This paper is presently a draft (3rd), written carefully. I would greatly appreciate comments, questions, and criticism. Send to `j.frampton@neu.edu`.

Heavy Syllable Effects in Some Trochaic Syllable-Counting Word Stress Systems*

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I assume that the prosodic shape of words is represented by a metrical grid Liberman (1975). It shows the relative prominence of the metrical beats associated with the syllables (or moras) of the word. The metrical grids associated with the two Finnish words (*ér.go.nò.mi.a* and *ká.las.te.lèm.me*) are given below.

```
              ×                               ×
              ×       ×                       ×               ×
              ×   ×   ×   ×   ×               ×   ×   ×   ×   ×
(1)      a.   er  go  no  mi  a          b.   ka  las te  lem me
```

The bottom grid line is called the beat line. Finnish projects syllables to the beat line, hence the term *syllable-counting*. Mora-counting languages project moras, not syllables.

I assume that the representations (1) are derived from grouping beats on the beat line into feet. The higher lines are not projected until after the feet have been demarcated.

```
             [×   ×][×   ×] ×              [×   ×] ×  [×   ×]
(2)      a.   er  go  no  mi a         b.   ka  las te lem me
```

(2a) and (2b) are just the bottom lines of the full bracketed-grid representations proposed by Halle and Vergnaud (1987). A foot is just a string of beats on the first level with brackets marking the boundaries. We will call the structures in (2) *bare foot structure*. The metrical grid is erected over the bare foot structure. In Finnish, the line above the beat line in the representations (1) is found by projecting the leftmost beat in each foot to the higher line (trochaic stress) and the highest line is then found by projecting the leftmost beat on the second line to the top line (End Rule Left).

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Idsardi (1992) realized that it was not necessary to form the groups one by one, inserting balanced brackets at each step. The bare foot structures in (2) are a reflection of the structures (3), given the assumption that feet are maximal subject to the constraints that the (3) representations naturally impose.

(3)	a.	× ×] × ×] × *er go no mi a*	b. × ×] × [× × *ka las te lem me*

Call these representations I(dsardi)-representations.

The foot structure (2a) could be derived as shown in (4). The operation Bin can be specified in different ways. More on this below. Exactly how the computation of the bare foot structure from the I-representation is carried out most efficiently is not as simple as it may look, because long-distance relations may, in general, be needed. But what the transformation BrackGrid must accomplish is clear.

(4)	
	× × × × ×
Bin	× ×⟩× × ×
Bin	× ×⟩× ×⟩×
BrackGrid	⟨× ×⟩⟨× ×⟩× [1]

The goal of this paper is to introduce and defend a major revision of the H&I theory, which will be called *focused delimiter insertion*. H&I base iterative delimiter insertion on rules like (5).

(5) Insert a left (right) boundary for each pair of elements.

Halle and Idsardi (1995, p. 418)

There is a conceptual problem in this approach in that the rule applies to pairs of beats, although there is no 'pair of beats' object in the theory. (5) is an unnecessary holdover of the view that iterative footing is carried out foot by foot.

I will assume that delimiter insertion rules target individual beats, not pairs or triplets of beats. The iteration is a standard left to right directional iterative rule; it goes down the line of beats, targeting the beats in turn. Rather than iterating $[\times\times \rightarrow \times\times\rangle]_{LR}$, for example, Bin could be taken to be $[\times \rightarrow \times\rangle \;/\; \times \_\_]_{LR}$. This may seem like a trivial technical detail, but it has major advantages. This paper will try to show that it improves both the explanatory and empirical adequacy of the H&I theory.

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1. Brackets were used above to make the connection with bracket-grid representations clear. But balanced foot delimiters '⟨' and '⟩' are equivalent and simplify the translation of the Idsardi representation to the bare foot structure representation.

Section 1. Preliminaries

1.1 Feet

The bare foot structure makes explicit everything we need to know about foot structure; the group-initial beat and the group-final beat. Stress assignment is

(6) Trochaic: $\times \rightarrow \overset{\times}{\times} \,/\, [\,\_\_$ Iambic: $\times \rightarrow \overset{\times}{\times} \,/\, \_\_\,]$

I do not assume there is some 'foot object' in the theory. 'Foot' is simply a description of the string of adjacent beats in the bare foot structure which are demarcated by foot delimiters.

1.2 Local Conditions on Beats

The beat line is a string of beats and delimiters, which are called *beat line items*. A condition on beats is called local if its value (true or false) at a beat $\times$ is independent of beat line items which are not adjacent to $\times$. Conditions like $/\ \_\_\times$ or $/\ \langle\,\_\_$ are clearly local, with no comment needed. There are other important local conditions which do require some comment.

1. Say that a beat is *locally footed* if it is the context $/\ \_\_\rangle$ or the context $/\ \langle\,\_\_$. Say that a beat is *trapped* if it is locally footed but is not adjacent to another beat. Under the conditions on delimiter insertions (DIRs) which will be imposed shortly, once a beat is trapped it will remain trapped for the remainder of the derivation of the bare foot structure If a beat is trapped at the point that the bare foot structure is computed, it will be in a unary foot. In fact, a beat will be in a unary foot in the bare foot structure if and only if it is trapped at some point in the derivation. We will therefore call the constraint against trapped beats *UNARY. *UNARY is a local condition since 'locally footed' is a local condition and 'adjacent to a beat' is a local condition.

2. In a condition like $/\ \_\_\times\#$, for example, # is not a beat line item. I assume that *beats can have properties*. # is a diacritic indicating that visually nearest beat has an edge property. So, for example, $/\ \_\_\times\#$ is true of a beat which is left adjacent to a beat with an edge property. It is a local condition, depending only on the right adjacent beat line item and its properties..

1.3 Focused delimiter insertion

There are 4 ‘elementary’ delimiter insertion rules: $\times \to \times\rangle$, $\times \to \times\langle$, $\times \to \langle\times$, and $\times \to \rangle\times$. Delimiter insertion rules (DIRs) have the form (7).

(7) $R = \rho \ / \ SC \ ; \ DC$

ρ is one of the elementary delimiter insertion rules, and SC (the rule’s structural condition) and DC (the rule’s derivational constraint) are local conditions on beats. The rule is applicable at a beat if the beat satisfies SC and, if the delimiter were inserted, beats adjacent to the inserted delimiter would satisfy DC. ρ is called the base rule of R and R is sometimes said to be based on ρ. R applies by applying ρ.

To illustrate this, consider the DIR

$R = \times \ \to \ \times\,\rangle \ / \ \_\_\times \ ;$ *Unary

The effect of SC and DC in various configurations is shown in the derivation (8), which results from iterating R from left to right across a string of beats.

