1. Introduction

Stress systems which have rhythmic stress usually have binary stress; the basic pattern is that every second beat is stressed. There are some languages in which the basic pattern is to stress every third beat, so-called ternary stress systems. Ternary stress systems are important because the ability of the stress computation to generate both kinds of stress systems gives important information about the structure of that computation. The structure of the computation of stress should be such that the binary/ternary alternation should emerge naturally from the computational tools available and no other fundamental varieties of stress systems should be possible. There are several languages which vary between binary and ternary stressing, either ideologically or dialectically. This indicates that small changes in the stress grammar can shift the system from binary to ternary, or vice versa. This puts further constraints on theories of stress; they must be able to account for the binary/ternary alternation in a principled way.

* Thanks mostly to Morris Halle, my phonology mentor. Thanks also to Sam Gutmann for reading a draft and for years of discussion about the aims and methods of linguistic theory. My thanks and profound admiration for all those who conducted the skilled empirical investigations which this paper purports to explain.
I assume without discussion that the computational system is generative; surface forms are the result of the progressive modification of underlying forms. The approach taken will be to start from the theory of stress developed in Idsardi (1992) and Halle and Idsardi (1995) (henceforth H&I) and show that ternary stress systems suggest a particular reworking of that theory. The result will be a theory which not only gives an adequate account of ternary stress systems, but the imposition of locality principles give a more tightly constrained theory of binary stress systems. On the basis of locality, the theory predicts that stress systems must be binary or ternary. A second point of departure is Hayes (1995) (henceforth H95), which thoroughly studies the details of many languages of great interest. Although my theoretical point of departure is H&I, I rely heavily on Hayes’ work, both for the language studies and for the idea of weak local parsing.

Hammond (1990a,b) and Hayes (1995) proposed that ternary stress alternation is a consequence of the foot structure

\[ \ldots(\times \times)(\times \times)\ldots \]

in which an unfooted element intervenes between binary feet. Hayes analyzes footing as directional parsing into feet using a foot template. In this framework he proposes that the parsing algorithm is parametrized; one option is to abut each foot with the previous one, the other is to skip a light syllable where possible before starting to fill the template to make the next foot. He calls the second option \textit{weak local parsing}. ‘Where possible’, of course, needs discussion. His use of this idea to account for the complex Estonian stress system is particularly compelling because it is quite straightforward whereas, as he observes, stress theories like Halle and Vergnaud (1987) which rely on ternary feet are unable to give an adequate account of Estonian stress. The theory of
Idsardi (1992) is no more successful. H&I does not discuss ternary footing. On the other hand, there are languages with binary footing for which H&I provides a straightforward account but H95 fails. Finnish is one such language.

I will use an analysis of Finnish in the H&I framework as a starting point for reworking the theory. The central innovation will be iterative footing by a rule scheme rather than a single rule. Allowing iterative rule schemes is a weakening of the theory, but in several other respects the theory is strengthened. Most significantly, it allows only a single iterative rule. In some cases, the H&I theory requires multiple iterative rules, possibly running in opposite directions. Additionally, strong locality conditions will be imposed which will make many of the H&I rules and constraints impossible to formulate.

2. Preliminaries

With H&I, I follow Lieberman and Prince (1977) and assume that the prosodic structure of a word is in part represented by a grid, as in (1).

---

1. It relies on a binary footing rule $\times \times \rightarrow \times \times$, but restricted by a derivational constraint $\rangle \times \rangle \times \rangle$, so the effect is to create a ternary foot.
Level 0 has a special role since it is the foundation on which the prosodic grid is constructed. I will call it the *beat tier*. I assume that beats are projected either from syllables (in so-called *syllable counting* languages) or from moras (in so-called *mora counting* languages), as a parametric choice. In languages with no bimoraic syllables, the distinction between moras and syllables collapses. I will reserve the term ‘mora counting’ for languages which have bimoraic syllables and project beats from moras.

The computation of level 1 from level 0 is often complex because level 0 has its roots directly in the syllabic system and the computation which singles out certain beats for projection to level 1 is often be sensitive to properties of syllables or moras. In general, the computation of higher levels is relatively simple, even in cases in which the computation of level 1 is complex. In the stress systems considered in this paper, the rightmost or leftmost level 1 stress is projected to level 2. The grid is interpreted by phonetics; the height of columns is mapped to strength of accent. In the 3 level systems considered in this paper, level 2 is primary stress and unprojected level 1 stress is secondary stress.

There is an important question of the extent to which footing operations, which operate on the beat tier, have access to other related tiers. Although the footing computation can be sensitive to properties of the syllables or moras which are associated with beats, access is limited. I will assume that is communicated by means of a limited set of attributes which beats may bear. This will be discussed in Section 4.
2.1. Delimiter insertion

Before Idsardi (1992), the process of footing the beat tier was generally viewed as iterative constituent formation. Parentheses were viewed only as a convenient notation for constituency. Feet were viewed as phonological objects on their own tier, with associations to the beat tier. This point of view is illustrated well by (2), which reproduces the well-known diagram on the cover of Halle and Vergnaud’s *An Essay on Stress* (1987).

(2) (∗∗∗∗)

Derivations like (3a) were viewed as convenient shorthand for something like (3b). The objects were the feet, denoted by f.

(3)  

a. \( \times \times \times \times \times \)  
1. \((\times \times)\times \times \times \times \)  
2. \((\times \times)(\times \times)\times \times \times \times \)  
3. \((\times \times)(\times \times)(\times \times)\times \times \times \times \times \)

b. \( \times \times \times \times \times \)  
1. \(f\)  
2. \(f\)  
3. \(f\)

Idsardi proposed a subtler and more indirect relation between delimiters inserted into the beat tier and constituent structure. Observe that the constituent structure in derived in (3a) can be deduced from (4), using the obvious conventions that 1) a foot which is closed at the right by a right parenthesis extends maximally to the left and 2) that feet do not overlap.
He also proposed that footing is not iterative constituent formation, but iterative (one-sided) delimiter insertion. The groupings which delimiter insertion (implicitly) creates are called feet. Delimiters are not diacritics to indicate the presence of foot objects. Rather, feet are created by delimiters. I adopt this idea. In order to make clear the distinction between actual delimiters and the diacritics which are used to mark the boundaries of constituents, ‘⟨’ and ‘⟩’ will be used as the one-sided delimiters rather than parentheses. The use of parentheses will be restricted to their traditional use as paired constituent/group identifiers. The representations \( \langle \times \times \rangle \times \times \rangle \) and \( \langle \times \times \rangle \times \times \rangle \), for example, both yield the groups \( (\times \times)(\times \times) \). Further, \( \langle \) is taken to delimit the group of beats that follow it and is meaningless if not followed by a beat. Similarly, \( \rangle \) is meaningless if it is not preceded by a beat. It follows, for example, that the second delimiter in an expression like \( \ldots \times \rangle \rangle \times \ldots \) is meaningless and that no operation can construct such a representation.

Some definitions will be useful. Since delimiters are real items on the beat tier, beats which are separated by a delimiter are not adjacent.

(5) Adjacent properties of beats

a. A beat is locally delimited if it is in the context \( \langle \_ \_ \rangle \) or \( \_ \_ \rangle \).
b. A beat is delimited if it is locally delimited or adjacent to a delimited beat.
c. A delimited beat is trochaically stressable if it does not have a beat on its left; iambically stressable if it does not have a beat on its right.

In trochaically stressed languages, level 1 of the grid is formed by projecting the trochaically stressable beats and in iambic languages by projecting the iambically stressable beats. The groupings created by delimiter insertion are called feet. The precise definition is given in (6).
(6) a. Beats $x$ and $y$ are *connected* if $x$ is adjacent to $y$ or adjacent to some beat which is connected to $y$. This is a reflexive relation.

b. A maximal connected set of delimited beats is called a *foot*.

Feet will play a minor role in what follows, although use of the word is pervasive since it has played such a big role in the development of stress theory. The theory here does not have need for notions like hierarchical foot structure or ‘head of a foot’, ideas which were adopted in much early work in imitation of developments in syntax. But reference is made to the groups of beats which delimiter insertion creates.

For example, the well-known condition (7a) on feet plays a role in many stress systems. Although it is usually viewed as a condition on feet, it is equivalent to (7b), which is a local condition on beats; local in the sense that it depends only on the adjacent items on the beat tier.

(7) a. (*Unary) Feet have more than one element.

b. Locally delimited beats are adjacent to another beat.

Although this condition is always employed in this paper as a local condition on beats, the language of feet is maintained and the condition will be called *Unary.

2.2. Heavy syllable effects

In many syllable counting languages with a syllabic weight distinction, heavy syllables have inherent phonetic stress. There are often features of the stress system in such a language which favor the alignment of metrical stress with inherent stress, so that syllables with inherent stress are assigned metrical stress. This produces what are called *heavy syllable effects*. In Finnish, for example, stress on most words is on the first syllable and binary intervals between stressed syllables follow, except that the final syllable is never stressed. There is deviation from this only in the case $\ldots \tilde{\sigma} \sigma \tilde{\sigma} \ldots$, in which case there is a ternary interval between stressed beats. Stress
falls on a heavy syllable instead of a light syllable. I use \( \sim \) to denote a light syllable and \( \bar{\sim} \) to denote a heavy syllable. Whatever feature of the stress system causes this behavior can be viewed as a feature of the stress system favoring stress on heavy syllables. We will return to the Finnish system shortly.

The central issue in analyzing syllable counting languages with heavy syllable effects is an understanding of those aspects of the metrical computation which favor alignment of metrical stress with inherent phonetic stress, as well as the limitations on these effects. In Finnish, \( \sim \bar{\sim} \bar{\sim} \bar{\sim} \bar{\sim} \) has the stress pattern \( \sim \bar{\sim} \bar{\sim} \bar{\sim} \bar{\sim} \), so it is clear that although heavy syllable stress may be favored, there can be limitations on which heavy syllables can be stressed.

Heavy syllable effects in mora counting languages often have a different source; *Syllable Integrity*. In mora counting languages with bimoraic syllables, the system for computing word prosody generally (but not always) has features which prevent the two beats corresponding to a bimoraic syllable from being split up into different metrical groupings.

2.3. Edge marking and heavy syllable marking

Although there is no published H&I analysis Finnish, it provides an excellent illustration of the main features of their theory and as well as reveals a problem with Hayes’ analysis of weak local parsing. Later, an analysis of Estonian will illustrate some key features of Hayes’ theory and reveal some problems with the H&I theory. Finnish provides a good starting point for developing the theory proposed in this paper. The Finnish data is from Karttunen (2006), taken from Elenbaas (1999) and Kiparsky (2003). (C)VX(C) syllables are heavy, others are light.
The distribution of stress in the examples (8) is described by (9).

(8) a. ká.las.tè.let
b. ká.loas.te.lèm.me
c. strúk.tu.ra.lí.sí.mi
d. vòi.mis.te.lit.te.lè.màs.ta
e. ðú.he.li.mèl.la.ní
f. jáð.jes.tèl.màl.li.síy:del.là.ní
g. ó.pas.kè.li.ja
h. ér.go.nò.mi.a
i. fú.moí.tàu.tú.mi.nèn
j. ká.las.tè.le.mi.nèn
k. ón.ní.tè.le.mà.ní.kí

(9) a. \( \sigma_1 \) is stressed.
b. If \( \sigma_n \) is stressed, then
   1. \( \sigma_{n+2} \) is stressed if it is heavy and nonfinal; otherwise
   2. \( \sigma_{n+3} \) is stressed if it is heavy and nonfinal; otherwise
   3. \( \sigma_{n+2} \) is stressed if it is nonfinal.

Following H&I, the ordered list of delimiter insertion rules (10) coupled with projecting line 1 from trochaicly stressable beats yields the stress pattern above. \( \bar{\times} \) denotes a beat associated with a heavy syllable, \( \times \) one associated with a light syllable, and \( \times \) one which can be associated with either kind of syllable. Syllables with a long vowel, diphthong, or coda consonant are heavy; others are light. Stress is trochaic.

(10) Finnish stress rules:
1. Edge marking rule (EDG): Insert \( \langle \) in the context \# __
2. Heavy syllable rule (HVY): \( \bar{\times} \rightarrow \langle \bar{\times} \) LR iterative
3. Binary rule (BIN): \( \times \times \rightarrow \times \times \) LR iterative

Derivational constraints: *\( \langle \times \), *\( \times \#

The rules 1–3 are applied in order.
Here are some illustrative derivations of the examples (9). It risks confusion, but sometimes I let − and ~ denote beats and sometimes syllables. The context will make it clear. If delimiter insertion operations are involved, they denote beats (as below). SP denotes stress assignment (projection).

(11) a. struk.tu.ra.lis.me
   − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − 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− − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − − -
The Halle-Idsardi theory has only one way to account for heavy syllable effects, heavy syllable marking of some kind prior to iterative binary or ternary footing. In the case of Finnish, this gives a straightforward account. If it could be maintained empirically, this would be an elegant way to account for heavy syllable stress. But we will see later, in the case of Estonian in particular, that this approach is not adequate.

Hayes’ theory has two mechanisms for accounting for heavy syllable effects in trochaic languages. One is the specification of the template, the possible foot forms, and the other is to let the heavy/light weight distinction affect the parsing algorithm itself (the strong/weak local parsing distinction). Neither of these mechanisms accounts for Finnish. All varieties of ($\sigma\sigma$) feet must be allowed, ($\sim\sim$) feet in particular, see (11c) for example, and it is not the case that light syllables are skipped if possible; *ér.go.nò.mi.a* is footed as ($\sim\sim$)($\sim\sim$)$\sim$, not ($\sim\sim$)$\sim$($\sim\sim$).

In order to account for Finnish, the Hayes’ parsing algorithm would have to be granted more power than a simple weak/strong parametric choice. Something like the following is needed for Finnish: skip a light syllable if a ($\sim\sigma$) foot can be formed instead of a ($\sigma\sigma$) foot. This will work mechanically for Finnish, but would demand a principled theory of possible parsing conditions to provide an explanatory account.

3. Iterative rule schemes

Although the H&I analysis of Finnish is simple and adequate, it will be shown later that the approach is not sufficient to deal with heavy syllable effects in the full range of quantity sensitive syllable counting languages, particularly if ternary stress is involved. In this section, the H&I theory will be revised so that iterative footing is carried out by a rule scheme. For Finnish, the revision will not have a decisive advantage over the analysis it replaces. But we will go on to show
that revising the theory in this way will allow straightforward metrical analyses of other languages for which the H&I theory is insufficient.

The first step is to rewrite the rule BIN in (10) so that it applies to a single beat, not to a pair of beats.

(13) (BIN) \( \times \to \times \langle \) / \( \times \langle \)

There are two reasons for rewriting the LR footing rule in this way. First, it allows BIN and HVY, the rule \( \bar{x} \to \langle \bar{x} \rangle \), to compete for application at a particular beat. Second, it brings delimiter insertion within the general framework of normal phonological rules. A rule like \( \times \times \to \times \times \) is a peculiar kind of rule because the left hand side of that rule has no ontological status in phonological theory; it is not a “phonological thing”.

We first reformulate (10) as (14).

