic constituency. His version of Milton I looks like this:

(71) *Milton I* (grid version)
*Peak / [. . . __]$_{phrase}$

A peak is defined in terms of the grid as a grid column that is higher than at least one of its neighbors.

Let us now look at how this constraint separates the cases we have considered so far. Hayes represents grids in terms of a single symbol “x,” rather than numbers. In addition, he represents the line template as a simple single-level grid, rather than with nodes labeled “s” and “w.” For the line in (68), we would have this template:

```
(72)  . x    .      x     .   x   .   x   . x
      Resembling strong youth in his middle age
```

In subsequent diagrams, we leave the template out.

The relevant part of the illegal line in (68) is:

```
(73)                        x
       . x   .      x       x
      [Resembling strong youth] in his middle age
```

The syllable *youth* is a peak, defined with respect to the preceding syllable. It is in a weak position and phrase final. Hence it is illegal by the revised constraint.

The two legal cases we considered above involve mismatches that are not phrase final:

```
(74) a.         x
           .  . x   x
          [On a Sunbeam], swift as a shooting star
     b.                 x
           .    .   x   x
          [And his Son Herod] plac'd on Judah's Throne
```

Although **Kiparsky (1977)** was an important step forward in our understanding of meter, it would be fair to say that his argument for the foot from meter did not survive.

5.3 Reduplication

An additional class of arguments for feet come from *prosodic morphology* (**McCarthy and Prince 1986, 1993**). The key claim here is that the size and location of reduplication, infixation, and related morphological operations refer directly to prosodic units, including the metrical foot. In the remainder of this section, we review four arguments of this sort for the foot: reduplication, locus of infixation, minimal word constraints, and language games.

Yidinʸ (**Dixon 1977a, 1977b**; **Hayes 1982**; **Marantz 1982**) offers an example where a foot is reduplicated to mark the plural.[12]

(75)

Singular	Plural	
mulari	mulamulari	'initiated man'
gindalba	gindalgindalba	'kind of lizard'

The first two syllables of the word are reduplicated; there is extensive evidence that stress is assigned with binary feet in Yidin^y and that the first two syllables of words like these would be footed together.[13]

5.4 Locus of infixation

The position of infixation can also be sensitive to feet. One of the most celebrated examples of this is *expletive infixation* in English (**McCarthy 1982**; **Hammond 1997, 1999**).

Feet in English are clearly binary and left headed. There are a number of complications involving quantity-sensitivity and various sorts of ternary patterns, but the basic left-headed binary nature of stress feet is clear (**Liberman and Prince 1977**; **Hayes 1981**; **Halle and Vergnaud 1987**).[14]

The English expletive *fuckin'* can be inserted in the middle of a word, e.g. in *fantastic*, producing *fan-fuckin'-tastic*, to indicate emphasis. This is relevant in the present context because the expletive must occur between two feet and cannot interrupt a foot. Thus **fantas-fuckin'-tic* is illegal.

It then follows that if a word has only one stress – and therefore only one foot – it cannot undergo expletive infixation. In the following examples, stresses are marked in the usual way and foot boundaries with square brackets.

(76)

Word	Legal	Illegal
a[n'nounce]	–	a-fuckin'-nnounce
a['genda]	–	a-fuckin'-genda
		agen-fuckin'-da
A['meri]ca	–	A-fuckin'-merica
		Ame-fuckin'-rica
		Ameri-fuckin'-ca

With a two-syllable word with two stresses, expletive infixation is possible between the syllables:

(77)

Word	Legal	Illegal
[ˌmun]['dane]	mun-fuckin'-dane	–

With three-syllable words with two stresses, the position of the infix is precisely between the feet.

(78)

Word	Legal	Illegal
[ˌfan]['tastic]	fan-fuckin'-tastic	fantas-fuckin'-tic
[ˌTenne][s'see]	Tenne-fuckin'-ssee	Te-fuckin'-nnessee
a[ˌlong]['side]	along-fuckin'-side	a-fuckin'-longside

There are no monomorphemic examples of the third sort – like *alongside* – so these are confounded with morphological effects.

Longer examples behave as expected. Interestingly, if there are more than two feet, many speakers find multiple infixation sites acceptable.