(8)

		R applies	
1.	$\underset{\blacktriangle}{\times}\ \times\ \times\ \times\ \times\ \times$	no	*SC* satisfied, but *DC* blocks ρ
2.	$\times\ \underset{\blacktriangle}{\times}\ \times\ \times\ \times\ \times$	yes	*SC* satisfied, and *DC* does not block ρ
3.	$\times\ \times\rangle\underset{\blacktriangle}{\times}\ \times\ \times\ \times$	no	*SC* satisfied, but *DC* blocks ρ
4.	$\times\ \times\rangle\times\ \underset{\blacktriangle}{\times}\ \times\ \times$	yes	*SC* satisfied, and *DC* does not block ρ
5.	$\times\ \times\rangle\times\ \times\rangle\underset{\blacktriangle}{\times}\ \times$	no	*SC* satisfied, but *DC* blocks ρ
6.	$\times\ \times\rangle\times\ \times\rangle\times\ \underset{\blacktriangle}{\times}$	no	*SC* not satisfied
7.	$\times\ \times\rangle\times\ \times\rangle\times\ \times$		

Of note: This can be extended to account for the footing system of Palestinian Arabic by including the effects of bimoraic syllables.

The assumption that all delimiter insertion is done by focused DIRs has major implications. Schemes of DIRs allow different DIRs to vie for application to a given target, making it possible to analyze complex ternary systems. See Section 1.4. It also makes it possible for an iterative rule to be both sensitive to syllable and weight and to syllable count. See Section 1.6.1. Further, it makes it possible to subject footing systems to an analog of Prince’s (1985) Free Element Condition.[2]

2. This is only briefly mentioned in Section 1.5, but plays in a key role in various stress systems; Latin, Manam, and Winnebago, for example.

1.4 Schemes of DIRs

Focused delimiter insertion makes it possible for multiple delimiter insertion rules to organize themselves into schemes and compete for application to the target of the rule. The scheme (9) suggests the possibilities.

(9) $$\left[\begin{array}{l} \times \rightarrow \times \rangle \\ \times \rightarrow \times \langle \end{array}\right]_{\mathrm{LR}} ;\ {}^{*}\textsc{Unary} \qquad \begin{array}{l} (\mathrm{GB}) \\ (\mathrm{GF}^{\mathrm{x}}) \end{array}$$

Names of the subrules of the scheme are given at the right. Names are needed to discuss the action of the scheme.[3] The action of the iteration across a line of beats is shown in (10). A cursor guides the iteration.

(10)

		applicable rules
1.	$\underset{\blacktriangle}{\times}\ \times\ \times\ \times\ \times\ \times$	GF^{x}
2.	$\times\langle\underset{\blacktriangle}{\times}\ \times\ \times\ \times\ \times$	
3.	$\times\langle\times\ \underset{\blacktriangle}{\times}\ \times\ \times\ \times$	GB, GF^{x}
4.	$\times\langle\times\ \times\rangle\underset{\blacktriangle}{\times}\ \times\ \times$	GF^{x}
5.	$\times\langle\times\ \times\rangle\times\langle\underset{\blacktriangle}{\times}\ \times$	
6.	$\times\langle\times\ \times\rangle\times\langle\times\ \underset{\blacktriangle}{\times}$	GB
7.	$\times\langle\times\ \times\rangle\times\langle\times\ \times\rangle$	

*Unary blocks GB or GF^{x} or both, except at stage 3. There, both are applicable. GB is more highly ranked, so it applies.

3. The rule naming convention is this. GB (Group Back) groups beats, including the target beat, back towards the starting edge (left in LR systems, right in RL systems); GF (Group Forward) groups beats, including the target beat, in the other direction; GF^{x} also groups beats forward, but the target beat is excluded from the group which is formed, as in (9). GB, GF, and GF^{x} are the names of the elementary rule which the DIR is based on. The name can be subscripted to give information about which beats are targeted. The subscripts are local to the stress system under discussion. $\times \rightarrow \times\rangle \,/\, \_\_\times$ is called GB in discussing Tripura Bangla and $\times \rightarrow \times\rangle$ is called GB in discussing Estonian.

1.4.1. Derivation summaries

Full derivations like (10) are cumbersome. They will be summarized in a single annotated line, as in (11), called a 'derivation summary'.

(11) $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

If a DIR applies to a beat, a pointer under the beat points to the delimiter which was inserted and a rule name indicates which rule applied. (11) is not the representation of a phonological object. It is a representation of the output, but annotated to give information about the history of the derivation. Below are the derivation summaries for footing by (9) of sequences of beats of lengths 2 to 9.

(12)

a. $\times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

b. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

c. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \times$

d. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

e. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

f. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \times$

g. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

h. $\underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{\succ\\ \mathrm{GF^x}}}{\times} \langle \times \quad \underset{\substack{\succ\\ \mathrm{GB}}}{\times} \rangle$

1.5 Marking rules, footing systems

H&I proposed that prior to rhythmic footing, there could be the application of what they called *marking rules*. These are rules which target beats distinguished by their properties and local contexts, edge properties and heaviness properties in particular. No counting (iteration) is done, that is the job of the iterative rule. The marking rules build a skeleton, which the iterative rule fills in. The marking rules and rhythmic rule together form a *footing system*. Consider, for example, the footing system (13).

(13)
$$\left.\begin{array}{l} \times \rightarrow \langle \times \,/\, \#\_\_ \\ \left[\begin{array}{l} \times \rightarrow \times \rangle \\ \times \rightarrow \times \langle \end{array}\right]_{\mathrm{LR}} \end{array}\right\} ;\ {}^{*}\textsc{Unary} \qquad \begin{array}{l} (\mathrm{GF}_{\#}) \\ (\mathrm{GB}) \\ (\mathrm{GF^x}) \end{array}$$

The effect of the edge-marking rule is to pin a foot to the left edge.

If we reconsider (10), but assume the system (13), we get the derivation (14a), summarized in (14b).

(14)

a.
$$\begin{array}{ll} & \times\ \ \times\ \ \times\ \ \times\ \ \times\ \ \times \\ \mathrm{GF}_\# & \langle\!\langle \times\ \ \underset{\blacktriangle}{\times}\ \ \times\ \ \times\ \ \times\ \ \times \\ \mathrm{GB} & \langle\!\langle \times\ \ \times \rangle \underset{\blacktriangle}{\times}\ \ \times\ \ \times\ \ \times \\ & \qquad\ \ \vdots \end{array}$$

b.
$$\langle\!\langle \underset{\substack{<\\ \mathrm{GF}_\#}}{\times}\ \ \underset{\substack{>\\ \mathrm{GB}}}{\times} \rangle \underset{\substack{>\\ \mathrm{GF}^{\mathrm{x}}}}{\times} \langle \times\ \ \underset{\substack{>\\ \mathrm{GB}}}{\times} \rangle \times$$

As aid to the reader, delimiters inserted by marking rules are doubled. This is an annotation only, not recognized by the grammar. Note that a cursor does not appear until after the marking rule has applied. A cursor is only relevant to iterative footing. Note also that the cursor does not start at the beat which has already been subject to the marking rule. Here, it would be of no consequence to start the cursor at the beat which has already been acted on by the marking rule. But in other contexts, it is important to assume what I call the Free Beat Condition (FBC). It proposes that beats to which a delimiter insertion rule has already applied are no longer free to be the target of another DIR in the system. This is the analog of Prince's (1985) Free Element Condition in the framework adopted here.

I will assume that a footing system consists of a list (perhaps empty) of marking rules followed optionally by a *single* directional iterative rule.[4] H&I allows (and needs in some cases) multiple iterative iterative rules.