(14) 

<table>
<thead>
<tr>
<th>rule</th>
<th>name</th>
<th>mode of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( \times \to \langle \times ) / ( # ) _</td>
<td>EDG</td>
<td>non-iterative (edge marking)</td>
</tr>
<tr>
<td>2. ( \bar{x} \to \langle \bar{x} )</td>
<td>HVY</td>
<td>LR iterative</td>
</tr>
<tr>
<td>3. ( \times \to \times \rangle ) / ( \times \rangle ) _</td>
<td>BIN</td>
<td>LR iterative</td>
</tr>
</tbody>
</table>

Derivational constraint: *Unary

The H&I theory would impose the set of constraints \( K = \{ *\langle \times \rangle, *\langle \times \# \} \). Here *Unary is imposed as a derivational constraint rather than the set of constraints K. *Unary blocks the creation of any foot with a single beat. K blocks the creation of unary feet of a certain kind, but in this system they are the only kinds of unary feet that could potentially be created. It could be argued that K is more minimal than *Unary and sufficient, so that it is the appropriate derivational constraint. On the other hand, *Unary occurs over and over again in stress systems, so it should be regarded as one of the prominent tools in the ‘universal toolbox’ used for building stress systems and therefore
relatively cheap from the standpoint of learning. I take easy access in the universal toolbox to outweigh minimal description.

Rather than iterate HVY and then iterate BIN, they can be combined in a rule scheme and two applications of iterative rules can be replaced with a single application of an iterative rule. (15) produces the same footing as (14).

(15) Marking Rule: EDG
LR Iterative Rule: \[
\begin{bmatrix}
  \text{HVY} \\
  \text{BIN}
\end{bmatrix} ; *\text{Unary}
\]

The scheme applies at each beat, in turn, from left to right.

Directional iterative rules, like all rules which apply to their own output, must remember where they have already applied. How is this done? I assume that at each step in the derivation, only the current state is accessible, not the derivational history. The information needed to “remember” where the iterative rule has already applied must be coded in the current state in some fashion. I will assume that when a beat is targeted by a delimiter insertion rule, it acquires an attribute indicating that it has been targeted. This will be notated in representations by an asterisk under the beats which have already been acted on by a marking rule, or targeted by the iterative rule scheme, whether or not the scheme could apply to that beat.

(16) ODP (Once and Done Principle): Delimiter insertion rules target each beat exactly once.

Say that a beat is a free beat if it has not already been targeted. Say that a free beat is a current target if it does not have a free beat on its left, in an LR system, or on its right in an RL system. After the marking rule applies, the scheme applies to the current targets and iterates until there are no free beats remaining. If there are multiple current targets, there is no reason for the iterative
scheme to apply to them in any particular order, so it will be assumed that it applies to all of them simultaneously.

Some illustrative derivations are in (17). The rule which applies at each step is indicated at the left. If the current target is heavy, HVY applies unless the context is \( \times \_ \) or \( \_ \# \). In these contexts, \*Unary blocks HVY, so BIN will apply if its structural description is satisfied. Since the structural description is \( \times \_ \), there is no possibility that it will be blocked by \*Unary. I leave it to the reader to use this to verify the derivations below.

\[
\begin{array}{lll}
\text{(17) a.} & \text{struk.tr.a.} \quad \text{b.} & \text{er.go.n.} \\
\text{struk.tr.a.} & \text{struk.tr.a.} & \text{struk.tr.a.} \\
\text{er.go.n.} & \text{er.go.n.} & \text{er.go.n.} \\
\text{ka.las.te.mi.nen} & \text{ka.las.te.mi.nen} & \text{ka.las.te.mi.nen} \\
\end{array}
\]

Note that in spite of the availability of HVY, which favors placing heavy syllables in stress positions (foot initial in this case since stress is trochaic), neither of the heavy syllables in (17c) ends up stressed.

Two further derivations are instructive.
(18) a. \textit{il.moit.tau.tu.mi.nen}

\begin{center}
\begin{tabular}{c}
EDG \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
BIN \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
HVY \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
BIN \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
SP \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle
\end{tabular}
\end{center}

(18b) \textit{on.nit.te.le.ma.ni.kin}

\begin{center}
\begin{tabular}{c}
EDG \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
BIN \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
BIN \langle \frac{\varepsilon}{\varepsilon} \rangle \\
BIN \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \\
SP \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle \langle \frac{\varepsilon}{\varepsilon} \rangle
\end{tabular}
\end{center}

(18a) is interesting because of the appearance of $\rangle$ and (18b) because there is a heavy syllable which is not only unstressed, but unfooted. In spite of the 3 heavy syllables in (18b), none is targeted by HVY. It does not apply to the initial beat because EDG applies at the edge before the iterative rule applies.

So far, not much has been gained. Two cycles of LR iteration have been reduced to a single iteration. On the other hand, applying a rule scheme is more complicated than applying a single rule. The payoff to analyzing iterative delimiter insertion as the iterative application of a rule scheme will come later.

Much of the architecture of the footing system I propose in this paper has already emerged. It has several components. For want of a better name, it will be called the \textit{Schema Theory} (of footing).

(19) Schema theory

a. A process for constructing a beat tier and the association between beats and syllables or moras.
b. A LR/RL choice and an iambic/trochaic choice.
c. An ordered list of marking rules, each of which applies ATB.
d. A single directional iterative rule scheme, with the Once and Done Principle controlling how the iteration is carried out.
e. Derivational constraints, either on all rules or on particular rules.

ATB application (Across-the-Board) is just simultaneous application at all the positions at which it can apply.

Several amendments will be made as we proceed by more tightly constraining the possible rules and constraints.

4. Locality

It is tempting to immediately embark on examining the menagerie of stress systems, but that might give the false impression that the toolbox of possible rules and constraints is endless. In fact, there are natural locality constraints on delimiter insertion rules and derivational constraints that considerably restrict the range of possibilities.

There are three kinds of objects on the beat tier: edge markers, delimiters and beats. The delimiters are the left and right delimiters introduced by delimiter insertion rules. I assume that there are a limited number of attributes that beats can bear. Earlier, an attribute which indicates that a beat has been target by the delimiter insertion rules was introduced. In addition, in some syllable counting languages it will be necessary to distinguish between beats associated with heavy syllables and those associated with light syllables. In some mora counting languages it is necessary for delimiter insertion rules to distinguish between moras which are in the same syllable as the mora to the left, moras which are in the same syllable as the mora on the right, and moras associated with light syllables. In one case, Winnebago, there is class of light syllable sequences derived by splitting certain heavy syllables whose identity must be reflected in beat attributes so

2. The inclusion of ‘edge markers’ on the beat tier is only a convenience, greatly simplifying the statement of various assertions.
that the delimiter insertion rules can be sensitive to moras associated with these light syllable pairs.

End markers and delimiters do not have attributes.

The neighborhood of a beat $\times$ in a string is the substring containing the beat and the two adjacent items (i.e. its nearest neighbors).

(20) **Local condition on beats**: A predicate $K$ on beats in a string is called a *local condition* if $K(\times)$ depends only on the neighborhood of $\times$.

Here are some examples

(21) Conditions which are local

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>/ __⟩</td>
</tr>
<tr>
<td>b.</td>
<td>$\checkmark$ / # __ $\checkmark$</td>
</tr>
<tr>
<td>c.</td>
<td>‘in a unary foot’</td>
</tr>
<tr>
<td>d.</td>
<td>/⟩__⟨</td>
</tr>
<tr>
<td>e.</td>
<td>/⟩__#</td>
</tr>
<tr>
<td>f.</td>
<td>/ __⟩#</td>
</tr>
</tbody>
</table>

(22) Conditions which are not local

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>/ __⟨</td>
</tr>
<tr>
<td>b.</td>
<td>/ ××_</td>
</tr>
<tr>
<td>c.</td>
<td>‘in a foot’</td>
</tr>
<tr>
<td>d.</td>
<td>_⟩⟩</td>
</tr>
</tbody>
</table>

With respect to (22c), note that it is not even possible to local determine if the underlined beat in $⟩×⟩$ is in a foot.

I will say that a beat is affected by a delimiter insertion operation if it is adjacent to the inserted delimiter. I make the strong assumption that footing systems are highly local.

(23) **Footing locality**: Footing systems satisfy locality.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Delimiter insertion rules affect the beat they target.</td>
</tr>
<tr>
<td>b.</td>
<td>Derivational constraints on delimiter insertion rules are either local conditions on outputs which must be satisfied (after insertion) by the beats which are affected by the insertion or local conditions on inputs which must be satisfied (before insertion) by the target.</td>
</tr>
</tbody>
</table>
Derivational constraints are conditions on rule application outside those specified by the rules themselves. One local derivational constraint on inputs is always present. In an LR (RL) system the target beat must be active and cannot directly follow (precede) another active beat. *Unary is often, but not always, a local derivational constraint on outputs.

In order to make the discussion of rule locality as clear as possible, it is useful to write local rules as \( (r, p, k) \) where 1) \( r \) is a primitive delimiter insertion rule; 2) \( p \) is a local condition which the target must satisfy; and 3) \( k \) is a local condition which beats adjacent to the inserted delimiter must satisfy. A **primitive delimiter insertion rule** is a rule of the form \( \times \rightarrow \times D \) or \( \times \rightarrow D \times \), where \( D \) is one of the foot delimiters. I will call a rule written in this form a \( pk \)-rule. If a primitive delimiter insertion rule \( r \) inserts the delimiter to the left (or right) of the target it is called a left (or right) left primitive delimiter insertion rule and a \( pk \)-rule employing \( r \) is called a left (or right) \( pk \)-rule.

A context \( \alpha \beta \) (\( \alpha \) and \( \beta \) strings) is called a **deciding context** for a \( pk \)-rule \( R \) if applicability of \( R \) to \( \alpha' \alpha \times \beta \beta' \) does not depend on \( \alpha' \) and \( \beta' \). Only a small window around the target is needed to decide if a \( pk \)-rule is applicable. The **current left window** is the neighborhood of the current target augmented by the item to the left of the neighborhood in case the left edge of the neighborhood is a beat. The **current right window** is defined in an analogous way.

(24) The current left (right) window is a deciding context for a left (right) \( pk \)-rule.

Determining applicability is a question of having enough information to evaluate \( p \) and \( k \). The neighborhood of the target is always in the current window (either left or right) so \( p \) can always be evaluated if the current window is known. We need to show that \( k \) can be evaluated. First, suppose the current left window is \( u_1 \times \times u_2 \), with \( u_1 \) and \( u_2 \) beat tier items, either beats or delimiters. Then application of \( r \) would give \( u_1 \times D \times u_1 \) for some delimiter \( D \). \( k \) can be evaluated because
the neighborhood of both timing slots which flank the delimiter are known. Now suppose the neighborhood is $D' \times u_2$. Application of $r$ would give $D'D \times u_2$. The only beat which is adjacent to the inserted delimiter is the beat which was the target. Again, $k$ can be evaluated.

4.1. A rough classification of iterative rules in stress systems

Halle and Vergnaud (1987) gave an account of why rhythmic stress is either binary or ternary. It was based on a locality principle: heads of feet must be in a local relation with the foot boundaries. Local relation was taken to mean separated by at most one beat and ‘head of a foot’ is taken to mean the stressed beat. This implies that feet must be of the form $\times \times$, $\times \times$, $\times \times \times$, or $\times$. It is fair to say that the notion of a $\times \times \times$ foot is no longer considered tenable. After Halle and Vergnaud, the attempt to derive the restricted possibilities for rhythmic stress from basic properties of the stress computation seems to have been abandoned.

An explanation for why rhythmic stress is either binary or ternary can be derived from locality, as defined in (23). Provided that rules and constraints are local and that *Unary is imposed, we will show below that for words with only featureless beats (i.e. ones with no attributes) and rhythmic stress; if edge effects are ignored, there are only two possibilities, given in (25).

(25) The recurring foot structure is either (25a) or (25b).

Binary: $\cdots (\times \times) (\times \times)(\times \times) \cdots$

Ternary: $\cdots (\times \times) \times (\times \times) \times (\times \times) \cdots$

We will actually prove something stronger. There are only 4 ways that feet are delimited, again ignoring edge effects and assuming that the iterative scheme does in fact iterate (i.e. apply more than once).
The names assume that the system is LR. The meaning of ‘forward’ and ‘backward’ switch for RL iteration.

It is easy to see that each of these recurring patterns is possible by giving iterative rules which generate them. Below, RL iteration and *Unary are assumed.

It is more difficult to show that no other patterns are possible. A proof will be given shortly.

There is no claim implicit in (26) that feet with more than 2 beats are impossible, just that they are impossible in a string of featureless beats, except perhaps at the edges. Consider the following LR system, for example.

Marking Rule (EDG): \( \times \rightarrow (\times / \# \) \)
Iterative Rule (BIN): \( \times \rightarrow \times \)

Ternary feet can appear at the right edge, as the derivation below demonstrates.
If beats can have attributes which the delimiter insertion rules are sensitive to, ternary feet can appear away from the edges. In mora counting languages with bimoraic syllables, say that two beats are tautosyllabic if they are associated with moras of the same syllable. Footing is generally sensitive to this pairing. One way beat tautosyllabicity may be represented is via two attributes, one indicates that the beat which bears it is in a pair with the beat on its left, another that it is in a pair with the beat on its right. In representations, this can be notated via a ⌁ diacritic, as in:

\[
\times \times \times ⌁ \times \times
\]

It is common for languages with tautosyllabic beats to constrain delimiter insertion so that it never inserts a delimiter between the two beats of a tautosyllabic pair. The constraint *SplitSyl, as defined below as a conjuncture, is a local constraint.

(29) *SplitSyl: ⌁ AND ⌜

Now consider an LR mora counting language with bimoraic syllables and the following delimiter insertion rules:
Marking Rule (EDG):  \( \times \rightarrow \langle \times / \# \rangle \)

Iterative Rule (BIN):  \( \times \rightarrow \times \rangle \)

*SplitSyl* can force ternary feet. For example, consider the derivation below.

(30)
\[
\begin{align*}
&\times \times \times \times \times \\
&EDG \quad \langle \times \times \times \times \times \times \\
&BIN \quad \langle \times \times \times \times \times \times \times \rangle \\
&\quad \langle \times \times \times \times \times \times \times \rangle ^\dagger \\
&\quad \langle \times \times \times \times \times \times \times \rangle ^\ddagger \\
&BIN \quad \langle \times \times \times \times \times \times \rangle \times \\
&\quad \langle \times \times \times \times \times \rangle \times \\
&BIN \quad \langle \times \times \times \times \rangle \times \times \\
&\quad \langle \times \times \rangle \times \times \times \times \\
&\quad \langle \times \times \rangle \times \times \times \times \times \times \times \times \times \\
\end{align*}
\]

\( ^\dagger \) *Unary blocks BIN

\( ^\ddagger \) *SplitSyl blocks BIN.

4.2. Proof of (26)

The proof is somewhat tedious and not necessary for anything that follows. This section should be viewed as an appendix which the reader can choose to skip.

Assume LR iteration to simplify the discussion. The results will be symmetrical. We want to determine all of the possible results obtained by iteratively applying a scheme of \( Q \) which satisfies locality to an initial string \( \gamma_0 \) of the form \( \langle \times \times \cdots \rangle \times \times \cdots \) (extending indefinitely to the right). We represent \( Q \) as a scheme of \( pk \)-rules which all satisfy *Unary in the derivation of \( \gamma \).

The approach to proving (26) will be to define a small class of elementary rules and to show that any scheme of \( pk \)-rules is equivalent to a scheme of elementary rules. We can then determine the possible schemes of elementary rules and from this the possible footing patterns.

For each of the 4 rules \( r \), we specify a set of simple contexts \([r]_{\Omega}\) as follows.
The contexts \([r]_\Omega\) are mutually exclusive; no potential target can be in more than one of the contexts. By listing the possibilities and it is easy to check that any delimiter insertion in the derivation of \(\gamma\) is in one of these context, given that *Unary is satisfied. A rule of the form \(r/\omega\), with \(\omega\) in \([r]_\Omega\), will be called an elementary rule. The contexts in \([r]_\Omega\) are deciding contexts for any \((r,p,k)\) rule.