(79)	*Word*	*Legal*	*Illegal*
	[ˌMinne]['sota]	Minne-fuckin'-sota	Mi-fuckin'-nnesota Minneso-fuckin'-ta
	[ˌTim][ˌbuk]['tu]	Tim-fuckin'-buktu Timbuk-fuckin'-tu	–
	[ˌHali][ˌcar]['nassus]	Hali-fuckin'-carnassus Halicar-fuckin'-nassus	Ha-fuckin'-licarnassus Halicarna-fuckin'-ssus
	[ˌApa][ˌlachi]['cola]	Apa-fuckin'-lachicola Apalachi-fuckin'-cola	A-fuckin'-palachicola Apala-fuckin'-chicola Apalachico-fuckin'-la

Strikingly, there are multiple infixation possibilities just in case we find two medial stressless syllables in a row. This follows directly from the claim that feet in English are binary.

(80)	*Word*	*Legal*	*Illegal*
	[ˌWinne]pe['saukee]	Winne-fuckin'-pesaukee Winnepe-fuckin'-saukee	Wi-fuckin'-nnepesaukee Winnepesau-fuckin'-kee
	[ˌKala]ma['zoo]	Kala-fuckin'-mazoo Kalama-fuckin'-zoo	Ka-fuckin'-lamazoo

The second stressless syllable is affiliated with neither of the adjacent feet allowing the infix to be positioned to either side of it, still satisfying the requirement that there be feet to each side and that the primary stress follows.

There are additional complications to the system (**Hammond 1997, 1999**). First, the main stress cannot precede the infix. Thus ˌ*Kalama-fuckin*'-'*zoo* is decidedly better than '*catama-fuckin'-ˌran*. In addition, if the syllable preceding the infix is stressed, it must be at least bimoraic. Hence, *mun-fuckin'-dane* [ˌmʌnˌfʌkən'den] is better than *ra-fuckin'-ccoon* [ˌræˌfʌkən 'kun].

Those complications notwithstanding, the locus of infixation provides additional evidence for foot constituency.

5.5 Minimum word size

Lardil (**Wilkinson 1988**) provides a nice example of a minimum word constraint based on the foot: words in Lardil must have at least two vowels. If they do not, then they are augmented to meet this target with an epenthetic [a]. This provides for alternations in the shape of the stem depending on whether it is suffixed or not; an unsuffixed sub-minimal stem is augmented. Verbs with at least two syllables are inflected as follows:

(81)	'tree'	'dugong'	'beach'	'inside'
underlying	/t̪uŋal/	/kentapal/	/kela/	/wit̪e/
uninflected	t̪uŋal	kentapal	kela	wit̪e
non-future	t̪uŋalin	kentapalin	kelan	wit̪en
future	t̪uŋaluɽ	kentapaluɽ	kelaɽ	wit̪eɽ

Monosyllabic consonant-final roots with long vowels behave in similar fashion.

(82)	'ti-tree sp.'	'spear gen.'
underlying	/peeɾ/	/maaɳ/
uninflected	peeɾ	maaɳ
non-future	peeɾin	maaɳin
future	peeɾuɽ	maaɳkuɽ

However, nouns with only a single vowel get augmented when uninflected.

(83)		‘thigh’	‘shade’
	underlying	/teɾ/	/wik/
	uninflected	teɾa	wika
	non-future	teɾin	wikin
	future	teɾuɽ	wikuɽ

The two-vowel target can be seen as foot based if we treat Lardil as **Hayes (1980)** treated Southern Paiute: each vowel element is a potential terminal element for footing. Alternatively, if we view vowels as the sole bearers of moras in Lardil, we can view this as a bimoraic target, which was later proposed to be a foot.[15]

5.6 Language games

Hammond (1990) discusses a language game in English that provides further evidence for the foot. The game is played by substituting names into the following rhyme.

(84)		
	Jack, Jack bo back	— , — , bo b —
	[ʤæk ʤæk bo bæk]	
	banana fana fo fack	banana fana fo f —
	[bənænə fæ nə fo fæk]	
	me my mo mack	me my mo m —
	[mi maj mo mæk]	
	Ja–ack	—
	[ʤæ–æk]	

The onset of the name undergoes various substitutions not relevant here. The relevant point here is that the name must fit a particular prosodic template: from one to three syllables, where the first syllable is stressed and any subsequent syllables are stressless.