1.5.1. Cayuvava

The well-known Cayuvava footing system is a good example of a simple system that produces a complex output and illustrates some important points. It has often been used to illustrate the workings of footing systems, as it will be here.

(15)
$$\begin{array}{ll} \times \rightarrow\ \rangle \times\ /\ \_\_\# & (\mathrm{GF}^{\mathrm{x}}_{\#}) \\ \left[\begin{array}{l} \times \rightarrow\ \langle \times\ /\ \times \_\_ \\ \times \rightarrow\ \rangle \times \end{array}\right]_{\mathrm{LR}} ;\ {*}\textsc{Unary} & \begin{array}{l}(\mathrm{GB}) \\ (\mathrm{GF}^{\mathrm{x}})\end{array} \end{array}$$

Note that the marking rule $\mathrm{GF}^{\mathrm{x}}_{\#}$ is not constrained by *Unary. It is not uncommon for systems to impose different, usually weaker, derivational constraints on marking rules than on the iterative rule. Note also that GB is subject to a structural condition, which prevents it from applying at the left edge. This same restriction on GB occurs in two of the languages later analyzed in this paper. It will be called *non-persistent* GB. The consequences of this restriction are evident in (16d) and (16g) below.

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4. There are many stress systems whose footing rules consist only of marking rules.

(16)

a. $\times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$ [1]

b. $\times \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$

c. $\times \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$

d. $\times \quad \times \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$ [2]

e. $\times \quad \times \rangle \underset{\mathrm{GF}^{\mathrm{x}}}{\underset{\prec}{\times}} \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$

f. $\times \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle \underset{\mathrm{GF}^{\mathrm{x}}}{\underset{\prec}{\times}} \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$

g. $\times \quad \times \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle \underset{\mathrm{GF}^{\mathrm{x}}}{\underset{\prec}{\times}} \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$ [2]

h. $\times \quad \times \rangle \underset{\mathrm{GF}^{\mathrm{x}}}{\underset{\prec}{\times}} \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle \underset{\mathrm{GF}^{\mathrm{x}}}{\underset{\prec}{\times}} \langle \underset{\mathrm{GB}}{\underset{\prec}{\times}} \quad \times \rangle\!\rangle \underset{\mathrm{GF}^{\mathrm{x}}_{\#}}{\underset{\prec}{\times}}$

1. It is crucial here that $\mathrm{GF}^{\mathrm{x}}_{\#}$ is not subject to *Unary. Otherwise, 2-beat words would not be footed.
2. GB does not apply unless the context is $\times$ __, consequentially 2 unfooted syllables can remain at the left edge.

Note the importance of being able to insert unmatched delimiters. This is crucial in (16a,b,e,h), which would need left-edge application of GB in order to pair foot delimiters.

If stress is trochaic, the stress pattern is (17), which is the stress pattern of Cayuvava.

(17) The penultimate beat is stressed in 2-beat words, the antepenultimate beat in longer words. If σ_n is stressed, then σ_{n-3} is stressed.

1.6 Heaviness effects; Alignment

Many syllable-counting languages partition the line of metrical beats into 2 classes, which corresponds roughly to the partition of the line of syllables into monomoraic and bimoraic syllables. The correspondence is not exact because in some languages some moras, called here extra-metrical moras, have no effect on the metrical structure. The rule projecting the line of moras into the line of moraic beats is an important fact about a word-stress system which the language learner must deduce from the data. In this paper Estonian makes word-final consonantal moras extrametrical, as do many languages. Indonesian makes moras associated with Cə syllables extrametrical, Chugach makes consonantal moras of non-initial syllables extrametrical. What extrametrical means is simply that the mora does not project to the line of moraic beats. The partition of the line of syllabic beats is between those that are projected from syllables which project two metrical moras ('heavy' beats) and those that project only one ('light beats').

The distinction between light and heavy beats is a distinction which is made only in syllable-counting languages. In mora-counting languages, there is no notion of a heavy beat. There is a notion of a moraic beat which is cosyllabic with an adjacent moraic beat. Languages are very reluctant to split cosyllabic moras, i.e. it is highly marked. Consequently, footing systems are designed to minimize or eliminate syllable spitting. This has an effect on stress patterns. In some contexts, cosyllabic moraic beats do not act like a sequence of two monomoriac beats. So there is a cosyllabicity effect. But it has a different character than a heaviness effect.

In languages with heaviness effects, heavy beats are inherently more prominent than light beats. There is a tension between metrical prominence and inherent prominence. Heaviness effects are features of a stress system which ease this tension. It is only speculation, but my working assumption is that in the production mechanism and/or the perception mechanism, aligning heavy syllables with metrical stress reduces the rate of production or perception errors and exerts a pressure on the evolution of the language over time towards alignment. The following seems to be true.

(18) A footing rule does not mention syllable weight unless the rule enhances the ability of the footing system to better align metrical stress and inherent prominence.

(18) does not pretend to be a fact about the computational system. It would explain nothing to suppose that it was. If a fact, it is emergent from the way that the computational system is put to use. What is needed is an explanation of why (18) is true of stress systems.

This paper presents a formal apparatus for expressing footing systems. It is essentially a simple programming language (call it FL, Footing Language) for writing programs that build foot structure. The problem it faces is well known since Chomsky and Halle discussed it in SPE. The problem is that the features which enter into the FL have no inherent content. It is just as easy to write an FL program to align light beats with metrical stress as it is to write one to align heavy beats with metrical stress. How does heavy/metrical alignment enter the theory of stress? We could add a ‘heavy good, light bad’ principle, but that just states a fact and does not offer any explanation. It is not clear to me that there is such principle in the grammar, it may simply be a characteristic of grammars which emerges out of the interaction of phonetics, attention to complexity, and stable learnability. By stable learnability I mean long-term transmission of a language in spite of the errors in perception and production that are made, which I assume feed language change over time.

This idea of aligning metrical and phonological prominence is at the core of the complexities of all of the languages discussed in this paper. In trochaic languages, alignment effects are those that minimize the occurrences of heavy beats which are not in foot-initial position. In all of the systems analyzed in this paper, (18) is verified. It is not the case that alignment is improved in every example, just that there is an overall improvement. There are some examples of words in which a global maximization of alignment cannot be accomplished because of the restrictions of locality on the computation.

H will denote a heavy syllabic beat, L a light syllabic beat, and X a syllabic beat which might be either heavy or light.

1.6.1. Weight sensitive DIRs

Consider the scheme (19) and some derivations which result, in (20).

(19) $\left[\begin{array}{lcl} \mathrm{H} & \rightarrow & \langle\,\mathrm{H} \\ \mathrm{X} & \rightarrow & \mathrm{X}\,\rangle \end{array}\right]_{\mathrm{LR}}$; *Unary $\quad\begin{array}{l} (\mathrm{GF_H}) \\ (\mathrm{GB}) \end{array}$

(20) a. $\mathrm{L}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{L}}\,\rangle\,\mathrm{L}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{L}}\,\rangle\,\mathrm{L}$ b. $\mathrm{L}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{L}}\,\rangle\,\mathrm{L}\,\langle\,\underset{\substack{< \\ \mathrm{GF_H}}}{\mathrm{H}}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{L}}\,\rangle$ c. $\mathrm{L}\,\langle\,\underset{\substack{< \\ \mathrm{GF_H}}}{\mathrm{H}}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{H}}\rangle\langle\underset{\substack{< \\ \mathrm{GB_H}}}{\mathrm{H}}\ \ \underset{\substack{> \\ \mathrm{GB}}}{\mathrm{L}}\,\rangle$

If stress is foot left (trochaic), we get (21), a familiar heaviness effect in binary footing. It is sometimes said descriptively that heavy syllables ‘attract’ stress.