If \(\Omega' = \{\omega_1, \ldots, \omega_n\}\) is a set of mutually exclusive contexts, let \(r/\Omega'\) denote the scheme

\[
\begin{bmatrix}
 r/\omega_1 \\
 \vdots \\
 r/\omega_n
\end{bmatrix}
\]

The order is not relevant because no two of the subrules can apply in the same environment. Given \(R = (r, p, k)\), let \(R_\Omega\) be the subset of \([r]_\Omega\) consisting of those contexts in which \(R\) is applicable in some state in the derivation of \(\gamma\). Since the contexts in \([r]_\Omega\) are deciding contexts for \(R\), we know that \(R\) is applicable if and only if the target is in one of the contexts in \(R_\Omega\).

**Lemma:** In the derivation of \(\gamma\), \(R\) is equivalent to \(r/R_\Omega\).

**Proof:** The action of both \(R\) and \(r/R_\Omega\) is \(r\), so the only issue is whether they are both applicable in the same environments. The scheme is applicable if and only if the target is in any of the contexts \(\omega\) in \(R_\Omega\) because the rule \(r/\omega\) is a subrule of the scheme. This is precisely the environment in which \(R\) is applicable.

In order to facilitate the discussion, we name the elementary rules.
We know that every $pk$-rule equivalent to a scheme (list) of the elementary rules. It follows that every scheme of $pk$-rules is equivalent to a scheme of elementary rules. We will now show that there are remarkably few such schemes, provided that we remove rules that never apply in the derivation of $\gamma$. A rule can fail to ever apply if it is always bled by a more highly ranked rule, or if a context in which it could apply is never generated because of the particular rules which do apply. We now determine what these schemes are. Below, we say that a rule is active if it applies at some point in the derivation of $\gamma$.

$R_1$ and $R_2$ are mutually exclusive (in the sense that if one is active the other is not). $R_3$ and $R_4$ are also mutually exclusive, as are $R_5$ and $R_6$. If $R_1$ or $R_2$ is active, then neither $R_3$ or $R_4$ can be active because they require the preliminary step $\times \times \times \rightarrow \times \times \times$ with no rule applying. $R_1$ or $R_2$ activity precludes this. It follows that at most one of the rules from $\{R_1, R_2, R_3, R_4\}$ can be active. Since an iterative scheme with only rules from $\{R_5, R_6, R_7\}$ can apply at most once (in case end marking leaves $\rangle \times \times$), but cannot iterate, we know that at least one of the rules from $\{R_1, R_2, R_3, R_4\}$ must be active.

If $R_2$ or $R_4$ is active, the conditions for applying any of the rules from $\{R_5, R_6, R_7\}$ are never generated, so if either $R_2$ or $R_4$ is active the scheme must consist of single rule, either $R_2$ or $R_4$.

If $R_1$ is active, any one of the rules from $\{R_5, R_6, R_7\}$ can be active, but only one. If $R_5$ or $R_6$ is active, the condition for applying $R_7$ is never generated since that requires $\rangle \times \times \rightarrow \rangle \times \times$ with no rule applicable.
If $R_3$ is active, $R_7$ can be active. The condition for applying either $R_5$ or $R_6$ is never generated.

We conclude that there are 4 possible schemes of elementary rules which have a single subrule and 4 possible schemes of elementary rules with 2 subrules. They are grouped below by the pattern they generate.

\[
\begin{align*}
\text{Backward binary:} & \quad [ \times \rightarrow \times \rangle / \times \_ ] & & [ \times \rightarrow \_ \rangle / \times \times \_ ] \\
\text{Forward binary:} & \quad [ \times \rightarrow \langle \times / \times \_. ] & & [ \times \rightarrow \langle \times / \times \times \_] \\
\text{2-sided binary:} & \quad \left[ \begin{array}{c}
\times \rightarrow \times \langle / \times \_ \\
\times \rightarrow \langle \times / \times \_ \\
\end{array} \right] \\
\text{Ternary:} & \quad \left[ \begin{array}{c}
\times \rightarrow \times \rangle / \times \_ \\
\times \rightarrow \times \langle / \_ \\
\times \rightarrow \langle \times / \_ \\
\end{array} \right] & & \left[ \begin{array}{c}
\times \rightarrow \times \rangle / \times \times \_ \\
\times \rightarrow \langle \times / \times \_ \\
\times \rightarrow \langle \times / \_ \\
\end{array} \right]
\end{align*}
\]

This proves (26).

5. The toolbox for building stress systems

There are a limited number of local delimiter insertion rules and local derivational constraints. The object of this section is to catalog the most commonly used tools and to see what kind of systems they generate. Two local derivational constraints have already been introduced: *Unary and *SplitSyl.

5.1. Relativization to the choice of the Iambic/Trochaic and LR/RL parameters

There are left/right and trochaic/iambic symmetries that should be embedded in the computational system. The core parameters in footing schemes are 1) the direction of iteration; and 2) the assignment of stress to the left or right edge of feet. Some way to relativize various notions to the settings of the core parameters is needed. This will be done by relativizing the meanings of the names of various constructs to these settings.
I shall refer to the *forward* and *backward directions*. The forward direction is the direction in which the iteration proceeds; to the right if the directionality is LR and to the left if it is RL. I shall also refer to backwards and forward delimiters. In an LR system, ) is a backward delimiter, grouping beats back towards the starting edge, and ⟨ is a forward delimiter, grouping beats forward away from the starting edge. In an RL system, ) is a forward delimiter and ⟨ is a backward delimiter.

The two core delimiter insertion rules in stress systems with regularly alternating stress are given in (34). GB, in its LR form, is what was called BIN above.

(34)  

<table>
<thead>
<tr>
<th></th>
<th>LR iteration</th>
<th>RL iteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Backward (GB)</td>
<td>$\times \rightarrow \times$ / $\times$</td>
<td>$\times \rightarrow \langle \times$ / $\times$</td>
</tr>
<tr>
<td>Group Forward (GF)</td>
<td>$\times \rightarrow \langle \times$ / $\times$</td>
<td>$\times \rightarrow \times$ / $\times$</td>
</tr>
</tbody>
</table>

Mention of the LR/RL parametric difference could be avoided by specifying GB and GF in terms of the forward and backwards directions and forward and backward delimiters. But the resulting formulation, while more elegant, is much less clear.

For Finnish, there was an intuition that the rule HVY was present in the system because it favored alignment of metrical stress with inherent heavy syllable stress. Of course, the rule as formulated for Finnish only does this in a trochaic stress system. So there are both trochaic and iambic versions of this rule. A special rule for heavy syllables plays a somewhat different role in mora counting systems since it can apply ATB as a marking rule without incurring a *Unary violation since there are two beats in every heavy syllable. In what follows, there will be several examples of (36b) used as a marking rule in LR mora-counting systems (Palestinian Arabic, Chugach, and Winnebago).
Since an edge marking rule must target the leading edge beat and insert one of two delimiters adjacent to that beat, and since inserting a backwards delimiter at the edge would create the meaningless \( \langle \# \rangle \) or \( \langle # \rangle \), there are only 3 possibilities for simple rules.

(37) Edge marking rules

<table>
<thead>
<tr>
<th></th>
<th>( LR ) iteration</th>
<th>( RL ) iteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>( EDG^F )</td>
<td>( \times \rightarrow \langle \times / # _ \rangle )</td>
<td>( \times \rightarrow \langle \times _ \rangle )</td>
</tr>
<tr>
<td>( EDG^{FF} )</td>
<td>( \times \rightarrow \langle \langle / # _ \rangle )</td>
<td>( \times \rightarrow \langle \rangle / _ _ \rangle )</td>
</tr>
<tr>
<td>( EDG^B )</td>
<td>( \times \rightarrow \langle \rangle / _ _ \rangle )</td>
<td>( \times \rightarrow \langle \times / _ _ \rangle )</td>
</tr>
</tbody>
</table>

F for forward delimiter at the edge; FF for forward delimiter forward of the edge; and B for backward delimiter.

More complex marking is possible. Variations on the rules (37) occur, and there can be multiple marking rules. I will assume that marking is done via an ordered list of marking rules.

Tripura Bangla uses the scheme:

\[
\begin{bmatrix}
\text{EDG}^{FF} / \_ - \\
\text{EDG}^{F}
\end{bmatrix}
\]

See Section 6.2 for an analysis of Tripura Bangla. Each marking rule inactivates the beats which it applies to.

In the revised nomenclature, we summarize the Finnish footing system as (38).
Finnish: Syllable counting, CVX syllables heavy, LR, trochaic

Marking Rule: \[ \text{EDG}^F \]
Iterative Rule: \[ \left[ \begin{array}{c} \text{HVY} \\ \text{GB} \end{array} \right] \] \{ \text{*Unary} \}

In addition to relativizing the basic delimiter insertion rules to the core parameters, derivational constraints can also relativized to the core parameters, the LR/RL choice in particular. Two common constraints are given in (39) and (40).

(39) *Orphan (output constraint): LR: * / \rangle \_\_\_ \# 
     RL: * / \# \_\_ \langle 

The effect of *Orphan in an LR system is to prevent GB from applying to the penultimate syllable, and in a RL system to prevent GB from applying to the second syllable.

Another constraint on the way that footing finishes at the far edge plays a role in several systems. Like ‘extrametricality’, it blocks applying rules to the far edge beat.

(40) *Persist (input constraint): LR: * / \_\_\_ \# 
     RL: * / \# \_\_ 

Stated less formally, *Persist effectively inactivates the far edge beat. But importantly, unlike the notion of extrametricality, it does not prevent the far edge beat from being stressed. A foot \_\_\_ \langle \times \times \#, for example, is possible. If stress is iambic, the final beat will be stressed.

Since the conjunction of local conditions is a local condition, a local rule restricted by a local input constraint is still a local rule. In effect, the input constraint augments the structural condition of the rule.

3. I have preferred to treat *Persist as a derivational constraint. But unlike most derivational constraints, it is a constraint on inputs, not outputs. Alternately, a new class of constraints, “input constraints”, could be introduced.
5.2. The origin of the binary/ternary distinction

Before we look at the stress systems of particular languages (Garawa, Cayuvava and Palestinian Arabic in this section), it is useful to abstract from the particularities that languages almost always present and consider somewhat idealized systems. Consider two systems that both are syllable counting with no light/heavy distinction, right to left footing, trochaic stress, and the marking rule EDG$^F$. Suppose they differ only in the iterative rule schemes they employ, given in (41). They differ only in the order of the two rules in the iterative rule scheme.

(41) A. \[
\begin{array}{c}
GB \\
GF
\end{array} \]; *Unary

B. \[
\begin{array}{c}
GF \\
GB
\end{array} \]; *Unary

The effect of the rule order is illustrated by the different stress patterns in 5-syllable words.

(42) System A

\begin{align*}
\times & \times \times \times \\
EDG^F & \times \times \times \times \times \\
GB & \times \times \times \langle \times \times \rangle \\
\times \langle \times \times \rangle \langle \times \times \rangle & \times \times \times \langle \times \times \rangle \\
\times \langle \times \times \rangle \langle \times \times \rangle & \langle \times \times \rangle \langle \times \times \rangle \\
SP & \langle \times \times \rangle \langle \times \times \rangle
\end{align*}

System B

\begin{align*}
\times & \times \times \times \\
EDG^F & \times \times \times \times \times \\
GB & \times \times \times \langle \times \times \rangle \\
\times \times \langle \times \times \rangle \langle \times \times \rangle & \times \times \times \langle \times \times \rangle \\
\times \langle \times \times \rangle \langle \times \times \rangle & \langle \times \times \rangle \langle \times \times \rangle \\
SP & \langle \times \times \rangle \langle \times \times \rangle
\end{align*}

Notes on the derivations:
1. GB and GF both require the context $\times$ in right to left systems, so neither can apply.
2. GB and GF can both apply, but GB is ordered before GF in System A.
3. GF is blocked by *Unary, so GB applies.
4. GB and GF can both apply, but GF is ordered before GB in System B.

At many points in the derivation, no subrules of the scheme could apply. The current target is then marked as inactive and the iterative rule then goes on to the new current target.

4-syllables words are footed and stressed the same way in both languages.
(43) System A

\[ \text{EDG}^F \times \times \times \times \]
\[ \text{GB} \times \times \langle \times \times \rangle \]
\[ \langle \times \times \langle \times \times \rangle \rangle \]
\[ \text{SP} \langle \times \times \langle \times \times \rangle \rangle \]

System B

\[ \text{EDG}^F \times \times \times \times \]
\[ \text{GB} \times \times \langle \times \times \rangle \]
\[ \langle \times \times \langle \times \times \rangle \rangle \]
\[ \text{SP} \langle \times \times \langle \times \times \rangle \rangle \]

† GF is blocked by *Unary, so the lower ranked GB can apply.

The stress patterns of all words with between 2 and 8 syllables in the two systems are shown in (44).

(44) System A System B

<table>
<thead>
<tr>
<th></th>
<th>System A</th>
<th>System B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>× ×</td>
<td>× ×</td>
</tr>
<tr>
<td>b.</td>
<td>× × ×</td>
<td>× × ×</td>
</tr>
<tr>
<td>c.</td>
<td>× × ×</td>
<td>× × ×</td>
</tr>
<tr>
<td>d.</td>
<td>× × × ×</td>
<td>× × × ×</td>
</tr>
<tr>
<td>e.</td>
<td>× × × × ×</td>
<td>× × × ×</td>
</tr>
<tr>
<td>f.</td>
<td>× × × × ×</td>
<td>× × × × ×</td>
</tr>
<tr>
<td>g.</td>
<td>× × × × × ×</td>
<td>× × × × × ×</td>
</tr>
</tbody>
</table>

If we suppose that the marking rule is subject to *Unary, as is the iterative scheme, then neither the marking rule nor the iterative scheme will apply to monosyllables and they will not be footed, and therefore will not be stressed.

Crucially, ternary intervals between stress positions in System B occur as soon as there are sufficiently long strings of beats for iterative delimiter insertion to organize into feet separated by an unfooted beat. The ordering of GF over GB is the cause of this behavior. I take this as a definition: a stress system is ternary if iterative delimiter insertion uses both GB and GF, with GF ordered before GB.
In System A, with GB ranked over GF, the latter never applied. But we will shortly see an example with GB ordered before GF in which GF does apply in response to a constraint which affects footing at the far edge.

5.3. Examples

5.3.1. Garawa

The Garawa stress system is a minor variation of System A. However, because the derivational constraint *Orphan is imposed, GB does not always bleed GF, as it does in System A.

(45) Garawa: Syllable counting with no light/heavy distinction, RL, Trochaic

Marking Rule: \[ \text{EDG}^F \]

LR Iterative Rule:
\[
\begin{array}{c}
\text{GB} \\
\text{GF}
\end{array}
\} ; \{ \text{*Unary}, \text{*Orphan} \}
\]

Compare (46a) and (46b).

(46) a. \[
\begin{array}{c}
\text{EDG}^F \\
\times \times \times \times \\
\text{GB} \\
\times \times (\times \times) \\
\times \times (\times \times)^† \\
\text{GB} \\
(\times \times \times \times ) \\
\text{SP} \\
(\times \times \times \times)
\end{array}
\]

b. \[
\begin{array}{c}
\text{EDG}^F \\
\times \times \times \times \\
\text{GB} \\
\times \times \times \times (\times \times) \\
\times \times \times \times (\times \times)^† \\
\text{GB} \\
(\times \times \times \times ) \\
\text{SP} \\
(\times \times \times \times)
\end{array}
\]

† Neither GB nor GF can apply. Both require the context ___\times.
‡ *Orphan blocks GB, so GF can apply.