This corresponds to a single left-headed binary foot plus an optional extrametrical syllable. Marking feet with square brackets and the extrametrical syllable with angled brackets, we get a clear difference between names that are acceptable and those that are not.

(85)	*Permissible*	*Impermissible*
	['Jack]	A[n'nette]
	['To]<ny>	[ˌIsa]['do]<ra>
	['Jenni]<fer>	['Mira][ˌbeil]
	['Gwendo]<lyn>	O['livi]<a>

The game thus provides corroborating evidence for the role of foot constituency in phonology.

6 The typology of feet

Hayes (1987) proposes a radically different foot inventory. Rather than a symmetric parametric system, Hayes develops a non-parametric asymmetric system with only three basic feet: the syllabic trochee, the moraic trochee, and the iamb. This development and the subsequent responses is sufficiently important that it is treated in a chapter of its own: CHAPTER 44: THE IAMBIC—TROCHAIC LAW.

7 Some subsequent proposals

Kager (1993) offers a reformulation of the asymmetric typology that maintains a symmetric foot system, and derives surface quantitative asymmetries from syllable structure. Consider, for example, the asymmetry between an iambic foot and a moraic trochee. The iambic foot can contain a bimoraic right element, but the moraic trochee cannot. Kager argues that this follows from two independently required observations. First, when a heavy/bimoraic syllable bears stress, it is the first mora that does so. Second, languages avoid *lapses*, two stressless elements in a row. We can see then that lengthening the right node of an iambic foot is well formed, but lengthening the left node of a trochaic foot is not, since the latter results in two stressless elements – moras – in a row. (Syllable boundaries are marked with square brackets here.)

(86) *Iamb* | *Trochee*

Iamb	*Trochee*
(. x) → (. x .)	(x .) → (x . .)
[μ][μ] → [μ][μμ]	[μ][μ] → [μμ][μ]

An interesting advantage of invoking lapse like this is that the same principle can be used to rule out ternary feet. If we assume that the head of a foot must be peripheral, then either sort of ternary foot would result in a lapse.

(87)

Left-headed	*Right-headed*
(x . .)	(. . x)
σ σ σ	σ σ σ

Gordon (2002) offers an OT analysis of quantity-insensitive stress. This includes systems with a single peripheral stress and systems with binary and ternary patterns of iteration. The paper is important for several reasons. First, it brought quantity-insensitive systems back into the theoretical discourse that had focused on quantitative asymmetries for several years. Second, it offered a rigorous application of standard OT constraints to a broad cross-section of languages.

The logic of the approach is as follows. First, there are several Align constraints that put stresses on the edges of words. In addition, there is the Non-finality constraint, the OT analog of extrametricality.

Iterative footing is accomplished with various versions of Clash and Lapse constraints. Let us look at Cayuvava (**Key 1961, 1967**) to see how the system works.

(88)

'eɲe	'tail'
'ʃakahe	'stomach'
ki'hibere	'I ran'
ari'uuʧa	'he came already'
ˌʤihira'riama	'I must do'
maˌrahaha'eiki	'their blankets'
ikitˌapare'repeha	'the water is clean'
ˌʧaadiˌroboβu'ruruʧe	'99' (1st digit)
meˌdaruʧeˌʧeiro'hiiɲe	'15 each' (2nd digit)
ʧaaˌdairoˌboiro'hiiɲe	'99' (2nd digit)

Here are the key constraints Gordon assumes for this case, along with critical rankings:

(89) *ExtendedLapse, *Clash, Non-finality, Align(X_2,R) >>
Align(X_1,L) >>
Align(X_1,R) >>
. . .

The *ExtendedLapse constraint rules out stresses more than two syllables apart; this does the work of ternary iteration. The *Clash constraint prevents stresses from being adjacent. Non-finality is final extrametricality. Align(X_2,R) forces main stress on the right. Finally, the relative ranking of Align(X_1,L) and Align(X_1,R) forces iteration from the right.