(21) a. $\acute{\mathrm{L}}\ \mathrm{L}\ \acute{\mathrm{L}}\ \mathrm{L}\ \mathrm{L}$ b. $\acute{\mathrm{L}}\ \mathrm{L}\ \mathrm{L}\ \acute{\mathrm{H}}\ \mathrm{L}$ c. $\mathrm{L}\ \acute{\mathrm{H}}\ \mathrm{H}\ \acute{\mathrm{H}}\ \mathrm{L}$

We describe (19) as an alignment enhancing modification of the basic LR binary rule (22).

(22) $\left[\ \mathrm{X} \ \rightarrow\ \mathrm{X}\,\rangle\right]_{\mathrm{LR}}$; *Unary (GB)

(22) would produce the patterns below.

(23) a. $\acute{\mathrm{L}}\ \mathrm{L}\ \acute{\mathrm{L}}\ \mathrm{L}\ \mathrm{L}$ b. $\acute{\mathrm{L}}\ \mathrm{L}\ \acute{\mathrm{L}}\ \mathrm{H}\ \mathrm{L}$ c. $\acute{\mathrm{L}}\ \mathrm{H}\ \acute{\mathrm{H}}\ \mathrm{H}\ \mathrm{L}$

Compare these with the patterns in (21). The modification of (23) to (21) significantly improves alignment. It is not perfect, there is an unaligned heavy beat in (23c).

H&I accounted for heaviness effects of this kind in a very different way. They propose that there are two different iterative rules. The first, which they call Syllable Boundary Projection (SBP), affects only heavy beats, inserting a left delimiter to the left of some heavy beats and ICC (Iterative Constituent Construction), which makes no reference to weight. There is a discussion of this in Section 5, where it is shown that the H&I approach to heaviness effects is not empirically adequate.

Armed with computational systems allowed by the theory developed to this point, the next 5 sections will analyze the word-stress systems of Finnish, Estonian, Sentani, and Tripura Bangla.

Section 2. Finnish

A convenient data set to begin with is the wordlist in Karttunen (2006). The foot groups are, of course, not in the primary data. They are added here both as a preliminary proposal and an aid to looking at the data. If feet are binary and stress is trochaic, this footing is the only possibility. Syllables which are not simple (C)V syllables are bold-faced.

(24) 2. *(**tö̋n**.tä), (mä̋.ki), (**jä̋r**.**jes**)*

3. *(kú.**nin**)**gas**, (pé.ri)jä*

4. *(rá.**vin**)(tò.**lat**), (rè.pe)(ä̀.mä), (mé.ko)(nò.**min**), (ká.**las**)(tè.let)*

5. *(ér.go)(nò.mi)a, (**strúk**.tu)ra(**lìs**.mi), (ó.**pis**)(kè.li)ja,*
*(ó.**pet**)ta(**màs**.sa), (má.te)ma(**tíik**.ka), (ká.**las**)te(**lèm**.me),*
*(**kái**.**nos**)(tè.li)**jat***

6. *(íl.**moit**)(**tàu**.tu)(mì.**nen**), (pú.he)li(**mèl**.la)ni, (pú.he)li(**mìs**.ta)ni,*
*(ká.**las**)(tè.le)(mì.**nen**)*

7. *(**íl**.**moit**)(**tàu**.tu)mi(**sès**.ta), (**óm**.**nit**)(tè.le)(mà.ni)**kin**,*
*(**tèl**.**mät**)tö(**mỳy**.**des**)(**tàn**.sa), (**jä̋r**.**jes**)(**tèl**.**mäl**)(**lìs**.tä)mä*

8. *(rá.**kas**)ta(**jàt**.ta)(rè.na)ko, (**vói**.**mis**)te(**lùt**.te)le(**màs**.ta)*

9. *(**jä̋r**.**jes**)(**tèl**.**mäl**)li(**sỳy**.del)(lä̀.ni)*

All the skipped beats are of the form ($\acute{X}$ X) L($\acute{H}$ X), where light beats L correspond to syllables with a V nucleus and heavy beats H correspond to syllables which are not light. Speaking descriptively, the heavy beat has 'attracted' stress off a light beat.

The simplest perturbation of an LR binary system aimed at putting heavy beats in foot-initial position is to ensure that whenever the iterative rule encounters a heavy beat, it makes it foot initial, provided that *Unary allows it. That footing system is (25).

$$
(25)\quad \left.\begin{array}{l} \mathsf{X} \rightarrow \langle \mathsf{X} \;/\; \#\_\_ \\ \left[\begin{array}{l} \mathsf{H} \rightarrow \langle \mathsf{H} \\ \mathsf{X} \rightarrow \mathsf{X} \rangle \end{array}\right]_{\mathrm{LR}} \end{array}\right\} ;\ {}^{*}\textsc{Unary} \qquad \begin{array}{l} (\mathrm{GF}_{\#}) \\ (\mathrm{GF}_{\mathrm{H}}) \\ (\mathrm{GB}) \end{array}
$$

The marking rule ensures that a foot is pinned to the left edge, as shown in (24).

(25), along with trochaic stress assignment and the light/heavy syllable partition, accounts for all the examples in Karttunen's wordlist (24). Some derivation summaries are given in (26).

(26) a. *rá.**vin**.tò.**lat***
《 L H 〉 L H 〉
GF$_{\#}$ GB GB

b. ***ér**.go.nò.mi.a*
《 H L 〉 L L 〉 L
GF$_{\#}$ GB GB

c. *ká.**las**.te.**lèm**.me*
《 L H 〉 L 〈 H L 〉
GF$_{\#}$ GB GF$_{H}$ GB

d. *íl.**moit**.**tàu**.tu.mì.**nen***
《 H H 〉〈 H L 〉 L H 〉
GF$_{\#}$ GB GF$_{H}$ GB GB

e. ***vói**.**mis**.te.**lùt**.te.le.**màs**.ta*
《 H H 〉 L 〈 H L 〉 L 〈 H L 〉
GF$_{\#}$ GB GF$_{H}$ GB GF$_{H}$ GB

f. ***jä̋r**.**jes**.**tèl**.**mäl**.**lìs**.tä.mä*
《 H H 〉〈 H H 〉〈 H L 〉 L
GF$_{\#}$ GB GF$_{H}$ GB GF$_{H}$ GB

g. ***jä̋r**.**jes**.**tèl**.**mäl**.li.**sỳy**.**del**.lä̀.ni*
《 H H 〉〈 H H 〉 L 〈 H H 〉 L L 〉
GF$_{\#}$ GB GF$_{H}$ GB GF$_{H}$ GB GB

To these examples, we add some further examples from Karttunen (not on the wordlist), which were given as counterexamples to the analyses of Kiparsky (2003) and/or Elenbaas (1999).