The derivations for longer words follow the model of the derivations (46); there is a binary foot at the left edge and abutting binary feet at the right edge.

The foot/stress patterns are:
The stress system is not ternary (GB is ordered before GF), but a ternary interval does appear in words with 5, 7, 9, ... syllables.

Shorter words are interesting. Monosyllable cannot be footed. The stress patterns of 2 and 3 beat words are derived in (48).

A 3 beat foot is produced in (48b). This is the only case in this system in which a 3 beat foot is produced.

5.3.2. Cayuvava

The Cayuvava stress system is a minor variation of System B. It illustrates the effects of EDGFF edge marking and the derivational constraint *Persist.

(49) Cayuvava Syllable counting, no light/heavy distinction, RL, Trochaic

Marking Rule: EDGFF

Iterative Rule: $\begin{bmatrix} GF \\ GB \end{bmatrix} ; \{ *\text{Unary}, *\text{Persist} \}$
It differs from Garawa in that: 1) the edge marking rule is $\text{EDG}^\text{FF}$, not $\text{EDG}^\text{F}$, and it is not constrained by the derivational constraints; 2) *Persist constrains iterative footing, not *Orphan; and most significantly 3) GF is ordered before GB. It is not uncommon for weaker derivational constraints to be imposed on marking rules.

Consider the effect of these features of the system on some derivations.

(50)  a. \[ \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times \times 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(52) a. The penultimate syllable is stressed if it is not initial, otherwise the antepenultimate syllable is stressed.
   b. If $\sigma_n$ is stressed then $\sigma_{n-3}$ is stressed.

This is the well-known stress pattern of Cayuvava.

Note that in Cayuvava the ternary pattern derives entirely from rule ordering in the iterative rule; GF is ordered before GB. If the rule order is switched, a simple RL binary pattern results, except that *Persist would prevent stress on the first syllable of words with $2n + 3$ syllables ($n = 1, 2, \ldots$). GF would always be bled by GB so that it would never apply.

H95 explains the appearance of two unfooted beats at the trailing edge in (52a) as the consequence of ‘non-persistence’ of weak parsing, which is parametrized as $\pm$Persistent. The issue is the action that is taken by the parsing algorithm if only two beats remain, in which case it is impossible to skip a beat. If $+\text{Persistent}$ is in force, another foot is formed without skipping a beat if skipping a beat is not possible. If $-\text{Persistent}$ is in force, skipping a beat is obligatory. The name *Persist is derived from this idea.

Although the name *Persist is derived from Hayes’ parametrization of weak local parsing, the derivational constraint *Persist is much more general. An example of the effect of *Persist in a language without ternary intervals, and of course no weak local parsing, is given in the next section. In Cayuvava, an RL language, *Persist results in some $\#\times\times\langle\ldots$ output forms. In Palestinian Arabic, an LR language, *Persist results in some $\ldots\rangle\times\times\#$ output forms. Since both languages are trochaic, the results in Palestinian Arabic are more striking, with the final three syllables unstressed.
5.3.3. Palestinian Arabic

Up to this point, the only marking rules which have been considered are edge marking rules. Since marking rules are local and apply ATB, the only viable way to mark a string of featureless beats is at the edges. But if beats have attributes, marking rules can be triggered by these attributes. In this section, we show that Palestinian Arabic can be easily analyzed as a mora counting language in which HVY applies across-the-board prior to iterative footing.

The examples below, the first two columns of (53), are taken from Hayes (1995, pp. 126–27). 4 The foot structures in the third column are generated by the stress system given in (54). In order to make it easier for the reader to understand how the foot structure is imposed, delimiters inserted by marking rules are doubled. This is only for the benefit of the reader; the metrical computation makes no distinction. This convention will be used for the remainder of this paper. The last column is the result of rules which convert the foot structure to surface form. The rightmost primary stress (level 1) is projected to main stress. Secondary stress is suppressed and main stress appears on the syllable containing the stressed mora.

---

Palestinian Arabic: Mora counting, LR, Trochaic

a. Mora Projection: CVXC and nonfinal CVC syllables bimoraic, others monomoraic

b. Delimiter Insertion:

\[ \begin{array}{c}
\text{Marking rules: } \\
\text{GB} \\
\end{array} \] ; \{ *\text{Unary}, *\text{Persist} \}

Iterative rule: GB

c. Main stress: Rightmost (secondary stress does not surface)

Since the iterative delimiter insertion rule is so simple, the derivation of the foot structures in (53) from (54) is fairly straightforward. The final syllables in (53b,i) are monomoraic; the final syllables in (53f,k) bimoraic. Since marking is subject to *Unary and HVY is ordered before EDG[^F], edge-marking is blocked in (53f,g,h). *Persist prevents delimiter insertion at the right edge. Consequently, there are two unfooted beats at the right edge in (53d,h,i). In (53d), there are three unstressed syllables at the right edge.

HVY is used as a marking rule in both Winnebago and Chugach, both of which are mora counting LR trochaic languages like Palestinian Arabic. In Winnebago we will again see one
marking rule blocking another in certain configurations. This is taken up in Section 7. *Persist was important for Cayuvava and will also be important in analyzing Tripura Bangla in Section 6.2.

Hayes’ analysis proceeds rather differently, invoking both final consonant extrametricality and final foot extrametricality. Idsardi’s idea of one-sided delimiters makes an explanation based on *Persist relatively simple and needs no special mechanisms like “final foot extrametricality”.

5.3.4. Latin

Latin is a good illustration of the Once and Done Principle (ODP). Recall the idea; each beat is targetted once and only once.

Consider the system:

(55) Syllable counting with a light/heavy distinction, RL, trochaic

Marking Rule: \[ \text{EDG}^{FF} \]

Iterative Rule: \[ \begin{cases} \text{HVY} \\ \text{GB} \end{cases} \]

There are no derivational constraints. The iterative rule is the same as the iterative rule in Finnish, but because the direction is RL and *Unary is not in force, the results are quite different.

Here are some illustrative derivations. The final syllable in (56b,c) can be either heavy or light; it makes no difference.

(56) a. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

b. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

\[ \text{HVY} \text{~} \text{~} \text{~} \]

c. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

There are no derivational constraints. The iterative rule is the same as the iterative rule in Finnish, but because the direction is RL and *Unary is not in force, the results are quite different.

Here are some illustrative derivations. The final syllable in (56b,c) can be either heavy or light; it makes no difference.

(56) a. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

b. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

\[ \text{HVY} \text{~} \text{~} \text{~} \]

c. \[ \text{EDG}^{FF} \text{~} \text{~} \text{~} \]

\[ \text{HVY} \text{~} \text{~} \text{~} \]

\[ \text{SP} \text{~} \text{~} \text{~} \]

\[ \text{SP} \text{~} \text{~} \text{~} \]

\[ \text{SP} \text{~} \text{~} \text{~} \]

† Crucially, because the right edge slot has already been targetted by EDG^{FF}, HVY cannot apply and produce \( \text{~} \text{~} \text{~} \). This is an effect of the ODP.\(^5\)
The distribution of stress that results from (55) is:

(57) If the penultimate syllable is heavy, it is stressed, otherwise the antepenultimate syllable is stressed. If \( \sigma_n \) is stressed, then \( \sigma_{n-1} \) is stressed if it is heavy, otherwise \( \sigma_{n-2} \) is stressed.

Plausibly, this is the stress system for Latin. It correctly locates the rightmost stress, which we can assume is the main stress. Main stress in Latin is known with some certainty from poetry, but little is known about secondary stress. Main stress is correctly predicted by (57), so all that can be said is that the analysis is plausible.

5.3.5. Tübatalabal

There were multiple illustrations of \( \text{EDG}^F \) and \( \text{EDG}^{FF} \) above. Tübatalabla illustrates the other basic edge-marking rule, \( \text{EDG}^B \).

There is a strong cross-language tendency to avoid unary feet, manifested in the frequent appearance of \( *\text{Unary} \). \( \text{EDG}^B \) always creates a unary foot, so it is not surprising that it is not a common edge-marking rule. There are, however, systems in which it is employed. Consider the following system.

(58) Mora counting, RL, trochaic

\[
\begin{align*}
\text{Marking Rule:} & \quad \text{EDG}^B \\
\text{Iterative Rule:} & \quad \text{GB} \\
& \quad \{ *\text{Unary}, *\text{SplitSyl} \}
\end{align*}
\]

\( *\text{SplitSyl} \) disallows ‘splitting’ syllables. See (29) and the discussion which proceeds it.

Some sample derivations follow.

---

5. Halle and Idsardi explain this by imposing the derivational constraint \( *)(. \) This derivational constraint cannot be expressed as a local constraint on beats, so it is not a possibility in the more restricted theory presented in this paper.
A description of the distribution which (58) leads to is given in (60).

(60) The final syllable is stressed. If $\sigma_n$ is stressed, then $\sigma_{n-1}$ is stressed if it is heavy, otherwise $\sigma_{n-2}$ is stressed.

This is the distribution of stress in Tübatalabal.

6. Trochaic syllable counting languages with ternary alternation.

In this section, the word stress systems of three languages which have ternary alternation will be analyzed: Estonian, Tripura Bangla, and Sentani. All have similarities to the Finnish system. All are syllable counting languages with a light/heavy distinction which is used in computing word stress. All use $\text{EDG}^F$ for edge marking, except for some special environments in Tripura Bangla and Sentani. Estonian is notable in that there is optionality; many words can appear with two different stress patterns. Under the natural assumption that the two patterns must result from a minor difference in the footing rules or the way they are applied, this poses a rigorous constraint on theories of stress. Hayes’ local/nonlocal parsing parameter is highly successful in giving an account of Estonian stress. The core parametric choice, weak versus strong local parsing, corresponds precisely to the observed optionality.
Recall that we earlier identified the “ternarity parameter” as the inclusion of GF in the iterative scheme, ordered before GB. If we form the ternary version of Finnish, adding GF ordered before GB, we get the delimiter insertion system in (61).

(61) Syllable counting, LR, trochaic

Marking Rule: \( \text{EDG}^F \)

Iterative Rule: \[
\begin{bmatrix}
\text{H} & \text{V} & \text{Y} \\
\text{G} & \text{F} \\
\text{G} & \text{B}
\end{bmatrix}
\]; *Unary

The three stress systems analyzed in this section are all variations on (61).

6.1. Estonian

The Estonian data is from Hayes (1995), who takes it from Hint (1973). The data here does not contain any words with so-called “overlong syllables”, so the account which will be given is less than a full account of Estonian stress.\(^6\) The most striking thing about the data is that many words have two different stress patterns.

---

6. See Hayes 95, p. 318–328 for an account of the metrical properties of overlong syllables. Hayes’ framework is different than the one in this paper, but his conclusions could be translated into this framework.
(62) Light syllable words

a. pá.tu
b. o.sa.va
c. o.sa.va.ma
d. pi.me.sta.va.le / pi.me.sta.va.le

(63) a. pi.me.stà.va.le / pi.me.stà.và.le

b. vá.li.sát.te.le

On the basis of (62), we can make the preliminary proposal that delimiter insertion is specified by (61), except that the *subrules of the iterative scheme are unordered*. The derivations below shows why there is an option in (62d) but none in (62f).

(63) a. pi.me.stà.va.le / pi.me.stà.và.le

b. vá.li.sát.te.le

† There is no option at this point. Neither GB nor GF can target the heavy syllable since both require the context × __.

Apart from relaxing rule order in the iterative scheme, one further amendment of (61) is needed. Compare (64a) and (64b).

(64) a. ⟨ ⟨ ) ( )⟩ ó.sa.va

b. ⟨ ⟨ ) ( )⟩ ó.sa.vátt
Estonian relaxes the *Unary constraint on HVY to permit heavy final unary feet. Like HVY itself, this feature of the stress system gives better alignment of inherent heavy syllable stress and metrical stress. The relaxed *Unary will be called *Unary$_w$.

(65) \*Unary$_w$: *Unary or /__#

*Unary$_w$ is a local constraint. It is used in all the languages discussed in this section; Estonian, Tripura Bangla and Sentani.

The Estonian stress system is:

(66) Estonian: Syllable counting, LR, Trochaic

Marking Rule: EDG; *Unary

Iterative Rule: \{HVY, GF, GB\}; *Unary$_w$

Note that the schema is unordered.\(^7\).

In trochaic languages, final unary syllables do not give rise to stress clash. Plausibly, allowing only final feet to be unary is related to stress clash avoidance. Although there is some tendency for languages to avoid stress clash, *Unary cannot be reduced to stress clash avoidance. In Finnish, which is like Estonian in many ways, *Unary is maintained for final heavy syllables, as the Finnish examples below demonstrate.

(67) a. \{\~\~\} pé.ri.jä
b. \{\~\~\} ku.nin.gas (*ku.nin.gás)

Further Estonian examples (i.e. evidence for (66)) follow.

---

7. Alternatively, one could suppose that GF is optional
(68) More words with no variation
a. \( \langle \circ \circ \rangle \) pa.lat
b. \( \langle \circ \circ \rangle \) pá.latt
c. \( \langle ' ' \rangle \) nó:.rikk
d. \( \langle \circ \circ \rangle \) ó.sa.vätt
e. \( \langle \circ \circ \rangle \) sór.ye.måttel
f. \( \langle \circ \circ \rangle \) pá.ru.måtteltt
g. \( \langle \circ \circ \rangle \) ká.ras.tát.tui.må.le
h. \( \langle \circ \circ \rangle \) vá.li.sát.te.le
i. \( \langle \circ \circ \rangle \) y.pet.tús.te.le.ki

(69) Words with variation
a. \( \langle \circ \circ \rangle \) tá.ra.vá.mått
té.ra.va.mått
b. \( \langle \circ \circ \rangle \) pí.me.stá.va.le
pí.me.sta.vá.le
c. \( \langle \circ \circ \rangle \) ýp.pet.ta.yat.tèks
ýp.pet.ta.yat.teks
d. \( \langle \circ \circ \rangle \) é.rí.nè.vat.tè.sse
é.rí.ne.vat.tes.se
e. \( \langle \circ \circ \rangle \) vál.lut.ta.yat.te.ká
vál.lut.ta.yat.te.ká
f. \( \langle \circ \circ \rangle \) ú.sal.tát.ta.vat.mat.tèks
ú.sal.tát.ta.vat.mat.teks

Some further full derivations are given below.

(70) a. ósaváma
b. té.ra.vá.mått / té.ra.va.mått
\( \circ \circ \circ \) \( \circ \circ \circ \)

EDG \( \langle \circ \circ \circ \circ \rangle \)
GB \( \langle \circ \circ \circ \circ \rangle \)
GB \( \langle \circ \circ \circ \circ \rangle \)

SP \( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)

\( \langle \circ \circ \circ \circ \rangle \)
(71) a. pá.ri.mátt.tellt  
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td></td>
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</tr>
</tbody>
</table>

EDG⁰  ⟨   ⟨   ⟩   ⟩
GB  ⟨   ⟩   ⟩
HVY  ⟨   ⟩   ⟩   †
GB  ⟨   ⟩   ⟩   †

† HVY does not apply because ⟨σ⟩ is blocked by *Unary.<..