Let us now see how this works in the case of [ma, rahaha'eiki].

(90)

/marahahaeiki/	*EL	*Cl	NF	Al(X_1,L)	Al(X_1,L)	Al(X_1,R)
☞ a. maˌrahaha'eiki					5	7
b. ˌmarahaha'eiki	*!				4	8
c. ma'rahahaˌeiki				*!	5	7
d. marahaha'eiki	*!*				4	2
e. ˌmaraha'haeiki	*!				3	9

Stresses are positioned at the right distance apart because of the interaction of *ExtendedLapse and *Clash. The former also forces stress to iterate in the first place.

In the context of foot theory, the key observation is that the system does not require feet to describe QI stress patterns. As with Prince (1983), however, such an account leaves open how apparent patterns of foot-related prosodic morphology are accommodated.

Finally, another interesting proposal is developed by Hyde (2002). The core of the proposal is that there is a metrical grid that is independent of footing. Feet are all binary and have heads, but foot heads need not bear stress. A further point of interest is that feet may overlap. These innovations allow Hyde to maintain exhaustive footing and develop a spare model of directional stress effects.

8 Summary

There are a number of other important and interesting proposals regarding foot theory, but we have only been able to touch on some very salient ones here.

What does the future hold? There are a number of threads that seem like promising avenues of development for feet.

First, Optimality Theory has a huge effect on all of phonological theory, but the framework seems to be reaching its limits. There are several alternative versions of the framework that have developed – for example, Stochastic OT (Boersma 1997) and Harmonic OT (Smolensky and Legendre 2006) – but it is unclear where the general framework is going at this time.

What OT has left us with is a clear refocusing of attention from structural elements of phonological representations to constraints on those representations. On such a view, feet per se no longer exist. Moreover, there is no one-to-one mapping of constraints and the foot inventory (necessarily).

If this thread continues, we would reasonably expect less attention to large-scale foot effects and more attention on the constraints from which those effects derive. For example, we might expect more attention to constraints like *Clash or the Weight-to-Stress Principle.

Given the shift in attention from strictly ranked constraints to other ranking algorithms, including probabilistic ranking, we would expect developments along the lines of probabilistic feet. Perhaps some metrical phenomena are best treated in terms of footing which is only probabilistic in nature. A word might not have a fixed structure, but a structure that is only partially fixed, e.g. locus of footing or headedness, might be indeterminate. One might use this to account for variation in stress or exceptions of various sorts, i.e. ternarity.

Another direction of current research is increased attention to the extra-grammatical features that impinge on the grammar, e.g. phonetics, perception, production, lexical access, and acquisition. It seems quite likely that both our understanding of the basic facts of footing and the theoretical frameworks we use to describe footing phenomena will change as these efforts expand our empirical focus. The role of quantity has already been discussed from this perspective, for example, by Hayes (1987) and Kager (1993). These are extremely sketchy predictions, however.

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Notes

1 Some of the issues in this section are developed further in CHAPTER 51: THE PHONOLOGICAL WORD, CHAPTER 116: SENTENTIAL PROMINENCE IN ENGLISH and CHAPTER 41: THE REPRESENTATION OF WORD STRESS.

2 Ultimately, Kiparsky (1979) argued that cyclicity is still necessary in a metrical theory of stress. The debate resurfaced again a few years later. See Hammond (1989), Halle and Kenstowicz (1991), and Cole and Coleman (1992) for more discussion.

3 Hayes (1980) uses underlining, rather than circles.

4 Complications involve three-syllable words ending in a consonant: these have a final secondary stress, e.g. [θu'ŋuˌlan] 'I do not speak'. There are also contextual effects on short words.

5 The data cited by Hayes do not establish unequivocally that codas do not contribute to weight.

6 See Walker (1997) for a different description and analysis.

7 The parallel between these systems was first discussed by Kiparsky (1973). An alternative formalization of OB footing was proposed by Hammond (1986).

8 However, see Hayes (1984) for a treatment of rhythm in English not making use of clash.

9 This notation came to be referred to as "lollipops."

10 **Idsardi (1992)** pursues a representation with similar properties. Since Idsardi's representation allows unpaired parentheses, it entails a somewhat different notion of constituency.