(27) a. *ká.**las**.tè.le.mì.**nen***
'fishing' (Nom.Sg)
《 Ĺ H 〉 L̀ L 〉 L̀ H 〉
GF$_{\#}$ GB GB GB

b. *há.pa.**ròi**.**tut**.tà.**vaa***
'of the kind that causes one to fumble' (Prt.Sg)
《 Ĺ L 〉〈 H̀ H 〉 L̀ H 〉
GF$_{\#}$ GB GF$_{H}$ GB GB

c. *pú.hu.te.**tùim**.**mis**.tà.**kin***
'even the ones that have been made to talk the most' (Ela.Pl)
《 Ĺ L 〉 L 〈 H̀ H 〉 L̀ H 〉
GF$_{\#}$ GB GF$_{H}$ GB GB

d. *kú.ti.**tèt**.tu.jà.**kin***
'even the ones who have been tickled' (Prt.Pl)
《 Ĺ L 〉〈 H̀ L 〉 L̀ H 〉
GF$_{\#}$ GB GF$_{H}$ GB GB

2.1 Word-final unary feet

Elenbaas (1999) has examples outside the range of data that Karttunen presented. Largely, they concern morphological effects. But there is one phonological effect of particular interest since it anticipates an aspect of the footing systems of Tripura Bangla and Estonian that will be discussed later. Several examples are given in (28) (p. 118 in Elenbaas). Some words have variant stress patterns.

(28) a. *(kú.nin)gas/(kú.nin)(gàs)*
b. *(rá.vin)(tò.lat)/(rá.vin)to(làt)*
c. *(kái.no)(stèl.li)gat/(kái.no)(stèl.li)(gàt)*

Violations of *Unary must be permitted (optionally) for word-final heavy beats, in some multisyllabic words. It cannot be permitted in monosyllabic words, otherwise monosyllabic words consisting of a single heavy syllable would be stressed. But no such words appear to exist.

Let *UnaryT be the constraint that accepts beats that *Unary accepts or that are noninitial, final, and heavy. For some Finnish speakers, iterative footing can choose to operate under either constraint. The system (29) produces the outcomes (30).[5]

(29)
$$\begin{array}{ll} \mathsf{X} \rightarrow \langle\, \mathsf{X} \;/\; \#\_\_ \;;\; {*}\textsc{Unary} & (\mathrm{GF}_{\#}) \\ \left[\begin{array}{lll} \mathsf{H} & \rightarrow & \langle\, \mathsf{H} \\ \mathsf{X} & \rightarrow & \mathsf{X}\,\rangle \end{array}\right]_{\mathrm{LR}} ;\; {*}\textsc{Unary}/{*}\textsc{Unary}\mathrm{T} & \begin{array}{l} (\mathrm{GF}_{\mathrm{H}}) \\ (\mathrm{GB}) \end{array} \end{array}$$

5. The T in *UnaryT is for trochaic. Unlike an iambic system, a final unary foot does not produce stress clash in a trochaic system. So it is not surprising that *UnaryT only appears in trochaic systems.

(30) *Unary *UnaryT

		*Unary	*UnaryT
a.	*(kú.nin)gas/(kú.nin)(gàs)*	《 L H 〉 H $GF_{\#}$ GB	《 L H 〉〈 H $GF_{\#}$ GB GF_H
b.	*(rá.vin)(tò.lat)/(rá.vin)to(làt)*	《 L H 〉 L H 〉 $GF_{\#}$ GB GB	《 L H 〉 L 〈 H $GF_{\#}$ GB GF_H
c.	*(kái.no)(stèl.li)gat/(kái.no)(stèl.li)(gàt)*	《 H L 〉〈 H L 〉 H $GF_{\#}$ GB GF_H GB	《 H L 〉〈 H L 〉〈 H $GF_{\#}$ GB GF_H GB GF_H

In Elenbaas' wordlist for Finnish, only some of the words which have a shape that would permit variation in the resulting surface form do in fact show variation. This may be and artifact of the sampling of possible forms, or it may be that some words must be lexically marked as requiring the *Unary constraint.

*UnaryT will appear again in the analyses of Estonian and Tripura Bangla in sections 3 and 5.

Section 3. Estonian

This section, and the entire paper more generally, originated as a counterproposal to the analysis in (1995), which was a revision of Prince (1980). I rely on the examples in Hayes and the analysis was informed by his organization of the data. Hayes realized that Estonian is particularly interesting because many words have variant stress patterns. The key problem in Estonian is to account for this variation. The data in (31) is taken from Hayes (1995, pp. 318, 319), based on Hint (1973). The references given in the examples below are to Hint. This list does not contain any examples with what are called 'overlong syllables'. Their effect on delimiter insertion, and therefore footing, is postponed until Section 6. It assumes syllabic beats with possibly a heavy property, trochaic stress, and binary feet where possible. Beats associated with (C)V syllables and word-final (C)VC syllables are light, others heavy. We start with examples that manifest the variation. The foot structures shown in (31) are a tentative proposal, which will be substantiated shortly.

(31)

		binary	*ternary*	
a.	*té.ra.và.le/té.ra.va.màltt*	(X́X)(L̀H)	(X́X)L(H̀)	H 159
b.	*pí.mes.tà.va.le/pí.mes.ta.và.le*	(X́X)(ĹL)L	(X́X)L(ĹL)	H 161
c.	*ý̆p.pet.tà.yat.tèks/ ý̆p.pet.ta.yàt.teks*	(X́X)(ĹH)(H́)	(X́X)L(H́H)	H 162
d.	*ű.lis.tà.va.m̀ait/ű.lis.ta.và.mait*	(X́X)(ĹL)(H́)	(X́X)L(ĹH)	H 162

e. *é.ri.nè.vat.tès.se/ é.ri.ne.vàt.tes.se* $(\acute{X}X)(\grave{L}H)(\acute{H}L)$ $(\acute{X}X)L(\acute{H}H)L$ H 163

f. *ó.sa.và.ma.lè.ki/ó.sa.va.mà.le.ki* $(\acute{X}X)(\grave{L}L)(\grave{L}L)$ $(\acute{X}X)L(\grave{L}L)L$ H 163

g. *vál.lut.tà.yat.tè.ka/vál.lut.ta.yàt.te.ka* $(\acute{X}X)(\grave{L}H)(\grave{L}L)$ $(\acute{X}X)L(\acute{H}L)L$ H 163

h. *ú.sal.tàt.ta.và.mat.tèks/ú.sal.tàt.ta.va.màt.teks*

$(\acute{X}X)(\acute{H}L)(\grave{L}H)(\acute{H})$ $(\acute{X}X)(\acute{H}L)L(\acute{H}H)$ H 163

We start from (32), where the dagger, †, signifies optionality..

(32)
$$\left.\begin{array}{l} \mathsf{X} \rightarrow \langle\, \mathsf{X} \;/\; \#\_\_ \\ \left[\begin{array}{l} \mathsf{X} \rightarrow \mathsf{X}\,\rangle \\ \mathsf{X} \rightarrow \mathsf{X}\,\langle^{\dagger} \end{array}\right]_{LR} \end{array}\right\} ;\ {*}\textsc{Unary} \qquad \begin{array}{l} (GF_{\#}) \\ (GB) \\ (GF^{x}) \end{array}$$

There are two problems.