6.1.1. Other analyses

The weak/strong parsing parameter of Hayes (1995) is perfectly designed to explain the optionality in Estonian stress assignment. Light syllables can be skipped (optionally) if there is enough material to their right to make a viable foot. Since the theory is built on the idea of foot templates, with (−) and (σ σ) viable feet, the desired results follow.

The Halle-Idsardi two-stage theory of heavy syllable effects (footing associated with heavy syllables first, followed by iterative footing) does not fare well. Footing in the account developed in this section responds to inherently stressed grid marks (i.e. those associated with heavy syllables) according to the footing to the left that has already been carried out when the inherently stressed grid mark is encountered. The problem for the Halle/Idsardi two-stage account of heaviness is that decisions about inserting foot delimiters associated with heavy syllables must be made in advance of iterative footing.

We can see the problem easily by comparing the stress patterns of ó.sa.va, ó.sa.vàtt, and té.ra.và.màlt/té.ra.va.màltt.
In the Halle/Idsardi theory, the heavy syllable rule must obligatorily insert a delimiter in (72b), otherwise there is no way to distinguish (72a) and (72b). But if this is the case, there is no way to keep the heavy syllable rule from obligatory insertion of a delimiter in (72c). So the theory would have no account of the optionality in (72c). Hayes (1995, p. 329) makes a similar point about Halle and Vergnaud (1987). As far as I know, the criticism has never been answered.

As far as I can see, Halle and Idsardi’s two-stage account of heaviness effects cannot account for the Estonian stress pattern.

6.2. Tripura Bangla


Estonian modified (61) by relaxing rule order in the iterative scheme. Tripura Bangla maintains the rule order, but modifies it by 1) further constraining the iterative scheme by *Persist; and 2) using a special edge-marking rule for a certain class of words (minimally trisyllabic words which begin #\textcircled{–}). The stress system is:

(73) Tripura Bangla: Syllable counting, (C)VX(C) syllables are heavy, LR, Trochaic

- Marking Rules: \[
\begin{bmatrix}
\text{EDG}^{FF} / 
\text{EDG}^{F} \\
\text{HVY} \\
\text{GF} \\
\text{GB}
\end{bmatrix}; \text{*Unary}
\]

- Iterative Rule: \[
\begin{bmatrix}
\text{HVY} \\
\text{GF} \\
\text{GB}
\end{bmatrix}; \{ \text{*Unary}_w, \text{*Persist} \}
\]

Words with a single stress illustrate the edge-marking rule and the effect of *Persist.
(74) Words with a single stress

a. ⟨ ⟨ ´ ˘ ˘ g´ o.ra⟩⟩  ‘root’
b. ⟨ ⟨ ´ ˘ ˘ g´ o.ra.li⟩⟩  ‘ankle’
c. ⟨ ⟨ ´ ˘ ˘ k´ e.ra.mo.ti⟩⟩  ‘ingenuity’
d. ⟨ ⟨ ´ ˘ ˘ fá.til⟩⟩  ‘earthen pot’
e. ⟨ ⟨ ´ ˘ ˘ fò.o.rik.ka⟩⟩  ‘examination’
f. ⟨ ⟨ ´ ˘ ˘ bì.fjì.jòu⟩⟩  ‘immersion’
g. ⟨ ⟨ ´ ˘ ˘ a.bò.r.zò.na⟩⟩  ‘garbage’
h. ⟨ ⟨ ´ ˘ ˘ ʃà.fà.b.dà.wò.ta⟩⟩  ‘carelessness’
i. ⟨ ⟨ ´ ˘ ˘ ʃò.fò.n.ro.kì.tò⟩⟩  ‘unreserved’

Later examples will show that iterative delimiter insertion is constrained by *Unary_w, not *Unary.

One might expect the edge-marking rule to be similarly constrained; but it is not, as is shown by (74d). If the first subrule of the edge-marking scheme (EDG^FF) were constrained by *Unary_w and not by *Unary, we would expect EDG^FF to apply in (74d), producing ⟨ ⟨ ´ ˘ ˘ tò˘ . Instead, application of EDG^FF is blocked by *Unary, so the second subrule (EDG^F) of the edge-marking rule applies.

(74c,h,i) show that *Persist constrains interative delimiter insertion. It has the same effect that it had in Cayuvava and Palestinian Arabic; two unfooted syllables appear at the far edge.

Words with multiple stresses illustrate ternarity and the effect of *Unary_w.

(75) Words with a multiple stresses

a. ⟨ ⟨ ´ ˘ ˘ út.tfa.rò.n⟩⟩  ‘pronunciation’
b. ⟨ ⟨ ´ ˘ ˘ ʃò.nu.kòm.pà⟩⟩  ‘compassion’
c. ⟨ ⟨ ´ ˘ ˘ ʃò.nu.bò.tì.tà⟩⟩  ‘obedience’
d. ⟨ ⟨ ´ ˘ ˘ ʃò.fà.ʃò.dò.fì.kò.tà⟩⟩  ‘expertness’
e. ⟨ ⟨ ´ ˘ ˘ ʃò.mà.nò.fík⟩⟩  ‘inhuman’
f. ⟨ ⟨ ´ ˘ ˘ ʃò.nò.bò.lò.mò.bò.n⟩⟩  ‘resourcelessness’
g. ⟨ ⟨ ´ ˘ ˘ ʃò.kò.ʃò.fà.tì.tò⟩⟩  ‘partisanship’
h. ⟨ ⟨ ´ ˘ ˘ ʃò.ʃò.ri.bò.tì.tò⟩⟩  ‘unchanged’
i. ⟨ ⟨ ´ ˘ ˘ ʃò.ʃò.ri.bò.tò.nò.yò.nò.yò.na⟩⟩  ‘unchangeable’
j. ⟨ ⟨ ´ ˘ ˘ ʃò.dò.gò.ʃò.lò.sò.nà⟩⟩  ‘deliberation’
k. ⟨ ⟨ ´ ˘ ˘ ʃò.ńò.yò.zò.nò.yò.nò.yò.nà⟩⟩  ‘necessity’
l. ⟨ ⟨ ´ ˘ ˘ ʃò.nò.mò.ʃò.ro.nò.yò.nò.yò.nà⟩⟩  ‘unfollowability’
m. ⟨ ⟨ ´ ˘ ˘ ʃò.nò.mò.ʃò.ro.nò.yò.nò.yò.nà⟩⟩  ‘unfollowability’
Except for the effect of *Persist in (75d,i,l), all of the (75) foot structures would be generated by the Estonian rule system, on at least one ordering of the subrules of the Estonian iterative scheme. Since the derivations are almost identical to corresponding derivations in Estonian, I leave it to the reader to verify that (73) generates the foot structures given in (75).

6.3. Sentani

Sentani is a Papuan language spoken in what is now Papua Indonesia. The data in this section is from Cowan (1965). This data is also analyzed by Hayes (1995, p. 330), in weak local parsing terms.

CVC syllables are heavy. There are no underlying long vowels. The footing system is very close to the Tripura Bangla system, except that the iterative scheme is applied right to left. Apart from directionality, the only other difference between the systems is the edge marking rule. Both have the default edge-marking rule EDG, but both make an adjustment in some environments to better align inherent heavy syllable stress with metrical stress.

(76) Sentani: Syllable counting, (C)V syllables are heavy, RL, Trochaic

Marking Rules: \[
\begin{bmatrix}
\text{EDG}^B \\
\text{EDG}^F \\
\text{HVV} \\
\text{GF} \\
\text{GB}
\end{bmatrix}; \{ \text{*Unary}_w, \text{*Persist} \}
\]

Iterative Rule: \[
\begin{bmatrix}
\end{bmatrix}
\]

Words with a single stress illustrate the effect of *Persist and *Unary_w.

---

8. There are apparently significant difference between dialects of Sentani. Cowan’s data is from the eastern dialect.
(77) Words with a single stress

*Unary$w$ blocks EDG$B$, so EDG$F$ applies

a. ⟨ ˘ ⟨ ˘ ⟩ ⟩ yó. ku  ‘dog’
b. ⟨ ˘ ⟨ ˘ ⟩ ⟩ kám. bi  ‘neck’
c. ⟨ ˘ ⟨ ˘ ⟩ ⟩ ho. ko. lo  ‘young’
d. ⟨ ˘ ⟨ ˘ ⟩ ⟩ u. ké. w. ng  ‘he told him’
e. ⟨ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ho. bú. ké  ‘he killed (something)’
f. ⟨ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ho. ná. w. ng  ‘he burnt him’
g. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ho. nám. bón. de  ‘he will kill (something) for him’
h. − ⟨ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ⟩ ha. ná. w. ng  ‘we killed (something)’

EDG$B$ applies (permitted by *Unary$w$)
i. ⟨ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ fa. lóm  ‘head’
j. − ⟨ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ án. kéy  ‘ear’
k. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ha. ba. ký  ‘tobacco’

*Persist, in an RL system, blocks a left delimiter at the left edge. The consequence is the two unfooted beats at the left edge in (77g,h) and (77k).

(78) Words with a secondary stress

a. ⟨ ˘ ⟨ ˘⟩⟩ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ˙a. do. ka. wá. le  ‘I saw thee’
b. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ⟩ a. di. la. mi. lí. be  ‘you two will collect them’
c. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ⟨ ˘ ⟩ ⟩ a. di. là. do. mí. hím  ‘let me collect them’
d. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ − ⟨ ⟨ ˘ ⟩ ⟩ ⟩ ˙a. ná. y. ng. ké. r. kén. sín. de  ‘they (pl.) will throw it away’
e. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ⟩ ha. bów. do. kó. ké  ‘he hit me (aor.)’
f. ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟨ ˘ ⟩ ⟩ ⟩ ⟩ ˙a. ná. y. ng. wón. de  ‘they will go tell him’

Main stress is right. Cowan formulated the generalization: “a secondary stress [affect] the 3$^{nd}$ syllable forward from the main stress, or the 2$^{nd}$ syllable forward if this is closed by a consonant.”

This generalization is directly at odds with Hayes’ view that skipping a beat depends on the skipped beat being light. In (78), if $\sigma_n$ is foot final, $\sigma_{n-1}$ is skipped if $\sigma_{n-2}$ is light and nonfinal. The weight of $\sigma_{n-1}$ is not relevant. (78d) is impossible from the standpoint of weak local parsing.

9. Presumably, Cowan intended this to apply only to words that had a secondary stress, since otherwise (77h) would violate it.
Full derivations of (77h) and (78d,e) are given below.

<table>
<thead>
<tr>
<th></th>
<th>77h.</th>
<th>78d.</th>
<th>78e.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(79)</td>
<td>(\text{<a href="mailto:han.d@.b">han.d@.b</a>ó.ka})</td>
<td>(\text{\<a href="mailto:varepsilon.nay.n@.ken.s">varepsilon.nay.n@.ken.s</a>í.n.de})</td>
<td>(\text{ha.bów.do.kó.ke})</td>
</tr>
<tr>
<td>EDG</td>
<td>(-\ -\ -)</td>
<td>(-\ -\ -)</td>
<td>(-\ -\ -)</td>
</tr>
<tr>
<td>GB</td>
<td>(-\ \varepsilon\langle\ -\ \rangle)</td>
<td>(-\ -\ -\ \langle\ -\ \rangle)</td>
<td>(-\ -\ \langle\ -\ \rangle)</td>
</tr>
<tr>
<td>SP</td>
<td>(-\ \varepsilon\langle\ -\ \rangle)</td>
<td>(-\ -\ \langle\ -\ \rangle)</td>
<td>(-\ -\ \langle\ -\ \rangle)</td>
</tr>
<tr>
<td>(\text{<a href="mailto:han.d@.b">han.d@.b</a>ó.ka})</td>
<td>(\varepsilon\langle\ -\ \rangle)</td>
<td>(\varepsilon\langle\ -\ \rangle)</td>
<td>(\varepsilon\langle\ -\ \rangle)</td>
</tr>
<tr>
<td>(\varepsilon\langle\ -\ \rangle)</td>
<td>(\varepsilon\langle\ -\ \rangle)</td>
<td>(\varepsilon\langle\ -\ \rangle)</td>
<td>(\text{ha.bów.do.kó.ke})</td>
</tr>
</tbody>
</table>

† HVY and GB are blocked by *Persist and GF is blocked by *Unaryw.
‡ HVY is ordered before GF.

The analysis of Hayes (1995, p. 330) is less than satisfactory. It incorrectly assigns stress to the first syllable of \(\text{han.d@.bó.ka}\), (77h). It incorrectly predicts \(\varepsilon\text{ñay}(n@.ken)(sí.n.de)\), rather than \(\varepsilon(n@.ken)(sí.n.de)\), (78d). (Hayes does not include this word in his data, but the prediction the weak-local parsing theory makes is clear.) Further, the iterative foot construction he proposes overgenerates, so that later rules are needed to destress certain syllables. One such rule eliminates certain unary feet. For \(\text{ha.ba.kay}\), the footing construction produces \((\varepsilon)\sim(\sim)\), but a later rule applies after word level stress is assigned which eliminates unary feet which do not receive word level stress. Another rule destresses stressed syllables which directly precede stressed syllables.

For \(\text{how.bo.ke}\), (77e), for example, footing produces \((\sim)(\sim)\), which then undergoes destressing to produce the desired result. To be fair, it should be noted that both of these rules appear other places in Hayes’ footing theory, so they are not obvious ad hoc fixes for Sentani. Nevertheless, it is problematic that so much adjustment of the core footing rule is needed. Aside from a few bisyllabic words, not many more than a dozen examples are available. In Hayes analysis, predictions are incorrect for two of them and four need post-footing adjustment.
7. Heavy syllable effects in mora counting languages

Two mora counting languages with ternary footing are discussed, Chugach and Winnebago. They both are LR mora counting languages. The stress systems of both have been the subject of numerous studies.

7.1. Chugach

Chugach, a dialect of Pacific Yupik (Alutiiq), is a particularly straightforward example of ternary footing in a mora counting language. The data is from Leer (1985a, 1985b, 1985c). Almost all the examples I use are in Hayes (1995, pp. 335–36). The stress system is given in (80). It will be justified below by showing exactly how it predicts the correct distribution of stress in the examples.

7.1.1. Stress system

The Chugach delimiter insertion rules are in (80).

(80) Chugach: Mora counting; (C)VV(C) and initial (C)VC syllables are bimoraic, LR, iambic

Marking Rules: \[
\begin{bmatrix}
\text{HVY} \\
\text{EDG}^f
\end{bmatrix}
\]

Iterative Rule: \[
\begin{bmatrix}
\text{GF} \\
\text{GB}
\end{bmatrix}; \ast\text{Unary}
\]

There are two marking rules, neither subject to \ast\text{Unary}. Recall that marking rules apply simultaneously to all the beats which satisfy their structural description. Recall also that HVY in an LR mora counting language is \(\times \rightarrow \langle \times / \_\_\_\_\_\_\_\_\rangle \times\).

The verification that the rules (81) are correct will come in two parts. I will first show that they lead to stress on the desired syllables, as shown in the column labeled ‘stressed’ of (81–83).
Then, in a later section, it will be shown that the foot structure which the rules generate provides a framework for analyzing the extensive stress-related phonological changes which occur in generating the surface form. (What I call the ‘surface’ form is actually somewhat less than that in some cases. Attention is focused on those aspects of the surface form that are directly related to the foot structure.)

We start with words with simple foot structure, in which edge marking makes a scaffolding for the foot structure that leaves no options other than simply closing some feet by applying GB. Note that since the two edge-marking rules are not constrained by *Unary, initial unary feet are generated in (81a,b).