11 See **Fabb and Halle (2008)** for a recent comprehensive theory.

12 For more general discussion of reduplication, see **CHAPTER 100**: REDUPLICATION.

13 The stress system of Yidin[y] is complex; see **Hayes (1982)** for further discussion.

14 Though see **Burzio (1994)** for another view.

15 **Garrett (1999)** argues, though, that word minimality is not connected to foot structure.

REFERENCES

Boersma, Paul. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* (21) . 43–58 (ROA-221).

Boxwell, Helen & Maurice Boxwell. 1966. Weri phonemes. In S. A. Wurm (ed.) *Papers in New Guinea linguistics No. 5*, 77–93. (Pacific Linguistics A37.) Canberra: Australian National University.

Burzio, Luigi. 1994. *Principles of English stress*. Cambridge: Cambridge University Press.

Chomsky, Noam, & Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.

Cole, Jennifer & John Coleman. 1992. No need for cyclicity in generative phonology. *Papers from the Annual Regional Meeting, Chicago Linguistic Society* (28) . 36–50.

Dixon, R. M. W. 1977a. *A grammar of idi*. Cambridge: Cambridge University Press.

Dixon, R. M. W. 1977b. Some phonological rules in idi. *Linguistic Inquiry* (8) . 1–34.

Echeverría, Max S. & Heles Contreras. 1965. Araucanian phonemics. *International Journal of American Linguistics* (31) . 132–135.

Fabb, Nigel & Morris Halle. 2008. *Meter in poetry: A new theory*. Cambridge: Cambridge University Press.

Garrett, Edward, 1999. Minimal words aren't minimal feet. *UCLA Working Papers in Linguistics 1, Papers in Phonology* (2) . 68–105 (ROA-1031).

Gordon, Matthew. 2002. A factorial typology of quantity-insensitive stress. *Natural Language and Linguistic Theory* (20) . 491–552.

Halle, Morris & Michael Kenstowicz. 1991. The Free Element Condition and cyclic versus noncyclic stress. *Linguistic Inquiry* (22) . 457–501.

Halle, Morris & Jean-Roger Vergnaud. 1978. *Metrical structures in phonology*. Unpublished ms., MIT.

Halle, Morris & Jean-Roger Vergnaud. 1987. *An essay on stress*. Cambridge, MA: MIT Press.

Hammond, Michael. 1982. Foot-domain rules and metrical locality. *Proceedings of the West Coast Conference on Formal Linguistics* (1) . 207–218.

Hammond, Michael. 1986. The obligatory-branching parameter in metrical theory. *Natural Language and Linguistic Theory* (4) . 185–228.

Hammond, Michael. 1988. *Constraining metrical theory: A modular theory of rhythm and destressing*. New York: Garland.

Hammond, Michael. 1989. Cyclic secondary stresses in English. *Proceedings of the West Coast Conference on Formal Linguistics* (8) . 139–153.

Hammond, Michael. 1990. The Name Game and onset simplification. *Phonology* (7) . 159–162.

Hammond, Michael. 1997. Vowel quantity and syllabification in English. *Language* (73) . 1–17.

Hammond, Michael. 1999. *The phonology of English: A prosodic optimality-theoretic approach*. Oxford: Oxford University Press.

Hayes, Bruce. 1980. *A metrical theory of stress rules*. Ph.D. dissertation, MIT. Published 1985, New York: Garland.

Hayes, Bruce. 1982. Metrical structure as the organizing principle of idi phonology. In Harry van der Hulst & Norval Smith (eds.) *The structure of phonological representations, part 1*, 97–110. Dordrecht: Foris.

Hayes, Bruce. 1983. A grid-based theory of English meter. *Linguistic Inquiry* (14) . 357–394.

Hayes, Bruce. 1984. The phonology of rhythm in English. *Linguistic Inquiry* (15) . 33–74.

Hayes, Bruce. 1987. A revised parametric metrical theory. *Papers from the Annual Meeting of the North East Linguistic Society* (17) . 274–289.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago: University of Chicago Press.

Hyde, Brett. 2002. A restrictive theory of metrical stress. *Phonology* (19) . 313–359.