(33) a. The final unary foot in the ternary variation in (31a) and the binary variations in (31c,d,h) are not accounted for.

b. The absence of a skipped beat between the first two feet in the ternary variation in (31h) is not accounted for.

(33a) is accounted for in the same way that this phenomenon is accounted for in Finnish (see Section 2.1). The derivational constraint is weakened to *UnaryT; optionally in Finnish, but obligatorily in Estonian. (33b) is accounted for by restricting GF^{x} to apply to light beats only. These modifications of (32), which are outlined below, result in the system (34).

(34)
$$\left.\begin{array}{l} \mathsf{X} \rightarrow \langle\, \mathsf{X} \;/\; \#\_\_ \\ \left[\begin{array}{l} \mathsf{X} \rightarrow \mathsf{X}\,\rangle \\ \boxed{\mathsf{L} \rightarrow \mathsf{L}\,\langle}^{\dagger} \end{array}\right]_{LR} \end{array}\right\} ;\ \boxed{{*}\textsc{UnaryT}} \qquad \begin{array}{l} (GF_{\#}) \\ (GB) \\ (GF^{x}) \end{array}$$

The dagger, †, signifies optionality.

Some illustrations of the derivations that (34) yields is given in (35).

(35)

	GF^x *does not apply*	GF^x *applies*
[31a]	*té.ra.và.maltt* 《 L L 〉 L H 〉 < > > > GF$_\#$ GB GB	*té.ra.va.màltt* 《 L L 〉 L 〈 H 〉 < > > > GF$_\#$ GB GF^x GB
[31b]	*(pí.mes)(tà.va)le* 《 L H 〉 L L 〉 L < > > GF$_\#$ GB GB	*(pí.mes)ta(và.le)* 《 L H 〉 L 〈 L L 〉 < > > > GF$_\#$ GB GF^x GB
[31h]	*ú.sal.tàt.ta.và.mat.tèks* 《 L L 〉 H L 〉 L H 〉 H 〉 < > > > > GF$_\#$ GB GB GB GB	*ú.sal.tàt.ta.va.màt.teks* 《 L L 〉 H L 〉 L 〈 H H 〉 < > > > > GF$_\#$ GB GB GF^x GB

The restriction of GF^x to light beats is confirmed by many examples in which there is no binary/ternary alternation. GF^x never applies in these examples.

(36)	a.	*pá.lat, pá.latt*	(Ĺ X)	H 203
	b.	*pát.tu, nóː.rikk*	(H́ X)	H 156
	c.	*ó.sa.vàtt*	(X́ X)(H́)	H 157
	d.	*ó.sa.va*	(X́ X)L	H 157
	e.	*sóː.ye.màt.tel*	(X́ X)(H́ L)	H 159
	f.	*pá.ri.màt.teltt*	(X́ X)(H́ H)	H 159
	g.	*pí.mes.tàt.tut.te*	(X́ X)(H́ H)L	H 161
	h.	*vá.lu.sàt.te.le*	(X́ X)(H́ L)L	H 161
	i.	*ý.pet.tùs.te.lè.ki*	(X́ X)(H́ L)(Ĺ L)	H 163
	j.	*ká.ras.tàt.tui.m̀a.le*	(X́ X)(H́ H)(Ĺ L)	H 163

Some derivation summaries are given in (37). GF^x does not apply, so there is no variation.

(37)	[36c]	*ó.sa.vàtt* 《 L L 〉 H 〉 < > > GF$_\#$ GB GB	[36h]	*vá.lu.sàt.te.le* 《 L L 〉 H L 〉 L < > > GF$_\#$ GB GB
	[36j]	*(ká.ras)(tàt.tui)(m̀a.le)* 《 L H 〉 H H 〉 L L 〉 < > > > GF$_\#$ GB GB GB		

All the examples in (31) and (36) have been accounted for.

It is natural to speculate that the language evolved in this way because of the twin pressures of ternary footing and stress on heavy syllables. It is not surprising that the 'skip rule' GF^{x} which ternary footing requires would be restricted so that perception and production errors which took the form of 'stress attraction' would have an account in the grammar.

Section 4. Sentani

Word stress in the dialect of Sentani described by Cowan (1965) (henceforth C) was analyzed in Hayes (1995, pp. 330-33) (henceforth H).[6] All of the examples in this section are from pages 9 and 10 in Cowan. Those that appear as numbered examples in H will be referenced to H since they are organized there in a useful way. References directly to Cowan are to the appropriate page.

I will present the core data in 2 groups. The first has words with a single stress. The second has words with multiple stressed syllables. An additional group (of 3 words) has words with a perturbation caused by what I will call here extra-light syllables. As in the previous analyses, the foot groups in (38) are a tentative objective for the delimiter insertion system, not part of the data. Trochaic stress is implicit. Stress is weight sensitive. Closed (C)VC versus open (C)V plays a role in footing. In examples which follow, closed syllables are boldfaced.

(38) Words with a single stress

a.	*(fá)*	'child'	C9[7]
b.	*(yó.ku)*	'dog'	H46b
c.	*(**kám**.bi)*	'neck'	H46b
d.	*ho(kó.lo)*	'young'	H46d
e.	***hon**(**kə́w**.nə)*	'he burnt him'	H50c
f.	***how**(bó.ke)*	'he killed (something)'	H50b
g.	*u(**kə́w**.nə)*	'he told him'	H46c
h.	***han**.də(bó.ke)*	'we (pl.) killed (something)'	C9[7]
i.	*ho.**nəm**(**bón**.de)*	'he will kill (something) for him'	H50d
j.	***an**(**kɛ́y**)*	'ear'	H50a
k.	*fa(**lə́m**)*	'head'	H46a
l.	*ha.ba(**káy**)*	'tobacco'	H48a

All of these examples are accounted for by modifications (outlined below) of the basic RL binary footing system

6. The dialect of Sentani analyzed by Elenbaas (1999) is quite different.

7. These examples appear in H in the running text, not in a numbered example.

(39) H → ⟨ H / __# ($GB_{H\#}$)
X → X ⟩ / __# ($GF_{\#}$)
[X → ⟨ X / X __]$_{RL}$; *Unary (GB)

$GB_{H\#}$, not subject to *Unary, is responsible for the final unary foot in (38j,k,l). $GF_{\#}$, also not subject to *Unary, is responsible for *fá*, (38a). The structural condition on GB is responsible for the double upbeat in (38h,i,l), just as in Cayuvava.

Some illustrations are in (40).

(40)	a. ***an.key***	b. *ha.ba.**kay***	c. ***han**.də.bo.ke*	d. *fa*	e. *ho.ko.lo*
	H《H	L L《H	H L ⟨ L L 》	L 》	L ⟨ L L 》
	GB_{H}	GB_{H}	GB $GF_{\#}$	$GF_{\#}$	GB $GF_{\#}$

Now consider words with multiple stressed syllables.