(81) Words with simple foot structure

<table>
<thead>
<tr>
<th></th>
<th>edge marked</th>
<th>GB applied</th>
<th>stressed</th>
<th>surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>nu.yai</td>
<td>⟨××⟩</td>
<td>⟨××⟩</td>
<td>(nú)(yái)</td>
</tr>
<tr>
<td>b.</td>
<td>u.lua</td>
<td>⟨××⟩</td>
<td>⟨××⟩</td>
<td>(ú)(lua)</td>
</tr>
<tr>
<td>c.</td>
<td>mu.lu.ku:t</td>
<td>⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩</td>
<td>(mu.lú)(kú:t)</td>
</tr>
<tr>
<td>d.</td>
<td>a.ta.ka</td>
<td>⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩</td>
<td>(a.tá)ka</td>
</tr>
<tr>
<td>e.</td>
<td>pin.ka</td>
<td>⟨××⟩</td>
<td>⟨××⟩</td>
<td>(pín)ka</td>
</tr>
<tr>
<td>f.</td>
<td>an.či.qua</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>(án)či(quá)</td>
</tr>
<tr>
<td>g.</td>
<td>u.xa.či.mán</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>(u.xá)či(mán)</td>
</tr>
<tr>
<td>h.</td>
<td>iq.łu.ki:ya</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>(iq)lu(ki:ja)</td>
</tr>
<tr>
<td>i.</td>
<td>na:qa:</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>(ná:)(qá:)</td>
</tr>
<tr>
<td>j.</td>
<td>kal.ma:nuq</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩ ⟨××⟩</td>
<td>(kál)(má:nuq)</td>
</tr>
</tbody>
</table>

Several stress-related phonological processes must be analyzed. Stressed open light syllables always strengthen (i.e., become heavy), usually by lengthening the vowel to a long vowel, as in (81d,g,h). In (81a,b), however, the initial light syllable acquires a coda. In (81c), the vowel becomes only half-long, described by Leer as somewhere between a standard vowel and a long

---

10. Page reference to Leer (85a) is given in brackets: a. ‘her hair’ [102]; b. ‘its tongue’ [87]; c. ‘if you take a long time’ [87]; d. ‘my father’ [116]; e. ‘mine (pl)’ [110]; f. ‘I’ll go out’ [84]; g. ‘you must be good at it’ [112]; h. ‘she lied to me’ [112]; i. ‘she’s reading it’ [115]; j. ‘pocket’ [103].
There is consonant fortition in some examples in (81) as well. We discuss all this
post-stress phonology in the next section.

In the next group of words, GB must iterate, but GF cannot apply.¹¹ Because of its structural
condition and *Unary, GF can only apply to a form with \( \overline{\times \times \times} \), producing \( \overline{\times} (\times \times) \). Since \( \overline{\times} \) is
inserted only by GB, GF will not be called on unless \( \times \times \times \times \times \) is generated at some point in the
derivation, in which case it will be called on after GB applies.

(82) Words in which GB iterates¹²

<table>
<thead>
<tr>
<th>foot structure</th>
<th>stressed</th>
<th>surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. an.ku.ta(_)tua</td>
<td>(\times\times\times)(\times\times)</td>
<td>(án)(ku.tá(_))tuá</td>
</tr>
<tr>
<td>b. a.ku.ta.m(_)k</td>
<td>(\times \times \times)</td>
<td>(a.(_)k)(ta.m(_)k)</td>
</tr>
<tr>
<td>c. an.(_)ya.g(_)a</td>
<td>(\times \times \times)</td>
<td>(án)((_)ya.q(_))</td>
</tr>
<tr>
<td>d. at.max.č(_)i.qua</td>
<td>(\times \times \times)(\times\times)</td>
<td>(át)(max.č(_))quá</td>
</tr>
</tbody>
</table>

Finally, words with ternary intervals. The derivation should be familiar at this point. GF
ordered before GB, operating on a string of light beats, generates binary feet with skipped syllables
just as in Cayuvava or Tripura Bangla.

¹¹ In some words in (81), GB applies at more than one position. But this is simultaneous application, not iteration.
¹² a. ‘I’m going out now’ [116]; b. ‘(kind of food) (abl.sg.)’ [84]; c. ‘my older brother’ [110]; d. ‘I will back-
pack’ [115].
(83) Words in which GF applies\textsuperscript{13}

<table>
<thead>
<tr>
<th>foot structure</th>
<th>stressed</th>
<th>surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. pi.su.ta.qu.ni</td>
<td>(pi.sīu)qu.ta.qūni</td>
<td>pi.sīu: qu.ta.qū:ni</td>
</tr>
<tr>
<td>b. a.tu.qu.ni.ki</td>
<td>(a.tū)qu(ni.kī)</td>
<td>a.tū: qu.ni.kī</td>
</tr>
<tr>
<td>c. an.či.qu.kut</td>
<td>(án)či(qu.kūt)</td>
<td>án.či.qu.kūt</td>
</tr>
<tr>
<td>d. na:qu.ma.lu.ku</td>
<td>(nā:qu.ma.lū:kū)</td>
<td>nā:qu.ma.lū:ku</td>
</tr>
<tr>
<td>e. u.łu.ta:ku.ta:ga</td>
<td>(u.łu)ta:ku.ta:kä</td>
<td>u.łu:ta:ku.ta:kä</td>
</tr>
</tbody>
</table>

7.1.2. Post-stress phonology

The various observations made about the examples are summarized in (84).

\textsuperscript{13} a. ‘if he (refl.) is going to hunt’ [113]; b. ‘if he (refl.) uses them’ [113]; c. ‘we’ll go out’ [84]; d. ‘apparently reading it’ [89]; e. ‘he is going to watch her’ [104]; f. ‘if he (refl.) is going to undertake constructing a freezer for them’ [113].
(84)  a. A light open stressed nonfinal syllable always strengthens.
   1. If not followed by a heavy syllable, the vowel lengthens. See (81a–h), (82b),
      and (83c).
   2. If word initial and followed by a heavy syllable, it acquires a coda via gemination
      of the onset of the heavy syllable. See (83b,c).
   3. If noninitial and followed by a heavy syllable, its vowel becomes half-long. See
      (83b,c) and (83g,f).

   b. Onsets of heavy syllables always strengthen to a half-long consonant.

   c. Word final long vowels shorten. See (83c).

Strengthening of stressed light open syllables is very common in languages with iambic stress. This is discussed in detail in Hayes (p. 83). It usually takes the form of vowel lengthening.

If we regard the various cases in (84a) as varieties of iambic strengthening, the usual form of strengthening, (84.a.1), appears only if the stressed light open syllable is not directly followed by a heavy syllable. Heavy syllables always undergo onset strengthening, so the phonological issue is to see why a strengthened onset of the following syllable leads to iambic strengthening of an unusual kind and why the particular kind of strengthening depends up whether the light syllable is word initial.

The key is considering the strengthening of word initial light open syllables where a geminate is introduced. For example, \( \text{mú}(\text{yái}) \rightarrow (\text{múy})(\text{yái}) \), (81a). The light syllable becomes heavy not by lengthening the vowel but by acquiring a coda. Recall that initial CVC syllables are heavy. This indicates that heavy syllable strengthening makes available a timing slot linked to its initial syllable, and that this timing slot is used to add weight to the light syllable. This leads to the following proposal.
In addition there are is a rule Final Vowel Shortening (FVS). The order of application, after footing, is HSOG, then IS, then FVS. The rule HSOG is inspired by Hayes’ rule PLS which will be discussed later. Several significant differences will be clear.

To understand the relation of IS and HSOG, there are 3 possibilities to consider. Consider a sequence of syllables \( \sigma_1 \sigma_2 \). We need to consider the cases 1) \( \sigma_1 \) is subject to IS and \( \sigma_2 \) is heavy; 2) \( \sigma_1 \) is not subject to to IS and \( \sigma_2 \) is heavy; and 3) \( \sigma_1 \) is subject to IS and \( \sigma_2 \) is not heavy. We consider them in turn. The results will verify (84a,b).

Case 1: Suppose first that the form produced by HSOG appears after a stressed light open syllable (which I will suppose is CV). Giving content to the mora introduced by IS is particularly easy.

If the CV syllable is initial, this is exactly what appears at the surface: \( \text{núy.yai} \) and \( \text{čás.sá.í} \) are of this form. This accounts for (84a.2).

If the CV syllable is noninitial, further repair is needed since only initial syllables can have a consonant headed mora. By ‘head of a mora’ I mean the slot in the mora whose associated
A vocalic head is obtained by linking the mora to the vowel.

\[
\begin{align*}
\sigma & \quad \mu \\
\mu & \quad \sigma \\
\mu & \quad \mu \\
C & \quad V
\end{align*}
\]

The peculiarity of the structure produced in (88) is the timing slot which is associated with two phonemes.

This is the structure which surfaces with a half-long vowel and a half-long consonant; as in (82d) \((áť)(máx.čí)(quá) → (áť)(máx.čí')(q'úá),\) for example. It is tempting to conclude that timing slots that are split between phonemes simply divide up length so that each phoneme is realized with an extra half unit of length. I will assume that (or some equivalent statement) for vowels, but it is not so straightforward for the consonant. Recall that onset consonants of noninitial heavy syllables surface half-long whether or not the free timing slot introduced by HSOG is captured in the wake of iambic strengthening; in, for example, (81i) \(( nú:)(qá:) → nú:qá\) (with final vowel shortening) or (82a) \((án)(ku.táč)(tuá) → án.ku.táč.tuá\) for example.

---

14. The question of how the head is determined when there is a sonority tie is not relevant to the present discussion.
Neither leg of the geminate in (88) heads a mora. Such a geminate will be called a *nonmoraic geminate*. I assume that nonmoraic geminates are phonetically realized as somewhere in length between a moraic geminate and a nongeminate and that what surface as ‘half-long’ consonants in Chugach are simply nonmoraic geminates.

**Case 2:** If the free slot produced by HSOG is not used by IS, because it follows a syllable which is heavy or unstressed or C-final, I assume it simply becomes a geminate onset, as in (89) in the case of an unstressed light syllable (denoted by $\check{\sigma}$, contrasting with stressed $\acute{\sigma}$).

If the heavy syllable is word initial, or if the syllable preceding the heavy syllable is light with a consonantal onset, or heavy, the result is as in (89). A nonmoraic geminate results, which surfaces as a half-long onset, with no effect on the preceding syllable.

This accounts for (84a.3).

**Case 3:** From the standpoint of fleshing out the structure produced by the IS rule, this requires the most work since a timing slot must be epenthesized.

This accounts for (84a.1).
7.1.3. Other Analyses

7.1.3.1. Idsardi (1992)

The schema theory presented in Section 7.1.1 is a simplification of the stress system proposed in Idsardi (1992, p. 30), which is given below in full detail. Idsardi’s analysis does predict the correct foot structure.

(91) 1. Project $\times$ from each vowel.
2. Project $\langle$ at the left edge of the word.
3. Project $\langle$ at the left edge of $[(C)VV(C)]_{or}$.
4. Project $\rangle$ at the right edge of $[(C)VC]_{or} / \#_\_$. 
5. $\times \times \rightarrow \times \times \ \rangle \ \text{LR iterative.}$ 
6. $\times \times \rightarrow \langle \times \times \ \text{RL iterative.}$
7. Constraint: $\langle \rangle \times \times \rangle$

(91.1–91.3) are more or less equivalent to the assumptions made in Section 7.1.1, quibbles aside.

Rule (91.4) is a plausible attempt to maintain (91.1) and avoid the awkward stipulation that initial CVC syllables are bimoraic, but noninitial CVC syllables are monomoraic and to maintain (91.1). But it is not quite successful. It gives no way to explain why iambic strengthening of, for example, $(nú)(yái)$ is accomplished by gemination, but iambic strengthening of noninitial syllables, in $(a.tá)ka$ for example, is accomplished by vowel lengthening. If noninitial CVC syllables are monomoraic and iambic lengthening is mora addition, as we have assumed, there is the basis for an explanation.

(91.5–91.7) are impossible in the much more constrained theory presented in this paper. In the first place, the schema theory allows only a single iterative rule, with the direction determined by the LR/RL parametric choice. In Idasrdi’s proposal, there are not only two iterative rules, but they run in different directions. The rules as stated do not have local contexts, but they could
be reformulated to have local contexts. But the derivational constraint (91.7) is nonlocal, which cannot be avoided.

7.1.3.2. Hayes (1995)

In the Hayes’ framework, admissible feet in iambic systems must be of the form (\(\cdot\sigma\)) or (\(\cdot\)). In an LR system which chooses weak local parsing, footing is carried out by gathering material into admissible feet from left to right, step by step, starting with a foot at the left edge. At each step, a light syllable is skipped if possible.

This gives the desired result for Chugach words consisting of light syllables. For example,

\[
\begin{align*}
\circ \circ \circ \circ \circ \circ & \rightarrow (\circ \circ) \circ \circ \circ \circ \circ \\
& \rightarrow (\circ \circ)(\circ \circ)(\circ)
\end{align*}
\]

But it appears to make the wrong prediction for words like \(\acute{\text{a}}\text{n.ku.}\tilde{\text{a}}\text{t}\acute{\text{a}}\tilde{\text{x}}\tilde{\text{u}}\tilde{\text{a}}\). If \(\acute{\circ} \circ \circ \circ\) is footed, it predicts \((\circ)(\circ)(\circ)(\circ)\), not \((\circ)(\circ)(\circ)(\circ)\).

There are several options for how to proceed maintaining the templatic framework.

(92) a. Try to show that the appearance is deceiving and the structure is not \((\cdot)(\circ)(\circ)(\cdot)\).

b. Allow only a more limited set of admissible foot types in Chugach; \((\circ)(\circ)\) and \((\cdot)(\sigma)\).

c. Maintain that iterative footing in iambic systems is done on the basis of admissible feet \((\circ)(\cdot)\) and \((\cdot)(\cdot)\), but that something analogous to heavy syllable marking takes place prior to iterative footing.

The last option is closest my analysis. Without heavy syllable marking prior to iterative footing, the derivation would have gone wrong with

\[
\langle \times \times \rangle \times \times \times \times \times \rightarrow \langle \times \times \rangle \times (\times \times \times \times \times \times)
\]
Heavy syllable marking avoided this because the starting point for iterative footing was

\[ \left\{ \times \times \times \times \right\} \]

and *Unary forces

\[ \left\{ \times \times \right\} \times \times \left\{ \times \times \right\} \rightarrow \left\{ \times \times \times \times \right\} \left\{ \times \times \right\} \]

A solution along these lines is available in Hayes’ general terms. It could be proposed that heavy syllables are footed across the board prior to iterative footing, so that the starting point for iterative footing is \((-) \odot (--)\). This, effectively, was what Leer (1985a) proposed.

Instead, Hayes tries to show that the appearance is deceiving. He argues that the rule which lengthens the onset of the final syllable applies before footing and simultaneously adds a mora to the preceding syllable. Hayes call the rule is called Pre-long strengthening (PLS). If the various configurations in which PLS applies are considered, there is some support for this idea. We might entertain the idea that what appears to be iambic strengthening in (93a,b) is actually the result of a rule which applied before footing, not iambic strengthening in response to stress assignment.