Hyman, Larry M. 1977. On the nature of linguistic stress. In Larry M. Hyman (ed.) *Studies in stress and accent*, 37–82. Los Angeles: Department of Linguistics, University of Southern California.

Idsardi, William J. 1992. *The computation of prosody*. Ph.D. dissertation, MIT.

Kager, René. 1993. Alternatives to the iambic-trochaic law. *Natural Language and Linguistic Theory* (11) . 381–432.

Kahn, Daniel. 1980. *Syllable-based generalizations in English phonology*. New York: Garland.

Kessler, Brett & Rebecca Treiman. 1997. Syllable structure and the distribution of phonemes in English syllables. *Journal of Memory and Language* (37) . 295–311.

Key, Harold H. 1961. Phonotactics of Cayuvava. *International Journal of American Linguistics* (27) . 143–150.

Key, Harold H. 1967. *Morphology of Cayuvava*. The Hague: Mouton.

Kiparsky, Paul. 1973. “Elsewhere” in phonology. In Stephen R. Anderson & Paul Kiparsky (eds.) *A Festschrift for Morris Halle*, 93–106. New York: Holt, Rinehart &.

Kiparsky, Paul. 1977. The rhythmic structure of English verse. *Linguistic Inquiry* (8) . 189–247.

Kiparsky, Paul. 1979. Metrical structure assignment is cyclic. *Linguistic Inquiry* (10) . 421–441.

Liberman, Mark & Alan Prince. 1977. On stress and linguistic rhythm. *Linguistic Inquiry* (8) . 249–336.

Marantz, Alec. 1982. Re reduplication. *Linguistic Inquiry* (13) . 435–482.

McCarthy, John J. 1979. *Formal problems in Semitic phonology and morphology*. Ph.D. dissertation, MIT.

McCarthy, John J. 1982. Prosodic structure and expletive infixation. *Language* (58) . 574–590.

McCarthy, John J. & Alan Prince. 1986. *Prosodic morphology*. Unpublished ms., University of Massachusetts, Amherst & Brandeis University.

McCarthy, John J. & Alan Prince. 1993. *Prosodic morphology I: Constraint interaction and satisfaction*. Unpublished ms., University of Massachusetts, Amherst & Rutgers University.

Osborn, Henry A. 1966. Warao I: Phonology and morphophonemics. *International Journal of American Linguistics* (32) . 108–123.

Prince, Alan. 1983. Relating to the grid. *Linguistic Inquiry* (14) . 19–100.

Rischel, Jørgen. 1972. Compound stress in Danish without a cycle. *Annual Report of the Institute of Phonetics* (6) . 211–228.

Sapir, Edward. 1930. Southern Paiute, a Shoshonean language. *Proceedings of the American Academy of Arts and Sciences* (65) . 1–296.

Sebeok, Thomas A. & Frances J. Ingemann. 1961. *An Eastern Cheremis manual: Phonology, grammar, texts and glossary*. Bloomington: Indiana University.

Smolensky, Paul & Géraldine Legendre (eds.) 2006. *The harmonic mind: from neural computation to optimality-theoretic grammar*. Cambridge, MA: MIT Press.

Street, John C. 1963. *Khalkha structure*. Bloomington: Indiana University & The Hague: Mouton.

Treiman, Rebecca & Catalina Danis. 1988. Syllabification of intervocalic consonants. *Journal of Memory and Language* (27) . 87–104.

Treiman, Rebecca & Andrea Zukowski. 1990. Toward an understanding of English syllabification. *Journal of Memory and Language* (29) . 66–85.

Tryon, Darrell T. 1970. *An introduction to Maranungku (Northern Australia). (Pacific Linguistics B15.)* Canberra: Australian

National University.

Voegelin, Charles F. 1935. Tübatulabal grammar. *University of California Publications in American Archaeology and Ethnology* (34) . 55–189.

Walker, Rachel. 1997. *Mongolian stress, licensing and factorial typology*. Unpublished ms., University of California, Santa Cruz (ROA–171).

Wilkinson, Karina. 1988. Prosodic structure and Lardil phonology. *Linguistic Inquiry* (19) . 325–334.

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