(41) Words with multiple stressed syllables

a.	*(ə̀.də)ka(wá.le)*	'I saw thee'	H47a
b.	*a(dì.lə)mi(hí.be)*	'you two will collect them'	H47b
c.	*ə(**này**.nə)**kɛn**(**sín**.de)*	'they (pl.) will throw it away'	H50e
d.	*ha(**bə̀w**.no)ko(ká.le)*	'I struck him (aor.)'	H47c
e.	*a.di(lə̀.də)mi(**hím**)*	'let me collect them'	H48b
f.	*ə(**này**.ne)(**wə́n**.de)*	'they (pl.) will go tell him'	H49b
g.	*ha(**bə̀w**.do)(kó.ke)*	'he hit me (aor.)'	H49a

Putting (41f,g) aside for the moment, the other examples are accounted for by augmenting (outlined below) the iterative rule scheme in (39). The system (42) results.

(42) H → ⟨ H / __# ($GB_{H\#}$)
X → X ⟩ / __# ($GF_{\#}$)
[X → ⟨ X / X __ (GB)
X → ⟩ X]$_{RL}$; *Unary (GF^{x})

$GF_{\#}$ is needed because in the absence of a final heavy syllable, a binary foot is pinned to the right edge. The iterative rule scheme is precisely the rule scheme employed in Cayuvava, including the restriction of GB to beats away from the word-initial beat.

We now turn to understanding the heaviness effect in (41f,41g). Just as in Estonian, there is no skipped beat if it would have the effect of shifting stress off a heavy beat. It is *ha(**bə̀w**.do)(kó.ke)*, with stress on *bəw*, not *(hà.bəw)do(kó.ke)*, with *bəw* unstressed. $\mathrm{GF^x}$ in (42) must be restricted so that it does not apply in the context $/\ \mathsf{H}\,\_\_$. The system (43), a modification of (42) accomplishes this.

(43)
$$\begin{array}{ll} \mathsf{H} \rightarrow \langle\, \mathsf{H}\ /\ \_\_\# & (\mathrm{GB}_{H\#}) \\ \mathsf{X} \rightarrow \mathsf{X}\,\rangle\ /\ \_\_\# & (\mathrm{GF}_{\#}) \\ \left[\begin{array}{l} \mathsf{X} \rightarrow \langle\, \mathsf{X}\ /\ \mathsf{X}\,\_\_ \\ \mathsf{X} \rightarrow \rangle\, \mathsf{X} \boxed{/\ \mathsf{L}\,\_\_} \end{array}\right]_{\mathrm{RL}} ;\ {}^{*}\textsc{Unary} & \begin{array}{l} (\mathrm{GB}) \\ (\mathrm{GF^x}) \end{array} \end{array}$$

Some illustrations are in (44).

(44) a. *ə(**này**.nə)**kɛn**(**sín**.de)*

$\mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{H}}\ \ \mathsf{L}\,\rangle\,\underset{\mathrm{GF^x}}{\mathsf{H}}\,\langle\,\underset{\mathrm{GB}}{\mathsf{H}}\ \ \underset{\mathrm{GF_\#}}{\mathsf{L}}\,\rangle\!\rangle$

b. *a.di(lə̀.də)mi(**hím**)*

$\mathsf{L}\ \ \mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{L}}\ \ \mathsf{L}\,\rangle\,\underset{\mathrm{GF^x}}{\mathsf{L}}\,\langle\!\langle\,\underset{\mathrm{GB_\#}}{\mathsf{H}}$

c. *ha(**bə̀w**.do)(kó.ke)*

$\mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{H}}\ \ \mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{L}}\ \ \underset{\mathrm{GF_\#}}{\mathsf{L}}\,\rangle\!\rangle$

d. *ə.**này**.ne.**wə́n**.de*

$\mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{H}}\ \ \mathsf{L}\,\langle\,\underset{\mathrm{GB}}{\mathsf{H}}\ \ \underset{\mathrm{GF_\#}}{\mathsf{L}}\,\rangle\!\rangle$

The crucial point is that $\mathrm{GF^x}$ applies to the antepenultimate beat in (44a) and the penultimate beat in (44b) because they are in the environment $\mathsf{L}\,\_\_$, but does not apply to the antepenultimate beat in (44c), which is in the environment $\mathsf{H}\,\_\_$.

4.1 Sentani and Estonian: Two sides of the same coin,

In Estonian, skipping is disallowed if it produces $\mathsf{H}\,\langle$. In Sentani, skipping is disallowed if it produces $\mathsf{H}\,\rangle$. What the environments $\_\_\,\langle$ and $\_\_\,\rangle$ have in common is that in a trochaic system a beat in a binary foot in either of these positions will not be stressed. In a trochaic system, say that a beat in either of these positions is in a *weak position*.

(45) HWeak is the condition which is true of a heavy beat in a weak position.[9]

Formally, the iterative rules for Estonian and Sentani are equivalent to (46a) and (46b).

9. *HWeak is introduced here only to make clear the parallel beween Estonian and Sentani. All of the derivational constraints on the delimiter insertion rules introduced in this paper have the form *Unary or C, where C depends only on the properties of the beat which is being evaluated, edge properties or heaviness properties. If not excluded, a constaint like *HWeak is highly marked.

(46) a. $\left[\begin{array}{l} \mathsf{x} \ \rightarrow \ \mathsf{x}\rangle \\ \mathsf{x} \ \rightarrow \ \mathsf{x}\langle \text{ ; *HW}\textsc{eak} \end{array}\right]_{LR}$; *Unary

b. $\left[\begin{array}{l} \mathsf{x} \ \rightarrow \ \langle \mathsf{x} \ / \ \mathsf{x}\_\_ \\ \mathsf{x} \ \rightarrow \ \rangle \mathsf{x} \text{ ; *HW}\textsc{eak} \end{array}\right]_{RL}$; *UNARY

The Finnish system has something in common with the Estonian and Sentani systems. But in the latter systems skipping is the norm, so heaviness effects are manifested in weight dependent conditions under which skipping is blocked. In Finnish the norm is not to skip and heaviness effects are manifested in weight dependent conditions under which a beat is skipped.

4.2 Extra-light syllables

The examples in (47) are not accounted for by (43).

(47) Extra-light syllables

a.	*(**wə́w**.nə)le*	Ĥ ə̆ L	'say to him'	C9
b.	*(**kéj**.nə)hi*	Ĥ ə̆ L	'throw it away'	C9
c.	*u(**káj**.nə)lə*	L Ĥ ə̆ ə̆	'they (pl.) told him'	C9

ə̆ denotes an open syllable with schwa nucleus.

Stress is on the heavy ante-penultimate syllable rather than the extra-light penultimate syllable. Informally, we can say that it attracts stress. It cannot be that extra-light syllables are extrametrical. In (41e), there is a stressed extra-light syllable. The effect is another instance of a modification of a footing system in order to promote alignment of inherent heavy syllable stress with metrical stress.

Cowan formulates the effect as: "In words of 3 and 4 syllables, ending in a vowel, which have the antepenult closed by a consonant, the stress tends to shift to this syllable, if the penult is an open syllable in ə." Except for the limitation to words of 4 or fewer syllables, Cowan's formulation translates almost directly to the marking rule (48).

(48) ə̆ → ə̆ ⟩ / H __ L # (GF$_ə$)

GF$_ə$ must be ordered before GF$_\#$, since GF$_\#$ destroys the environment for applying GF$_ə$.