(93) a. \(nu.yai \rightarrow n\acute{u}.y\acute{a}\)  
b. \(at.max.\acute{c}i.qua \rightarrow \acute{a}t.max.\acute{c}i.q'u\acute{a}\)  
c. \(an.ku.\acute{t}a\acute{y}.tua \rightarrow \acute{a}n.ku.\acute{t}a\acute{y}.tu\acute{a}\)  
d. \(an.\acute{c}i.qua \rightarrow \acute{a}n.\acute{c}i.q'u\acute{a}\)  
e. \(na:.na: \rightarrow n\acute{a}:.n\acute{\acute{r}}\acute{a}\)\textsuperscript{15}

Hayes is then faced with the task in (93c,d,e) of justifying the legitimacy of adding a mora (linked to the onset of the long syllable) to the pre-long syllable and explaining why there is

\textsuperscript{15} Hayes (p. 339) says that “from Leers’s description (1985, p. 87), it seems that such syllables are most likely adjusted to bimoraic, with loss of the medial mora: \(n\acute{a}rq\acute{a}’\). As far as I can see, however, Leer is quite specific that he is talking about truncated \textit{lengthened} vowels, as in \(nu.lu.kut \rightarrow nu.lu:k\acute{u}\acute{t}\), not underlying long vowels.
no overt effect. The road is long and torturous. (93d) proves the most problematic, although there are problematic aspects in all three cases. Since the medial syllable is made heavy by PLS, footing produces \( \tilde{\ddash} \tilde{\bar{\ddash}} \tilde{\ddash} \). A destressing rule, whose formulation is such that this is the only environment in which it operates, is needed to return the structure to \( \tilde{\ddash} \tilde{\ddash} \). This is already unconvincing, but Kager (1993) raises another serious question about PLS as a prelude to footing. The issue is this. Footing following PLS produces \( \tilde{\ddash} \tilde{\bar{\ddash}} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \) in (93b), but Kager observes that there are foot boundary sensitive effects in Chugach which show that the structure is actually \( \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \). There are plausible augmentation processes that might accomplish \( \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \rightarrow \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \). But then another unmotivated stipulation must be invoked to keep this augmentation process from producing the structure \( \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \). The foot boundary effects show that the structure is \( \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \). The conclusion to be drawn from the failure of Hayes’ attempt to show otherwise, is that feet in Chugach are always \( \tilde{\ddash} \tilde{\ddash} \) or \( \tilde{\ddash} \tilde{\ddash} \tilde{\ddash} \). That is, they are bimoraic. In a templatic approach to the computation of stress, this means either: 1) accepting the idea that there are (noniterative) footing operations which are carried out before iterative footing; or 2) that the supposed ideal iambic foot \( \tilde{\ddash} \tilde{\ddash} \) is excluded from the template.

7.2. Winnebago

I take as a starting point the analysis of Winnebago in Halle and Idsardi (1995, p. 430–39), with the analysis of Hayes (1995, p. 346–65) providing important background. The data is from Susman (1943), Miner (1979, 1981, 1989), Hale and White Eagle (1980), and Halle (1990). Since there is some inconsistency in the data, it is important to know the source of examples. The examples below will refer to pages in S43, M79, M81, M89, HWE, and H90.

The footing system (94) suffices to correctly stress words whose syllables are CV(C).
(94) Winnebago footing system (preliminary):

LR, iambic

Marking Rules: \( \text{EDG}^{FF} \)

Iterative Rule: \( \left\{ \begin{array}{c} GF \\ GB \end{array} \right\} \); *Unary

Except for the fact that *Persist constrained delimiter insertion in Cayuvava, the system (94) is just the mirror image of the Cayuvava system, which has only light syllables. Cayuvava is RL trochaic while Winnebago is LR iambic.

Some examples follow.

(95) a. \(\text{hi.žá} \times \ddot{x} \rangle \) ‘dress’ HWE:130

b. \(\text{ho.ta.xí} \times \{\ddot{x} \times \} \) ‘expose to smoke’ M79:28

c. \(\text{ho.či.či.ňk} \times \{\ddot{x} \times \} \times \) ‘the taste’ M79:28

d. \(\text{ho.ki.wá.ro.ké} \times \{\ddot{x} \} \times \ddot{x} \) ‘swing (n.)’ M79:28

e. \(\text{ho.ki.wá.ro.ro.ké} \times \{\ddot{x} \} \times \{\ddot{x} \times \ddot{x} \} \) ‘swing (v.intr.)’ M81:342

All of the complications in Winnebago stem from the marking rules, as they apply to heavy syllables and to so-called Dorsey sequences (surface sequences of two light syllables which derive from certain underlying heavy syllables). If the delimiters that result from the marking rules are known, the rest of the derivation is completely straightforward.

The edge-marking rule is \(\times \rightarrow \times / \# \). The edge is marked by making the first beat of the word a downbeat. I take downbeat here to mean simply a beat which introduces a foot; and an upbeat to be the first beat in a foot. This is in analogy to music where a downbeat can be thought of as beat that directly precedes a measure. In Chugach, in contrast to Winnebago, edge marking made the first beat of the word an upbeat, the first beat of a foot.
7.2.1. Heavy-syllable marking

Initial heavy syllables behave like a pair of light syllables in the metrical computation. Compare (96a,b,c) with (95b,c,d).

(96)   a.  ho:ˇcák   ×(× ×)   ‘Winnebago’    M79:27
   b.  ho:ˇcag ra ×(× ×)×   ‘the Winnebago’    M79:27
   c.  ha:ki. tu.jik ×(× ×)× ×)   ‘I will pull taught’    HWE:118

It could be, that at the stage in the derivation that footing takes place, what appear at the surface as CVV syllables are CV.V syllable sequences; ho.o underlying and ho: at the surface, for example. Or, it could be that a delimiter is inserted between the beats of a word initial heavy syllable. I will return in Section 7.2.4 to discuss syllable integrity, the idea that delimiters cannot intervene between the beats of a bimoraic syllable. Whatever the account of apparent initial heavy syllable splitting, there is no evidence that noninitial heavy syllables behave the same way. If the heavy syllable in hit.ˇet.ˇéi.re, for example, were a light syllable sequence, we would expect stress on the final syllable (hit.ˇet.ˇé.i.re). Compare with (95d). There are different routes that can be taken to explain the difference. I will assume that what is different about noninitial syllables is not a question of their internal syllable structure, but that there is a heavy syllable marking rule similar to the heavy syllable marking rule in Chugach; a left delimiter is inserted to the left of noninitial heavy syllables.

We then need an explanation for why a left delimiter is not inserted to the left of word initial heavy syllables. Why are they exempted from heavy syllable marking? It could be that the order of the two marking rules, EDG\textsuperscript{FF} and heavy syllable marking, is such that EDG\textsuperscript{FF} applies first and *Unary then prevents heavy syllable marking. Instead, I think the answer is in the way that Winnebago marks prosodic beginnings—by creating a downbeat. That is, by applying the rule
×→×⟨. There is no beat before an initial heavy syllable, so no downbeat can be created. More formally, we can write the marking rules as:

(97) \[
\begin{align*}
\times &\rightarrow \times \langle / \; \_\_ \times \\
\times &\rightarrow \times \langle / \; \# \_\_ \\
\end{align*}
\]

In effect, the first rule says: make beats before heavy syllables downbeats. The heavy syllable marking rule will be called HVY\(^D\), with D a reminder that it is a downbeat rule, to distinguish it from HVY, which is an upbeat rule. Using the rule names, we can write (97) as (98).

(98) \[
\begin{align*}
\text{HVY}^D \\
\text{EDG}^{FF}
\end{align*}
\]

Now consider the computation of the foot structure of hit.\textit{ët.ëi.re}, supposing that the iterative rule is as in (94) and the marking rule is (98).

(99) \[
\begin{align*}
\times &\times \times \_\_ \times \\
1. &\text{HVY}^D \times \times \{\times \_\_ \} \times \\
2. &\times \times \{\times \times \} \times \\
3. &\text{GB} \times \times \{\times \times \} \times \\
4. &\times \times \{\times \times \} \times \\
5. &\text{SP} \times \times \{\times \times \} \times
\end{align*}
\]

At step 1, HVY\(^D\) inserts a delimiter before the two beats of the syllable and inactivates the second beat (because of the ODP). EDG\(^{FF}\) cannot apply after HVY\(^D\) because it is constrained by *Unary. The iterative rule then takes over. It first sees two current targets, but can apply to neither one. It marks them as inactive in step 2 and iterates.

That HVY\(^D\) is a downbeat rule which inactivates the beat before the heavy syllable beats is crucial in preventing #××⟩⟨××⟩×. Compare (99) with how the derivation would proceed with the heavy syllable marking rule HVY rather than HVY\(^D\).
More illustrative examples are in (101). As usual, the delimiters inserted by the marking rules are doubled for emphasis and the beats inactivated by marking rule application are marked with an asterisk under the beat.

(101) Heavy syllables

<table>
<thead>
<tr>
<th>Example</th>
<th>Delimiter</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>hit.ˈat.ˈá:k</td>
<td>×(×(××)×)</td>
<td>‘he (moving) talked’</td>
<td>S43:10</td>
</tr>
<tr>
<td>na.ˈwæk</td>
<td>×(×(××)×)</td>
<td>‘he (moving) was singing’</td>
<td>S43:10</td>
</tr>
<tr>
<td>ma.ˈcí.ɾe</td>
<td>×(×(××)×)</td>
<td>‘they cut a piece off’</td>
<td>M79:29</td>
</tr>
<tr>
<td>ha.ɾa.ɡí.ɲá.ˈće</td>
<td>×(××(××)×)</td>
<td>‘you will suffer it’</td>
<td>S49:139</td>
</tr>
<tr>
<td>ha.ˈjá:k</td>
<td>×(××)×</td>
<td>‘he (moving) saw’</td>
<td>S43:10</td>
</tr>
<tr>
<td>ho.ˈçák</td>
<td>×(××)×</td>
<td>‘Winnebago’</td>
<td>M79:27</td>
</tr>
<tr>
<td>nɪk.ˈší.ɾi.ɲɪk.ˈjá.ne:ˈná</td>
<td>×(××)× ×(××)×</td>
<td>‘it will not be weak for you’</td>
<td>S43:41</td>
</tr>
<tr>
<td>hi.ˈʒá.ˈkí.ːçá.ˈʃú.ɲá.ˈná.ˈgá</td>
<td>×(××)× ×(××)× ×(××)×</td>
<td>‘nine and’</td>
<td>M79:25</td>
</tr>
</tbody>
</table>

The leftmost delimiter in (101d,e,g) is inserted by EDGFF, not HVYD.

7.2.2. DL (Dorsey’s Law) sequences

There is a broad class of underlying CRV syllables (R a resonant) which split and surface as CV.RV sequences, with the V reduplicated to furnish the nucleus of the first syllable; pro → po.ро, for example. See Miner (1989) for a thorough discussion. The metrical properties of DL sequences, as Miner called them, have been of great interest and the subject of numerous studies.
I suppose that DL sequences are formed before footing occurs, but that the phonology
distinguishes DL sequences from other sequences of light syllables.\textsuperscript{16} I also assume that
Winnebago marks the beats of DL sequences in addition to marking the beats of heavy syllables.
The DL marking rule is a downbeat rule, just like the edge-marking rule EDG\textsuperscript{FF} and the heavy
syllable rule HVY\textsuperscript{D}. The first beat of the DL sequence is made a downbeat, like the first beat of the
word is made a downbeat. In representations, the two beats of a DL sequence will be represented
by (graphically) joining the beats as, $\times \rightarrow \times \langle / _{\cdots} \times$. The rule is $\times \rightarrow \times \langle / _{\cdots} \times$. It is subject to *Unary like all the other delimiter insertion
rules. It will be called DSY\textsuperscript{FF} using the same convention as in the name EDG\textsuperscript{FF} (in LR systems).
DSY\textsuperscript{FF} inserts a forward delimiter forward of the first beat of DL sequences.

Although DL sequences and heavy syllables both trigger marking rules, the rules operate
slightly differently in the two cases. The first beat of a DL sequence is the target of the DL
sequence marking rule, but the beat preceding a heavy syllable is the target of the heavy syllable
marking rule. I believe the difference is an effect of a constraint against splitting the two beats
of a heavy syllable between feet, so-called Syllable Integrity. This explanation, however, runs

\textsuperscript{16} Exactly how the necessary derivational history is built into the representation is a delicate question. I assume
that at each step the phonology responds only to what the current representation is, not how it came to be what it is.
One approach is to suppose that the reduplicated vowel in the first syllable of the DL sequence is the first slot of the
long-distance geminate created by reduplication. See Frampton (2009) for the theoretical underpinnings of this idea.
Miner (1989, fn. 3, p. 169), in fact, suggests the representation
\[ \begin{array}{c}
k \\ C \\ V
\end{array} \quad \begin{array}{c}
n \\ C \\ V
\end{array} \]
as a possible explanation for the fact that the nasal affects the vowels in both syllables of the DL sequence. The surface
form of the DL sequence derived from \textit{knu} is \textit{k\u{a}n\u{a}}, with both vowels nasalized. Although Miner does not pursue the
implications of representations like this, he is in effect suggesting a general approach to explaining overapplication
effects in reduplication. I was unaware of Miner’s insight in writing Frampton (2009), where this idea is central to the
theory developed there.
up against the fact that EDG\textsuperscript{FF} does split initial heavy syllables. Careful discussion is called for, which will be put off until Section 7.2.4.

In the examples below of the effect of DSY\textsuperscript{FF}, the beats which are inactivated by the marking rules are again indicated and DL sequences are indicated by dotted connectors.

(102) Words with DL sequences

\begin{enumerate}
\item \textit{hi.ko.ro.hó} \hfill \times \times\times\times \hfill \langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘prepare, dress (3sg.)’} \hfill \text{M79:30}
\item \textit{ha.nip.śā.nā} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘I swam (declar.)’} \hfill \text{WE82:314}
\item \textit{wi.ki.ri.pā ras} \hfill \times\times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘flat bug’} \hfill \text{HWE:131}
\item \textit{wa.ki.ri.pó.ro.pó.ro} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘spherical bug’} \hfill \text{HWE:131}
\item \textit{wa.pó.ro.pó ro} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘snowball’} \hfill \text{M79:30}
\item \textit{ču.gi.śa.nāp.kē} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘kingbird’} \hfill \text{M81:342}
\item \textit{ke.re.kē.reš} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘colorful’} \hfill \text{M79:30}
\item \textit{hi.rat.ʔát.ʔa.śa.nāk.śa.nā} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘you are talking’} \hfill \text{HWE130}
\item \textit{ha.ra.kì.śu.ru.jık.śa.nā} \hfill \times\langle\langle\times\rangle\langle\times\rangle\langle\times\rangle\langle\times\rangle\hfill \text{‘pull taught (2 sg. declar.)’} \hfill \text{HWE:126}
\end{enumerate}

The effect of the downbeat nature of the marking rules is particularly evident in (102h), which has a medial sequence of 3 unstressed beats, two of them unfooted. Note that word final DL sequences cannot be marked because DSY\textsuperscript{FF} is blocked by *Unary. Note also that even when the first syllable of a DL-sequence is made a downbeat, and inactive, it can end up bearing stress. See (102d,e).

We are now in position to give the full Winnebago stress system.

(103) Winnebago: Mora counting, LR, iambic

\begin{enumerate}
\item Mora Projection: CVV(C) syllables bimoraic, others monomoraic
\item Delimiter Insertion:

\begin{align*}
\text{Marking Rules: } & \left[ \begin{array}{c}
\text{DSY}^{\text{FF}} \\
\text{HVV}^\text{D} \\
\text{EDG}^{\text{FF}}
\end{array} \right] \\
; & \text{*Unary}
\end{align*}

\begin{align*}
\text{Iterative Rule: } & \left[ \begin{array}{c}
\text{GF} \\
\text{GB}
\end{array} \right]
\end{align*}
\item Main stress: Leftmost
\end{enumerate}
7.2.3. Binary/ternary alternation

If there are long enough strings of light beats, the environment for applying GF will arise. The word ho.ki.wá.ro.ro.ké, (95e), for example, has the derivation (104). Several of the early steps, which repeat footing already discussed, are omitted.

\[(104) \quad \cdots \rightarrow x\{x \Hat{x}\}x\times \times \rightarrow x\{x \Hat{x}\}x\{x \times \times \rightarrow x\{x \times \Hat{x}\}x\{x \times \times \}
\]

What follows is the structure of all the words in the data in which GF in (103) is applies.

\[(105)\]

a. wi.rá.guš.ge.rá \(\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘the stars’ M79:28
b. ho.ki.wá.ro.ro.kè \(\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘swing (v.intr.)’ M81:156
c. wi.pá.má.Ke.rê \(\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘rainbow’ M81:156
d. hi.zhú.go.ki.rús.ge \(\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘double-barreled shotgun’ M79:25
e. hi.zâ.kí:čâš.gu.nî \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘nine’ M79:25
f. yu.kí:hi.nâng.kî \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘if I could mix them’ H90:149
g. gu.sí:ča.nân.rî \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘the day before yesterday’ H90:149
h. te.jâ.ňâ.gop.ké \(\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘pelican’ M81:342
i. ni:wá.kâ.čâg.rá \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘Devil’s Lake, Wisconsin’ M81:342
j. hu:wá.žug.wi.rá \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘September (elk-call month)’ M81:342
k. măj.ta.wus.hí.ra \(\times\times\{x \times \Hat{x}\}\times\{x \times \Hat{x}\}\) ‘May (earth-drying month)’ M81:342

† There is exceptional stress on the first syllable, but what follows is ordinary ternary footing. I assume here that what is exceptional is that edge-marking does not apply, although other explanations are possible.

There are also words in the data for which (103) makes an incorrect prediction. In order to avoid confusion, it is worth precisely specifying two rule systems which will be contrasted discussion.
The ternary system correctly stresses the words in (105); the binary system does not. But the binary system correctly stresses the words in (107) and the ternary system does not.

(107) Examples in which GF does not apply, but could if it were available

a. \( wa:\text{-}r\acute{a}.\text{gu}\text{-}\text{š.g}e.\text{-}r\acute{a} \) \( x(\times \times)\times \times \) ‘the stars’ \( \text{HWE:118} \)

b. \( ha:\text{-}k\acute{ı}.\text{tu}\text{-}j\acute{i}k.\text{ša}n\acute{a} \) \( x(\times \times)\times \times \times \) ‘pull taught (1sg. declar.)’ \( \text{HWE:126} \)

c. \( ha:\text{-}k\acute{i}\text{-}r\acute{u}\text{-}j\acute{i}k.\text{ša}n\acute{a} \) \( x(\times \times)\times \times \times \) ‘pull taught (3sg delar.)’ \( \text{HWE:126} \)

d. \( ha:\text{-}k\acute{i}\text{-}tu\text{-}j\acute{i}k.\text{ga}j\acute{a} \) \( x(\times \times)\times \times \times \) ‘after I pull taught’ \( \text{M89:152} \)

e. \( ha:\text{-}k\acute{i}\text{-}r\acute{u}\text{-}j\acute{i}k.\text{ga}j\acute{a} \) \( x(\times \times)\times \times \times \) ‘after he pulls taught’ \( \text{M89:152} \)

Contrast (106a) \( wa:\text{-}r\acute{a}.\text{gu}\text{-}\text{š.ge.\text{-}r\acute{a}} \), from Miner (1979), with (107a) \( wa:\text{-}r\acute{a}.\text{gu}\text{-}\text{š.g}e.\text{-}r\acute{a} \), from Hale and White Eagle (1980). It is the only word which appears in both data sets. Aside from that example, the other four examples are different forms of the same verb.

All of the data from Miner (1979, 1981) is stressed as desired by the ternary iterative rule; all of the data from Hale and White Eagle (1980) and Miner (1989) are stressed as desired by the binary iterative rule. Hayes (1995, p.352) says that (102h) “might be analyzed as ternary.” In our analysis, the binary rule and the ternary rule give exactly the same results. In Hayes analysis, however, (102h) must receive a weak local footing parse, or stress is assigned incorrectly.\(^{17}\) For Hayes, (102h) is the only Hale and White Eagle example which requires weak local parsing.

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\(^{17}\) This makes the important point that the binary/ternary distinction cannot be made pre-theoretically.
There is enough evidence that the binary/ternary alternation in Winnebago is a real phenomena and not just a data artifact that theories of Winnebago stress must have an account of the phenomenon. We already saw in Estonian a case where GF could be optionally dropped from the iterative scheme.\textsuperscript{18} Winnebago seems to be no different. The fact that the variation is not randomly scattered, but seems to concentrate the ternary pattern in the early Miner data, may indicate that the variation is dialectical.

7.2.4. Syllable Integrity

In Section 7.2.1 I assumed that EDG\textsuperscript{FF} could insert a delimiter between the beats of a heavy syllable. This contradicts the principle of Syllable Integrity in the form that was originally proposed by Prince (1976). He proposed that the rules of foot construction cannot split syllables, as a derivational constraint. I assume a weaker version of Syllable Integrity and take it to be a condition on representations at some level, not an output condition on rules (i.e. not a derivational constraint). If suitable repair operations are available, which produce representations satisfying *SplitSyl, languages can choose to allow derivational syllable splitting in some or all contexts.

Frampton (2008, p. 245) proposed that if more or less automatic repair was available, a language could contain a foot delimiter insertion rule which violated Syllable Integrity. The idea of derivational violation of a basic phonological principle followed by later repair to satisfy the principle (as a condition on representations at some level) is developed in Frampton (2009). It is pointed out there that much work in autosegmental phonology which relies heavily on the No Crossing Constraint, makes a similar assumption. If Syllable Integrity is an output condition at some level, the simplest way to ensure that an output condition is to require inputs to satisfy the condition and that *SplitSyl is imposed as a derivational constraint on all rule application. There

\textsuperscript{18} For simplicity in analyzing Estonian, I assumed an unordered scheme. Making GF optional is equivalent.
is therefore a decided tendency to avoid violations altogether. But certain exigencies may prompt a grammar to allow derivational violation and later repair.

Certain Syllable Integrity violations are much easier to repair than others. Contrast (108a) and (108b), which shows what is involved in splitting bimoraic syllables into a sequence of monomoraic syllables. It compares splitting a CVV syllable and repairing a split CVC syllable.

If (108a) is needed to repair a Syllable Integrity violation, the cost is relatively small. There are other ways that a split CVC might be carried out, but in (109b) I supposed it was something like Dorsey splitting. It is clearly a much more complex operation that what is required in (109a). In general, languages obey Syllable Integrity derivationally, but some languages allow CVV splitting with the repair (108a). As far as I know, there are no languages that allow CVC splitting in response to footing demands, but I do not think it should be ruled out in principle.

Now consider the claim that EDG_FF violates Syllable Integrity if there is an initial heavy syllables. Heavy syllables in Winnebago, are (C)VV(C) at the point in the derivation that the footing rules apply. They can be restructured as a (C)V.V(C) sequence of two light syllables, at some cost. What is the benefit? Allowing EDG_FF to split heavy syllables means that all words begin with an unstressed syllable. It is plausible that the benefit of prosodic uniformity at the leading edge of words is worth the cost of Syllable Integrity driven repair.
Why is it only EDGFF that violates Syllable Integrity? Hayes points out that Miner’s (1979) analysis of the development of Winnebago accent from an earlier Siouan language as tone shift to the right is useful in understanding the Winnebago marking rules. Although Hayes pursues a different idea, he mentions that “Tone Shift might be construed as a wholesale Prosody Shift.”

What might a wholesale prosody shift look like? I interpret it to be a shift from the basic marking operation \(\times \to \langle \times \rangle\), which marks \(\times\) as an upbeat, to \(\times \to \times \langle\rangle\), which marks \(\times\) as a downbeat. This is akin to musical syncopation.

Ignoring marking rule order and ignoring the possibility that footing took place before Dorsey splitting in the earlier language, a ‘perfect prosodic shift’ would be (109).

\[
\begin{align*}
\{ \times &\to \langle \times / \_\_\_\times \} \\
\times &\to \langle \times / \_\_\_\_\_\_\times \} \\
\times &\to \langle \times / \# \_\_ \} \\
\} &\to \{ \times &\to \times \langle / \_\_\_\_\_\times \} \\
\times &\to \times \langle / \_\_\_\_\_\times \} \\
\times &\to \times \langle / \# \_\_ \} \\
\}
\end{align*}
\]

This shift would split all nonfinal heavy syllables, at considerable computational cost. Instead of a ‘perfect shift’, Winnebago avoided the problem of wholesale heavy syllable splitting by retaining the original heavy syllable marking rule. Prosodic shift therefore furnishes a plausible account of how Winnebago’s relatively complicated array of marking rules may have developed.

Syllable Integrity therefore gives an account of why marking heavy syllables is different than marking the word edge. The former in effect, marks the beat before the beats of the heavy syllable. The later marks the word edge directly. This difference corresponds, in Hayes’ tone shift analysis, to the stipulation that tone cannot shift off a heavy syllable.
7.2.5. Other analyses

7.2.5.1. Hayes (1995)

Hayes develops Miner’s idea that Winnebago underwent wholesale tone shifting into a synchronic account of Winnebago stress. The analysis is a mixed metrical/tonal analysis of stress. The basic idea is that stress is realized as tone and that tone shifting follows the metrical derivation and stress assignment. What appears as surface stress is tone that has been first associated with stress, but then undergone tone shift.

Hayes derives the stress pattern of *hokíwárokè* ‘swing (n.)’, for example, as in (110).

\[
\begin{array}{cccccccc}
\text{metric derivation} & \rightarrow & (\times \times)(\times \times \times) & \rightarrow & (\times \times)(\times \times \times) \\
H & H & H & H & H
\end{array}
\]

The metric analysis is straightforward LR iambic footing, with high tone the acoustic correlate of foot stress. Tonal rules follow, which shift stress to the right. The theory makes almost all of the correct predictions.

The weakness of the analysis is that the number of choices available in footing and then in tone shift, the latter with a number of rules which operate in very specific environments, give so many points of adjustment that fitting the empirical facts is not a compelling argument for the theory. There is a rule, for example, which shifts tone off light syllables and initial heavy syllables, but not off noninitial heavy syllables. There is no argument that initial heavy syllables group with light syllables or for why tone shifts off light syllable but not heavy syllables. Hayes admits that the tonal rules “have properties that look metrical in character.”

The most appealing aspect of the analysis is the explanation of the fact that a syllable immediately following a DL sequence is invariably stressed. In the metrical stage of derivation
the Dorsey syllable is bimoraic, hence gets high tone, the expression of stress. Afterward, Dorsey splitting takes place, with high tone on the second syllable of the DL sequence. Then it migrates to the following syllable under Tone Shift. For example,

\[ \text{(pras) (σ ... \rightarrow (pa ras) (σ ... \rightarrow } (pa ras) (σ ... \]

Unfortunately, although the idea is appealing and comes close to predicting the facts, it does not quite do so. It fails to predict the interior stress lapse in \text{hi.rat.?át.?a.šq.nāk.šq.nā}. The analysis in Hayes’ theory is given in (111).

\[(\text{ha.rat})(\text{?at.?a})(\text{šq.nāk})(\text{šq.nā}) \rightarrow (\text{ha.rat})(\text{?at.?a})(\text{šq.nāk})(\text{šq.nā})\]

\[\text{Tone Shift} \quad (\text{ha.rat})(\text{?at.?a})(\text{šq.nāk})(\text{šq.nā}) \rightarrow (\text{ha.rat})(\text{?at.?a})(\text{šq.nāk})(\text{šq.nā})\]

The prediction of a medial tone is incorrect.

Recall the derivation in our analysis was (112).

\[(\text{x x x x x x x x x}) \rightarrow (\text{x x}) (\text{x x}) (\text{x x}) (\text{x x}) \rightarrow (\text{x x}) (\text{x x}) (\text{x x}) (\text{x x})\]

The inactivation of a beat preceding a Dorsey syllable by Dorsey marking is the cause of the lapse. There is nothing corresponding in Hayes’ analysis and it is difficult to see how this idea could be adapted to Hayes’ theory.

In sum, although the account of the post-accenting properties of Dorsey’s syllables is appealing, the complexity of the analysis (both a prosodic and a tonal derivation are required) and the empirical problem noted above make it unsatisfactory.
7.2.5.2. *Halle and Idsardi* (1995)

H&I’s approach to deriving the post-accenting properties of Dorsey syllables is to suppose that Dorsey syllables are underlying monomoraic syllables, but are marked like heavy syllables by inserting a left delimiter before the beat corresponding to the Dorsey syllable. Dorsey splitting then intervenes in the footing process and applies before iterative footing.

The appealing aspect of Hayes’ proposal is that, prior to footing, nothing special needs to be said about Dorsey syllables; they behave just like any other heavy syllable. My account needed to specify a marking rule that acted on the DL sequence, as if remembering its past status as a heavy syllable. H&I’s account needs to specify a marking rule that acts on a monomoraic syllable, as if anticipating its future status as bimoraic.

The most problematic aspect of H&I’s analysis is the mechanics which must be stipulated for the interaction of delimiters and Dorsey epenthesis; the added beat is assumed to come before the delimiter, as illustrated in (113).

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19. In fact, the phonology does appear to remember the underlying status of DL sequences in some way. Miner (1979) call DL sequences “fast sequences” and says that “the sequences are spoken (and apparently, sung) faster than normal CVCV sequences.”
No justification or even plausibility argument is given.

Finally, H&I have only a stipulative solution to the problem of accounting for the medial stress lapse in _hi.rat.?a.šą.nąk.šą.ną_ and related examples (101g,h) involving lapses before heavy syllables. They impose the otherwise unmotivated derivational constraint *⟨⟩. They justify it partially by the fact that it is needed in Latin. We saw, however, in Section 5.3.4, that the mechanism of iterative rule application, incorporating the Once and Done Principle, accounted for the Latin facts just as it accounts for the Winnebago facts.

It is worth mentioning that the derivational constraint *⟨⟩ can not even be stipulated in the Schema Theory. As a constraint on beats, *×/___⟩ would be required. But that is not a local constraint; it involves more than the items adjacent to the beat whose satisfaction is being evaluated.

8. Summary

Most importantly, the Schema Theory of Footing adds considerable evidence in favor of Idsardi’s proposal that footing is carried out by one-sided delimiter insertion into a beat tier. The Schema Theory modifies the Halle-Idsardi theory, yielding better empirical coverage and less stipulative analyses. It allows straightforward analyses of binary/ternary alternation in Estonian and Winnebago, whereas there are no Halle-Idsardi analyses of these alternations. It supports Hammond’s proposal that ternary footing is binary footing with a beat skipped between feet but gives evidence that Hayes’ proposed weak/strong local parsing parameterization of a footing algorithm is incorrect.
The prediction, which follows from simple locality conditions, that there are only two core footing patterns, binary and ternary, is a significant accomplishment.

Significantly, it formulates footing theory in a traditional phonology framework. There is no special footing “algorithm”; simply ordinary phonological rules operating in simple environments. Whatever complexity results is due to the interaction of these simple rules. Binary/ternary alternation is a simple question of rule order, a traditional source of phonological variation.
References