But more must be said because GF$_\#$ is not subject to *UNARY. Otherwise 1-syllable words, *fá* (38a) for example, would not be footed. But then there is nothing to prevent GF$_\#$ from applying after GF$_ə$, resulting in

$$\mathsf{H}\ \breve{\text{ə}}\ \mathsf{L} \xrightarrow{\mathrm{GF}_{\text{ə}}} \mathsf{H}\ \breve{\text{ə}}\rangle\mathsf{L} \xrightarrow{\mathrm{GF}_{\#}} \acute{\mathsf{H}}\ \breve{\text{ə}}\rangle\acute{\mathsf{L}}\rangle$$

A simplest way to stipulate the rule order is straightforward; bare-faced stipulation. The language learner formulates the edge-marking rules $\mathrm{GB}_{\mathrm{H}\#}$, $\mathrm{GF}_{\#}$, and GF which operate in various specific contexts and observes that only one of them can apply.[10] The rule is "$\mathrm{GB}_{\mathrm{H}\#}$, otherwise $\mathrm{GF}_{\text{ə}}$, otherwise $\mathrm{GF}_{\#}$". The only order that is required is that $\mathrm{GF}_{\text{ə}}$ must take priority over $\mathrm{GF}_{\#}$.

(49)
$$\left[\begin{array}{lll} \mathsf{H} & \rightarrow & \langle \mathsf{H}\ /\ \_\_\# \\ \breve{\text{ə}} & \rightarrow & \breve{\text{ə}}\ \rangle\ /\ \mathsf{H}\_\_\ \mathsf{L}\,\# \\ \mathsf{L} & \rightarrow & \mathsf{L}\ \rangle\ /\ \_\_\# \end{array}\right] \qquad \begin{array}{l} (\mathrm{GB}_{\mathrm{H}\#}) \\ (\mathrm{GF}_{\text{ə}}) \\ (\mathrm{GF}_{\#}) \end{array}$$

Note that that not all of the subrules are competing for application at the same beat. This is unlike the case of a directional iterative scheme in which the implicit cursor means that the subrules of the scheme compete for application at the beat specified by the cursor.

Some examples follow in (50).

(50)

[47a] *(**wə́w**.nə)le*	[47c] *u(**káj**.nə)le*	[38h] ***han**.də(bó.ke)*
$\mathsf{H}\ \ \underset{>}{\mathsf{V}}\rangle\,\mathsf{L}$	$\mathsf{L}\,\langle\underset{<}{\mathsf{H}}\ \ \underset{>}{\mathsf{V}}\rangle\,\mathsf{L}$	$\mathsf{H}\ \ \mathsf{V}\langle\underset{<}{\mathsf{L}}\ \ \underset{>}{\mathsf{L}}\rangle$
$\mathrm{GF}_{\text{ə}}$	GB $\mathrm{GF}_{\text{ə}}$	GB $\mathrm{GF}_{\#}$

$\mathrm{GF}_{\text{ə}}$ does not apply in (50d). It applies only to penultimate beats in the appropriate context. GB does not apply at the left edge. This has no effect on stress in (50a,b). But it does in (50d), resulting in 2 unfooted beats at the left edge.

There are no examples in Cowan's data set which demonstrate the necessity of a 4 syllable limit on words which show this effect. If there are such words, a possible explanation is suggested by a similar phenomenon in Manam. There, normal penultimate stress shifts to antepenultimate stress if the antepenultimate syllable is heavy and the penultimate and final syllables are light. But in Manam the HLL sequence must be root internal. If could be that in the dialect of Sentani studied the shift to the heavy penult occurs only root internally and that this might give the appearance of a 4 syllable limit.

10. It could be that there is a category 'edge-marking' of rules and that it is a general principle that only one edge-marking rule can apply at each edge. This more or less implies that the edge-marking rules at each edge have to be prioritized, which results in a rule scheme. 'Each edge' is specified because there are stress systems, Lenakel's is one, which have one rule which marks the left edge and another which marks the right edge.

4.3 Summary

(51) correctly predicts the stress pattern of all of the examples in Cowan. The modifications of a simple RL ternary system with non-persistent GB are framed with a dotted box in (51). All the modifications enhance heavy/metrical alignment.

(51)
$$\left[\begin{array}{l} \boxed{\mathsf{H} \rightarrow \langle \mathsf{H} \,/\, \_\_\#} \\ \boxed{\breve{ə} \rightarrow \breve{ə}\rangle \,/\, \mathsf{H}\_\_\mathsf{L}\#} \\ \mathsf{X} \rightarrow \mathsf{X}\rangle \,/\, \_\_\# \end{array}\right] \quad \begin{array}{l} (\mathrm{GB_{H\#}}) \\ (\mathrm{GF_{ə}}) \\ (\mathrm{GF_{\#}}) \end{array}$$
$$\left[\begin{array}{l} \mathsf{X} \rightarrow \langle \mathsf{X} \,/\, \mathsf{X}\_\_ \\ \mathsf{X} \rightarrow \rangle \mathsf{X} \boxed{/\, \mathsf{L}\_\_} \end{array}\right]_{\mathrm{RL}} ;\ {}^*\textsc{Unary} \quad \begin{array}{l} (\mathrm{GB}) \\ (\mathrm{GF^X}) \end{array}$$

The iterative rule is identical to the iterative rule in the Cayuvava footing system (15), given that Cayuvava has no light/heavy syllable distinction.

4.4 Hayes' 1995 analysis

Since it is the only other transformational analysis of the dialect of Sentani described by Cowan that I am aware of, some comment is called for. The analysis comes in 2 parts. Two RL iterative rules are employed; the first part generates excess stressed syllables, but the second prunes away the excess.

(52) a. Parse the word RL into moraic trochees; (H́) or (Ĺ L). Assume a strong form of weak local parsing, so that light syllables must be obligatorily skipped in the context __(.

b. Destress syllables RL which are left adjacent to stressed syllables.

These assumptions do manage to predict almost all the examples which Cowan gives, but not all. They fail to predict *han.də.bó.ke* (38h), which has a single stress. Instead, it predicts *hàn.də.bó.ke*, with a stressed initial heavy syllable. Hayes suggests that Cowan may have transcribed this example incorrectly. (51) makes the correct prediction; see the derivation summary in (50). The data contains only 9 examples with 4 or more syllables, so this single incorrect prediction is significant.

The analysis (52) makes some improbable predictions. It predicts L L(H́)(Ĺ L), which gives L L(H)(Ĺ L) after destressing, with 3 leading stressless syllables, one of them heavy. This is dubious, but Cowan's data is too sparse to put it to the test. (52) more plausibly predicts (Ĺ L) H(Ĺ L). Without evidence it is difficult to be sure, but it seems likely that the analysis (52) only survives because the data set is so limited.

Hayes does not make the mode of application of destressing clear, but it must be RL iterative. Otherwise, either across the board or LR, we would get the implausible L L(H)(H)(Ĺ L). Unfortunately, there is not evidence in Cowan's published data to confirm this. The fact that there are 2 RL iterative rules, the second one devoted to correcting the mistakes that the first one made, suggests that there is only one RL rule which does not make mistakes. Our analysis predicts L L(H́H)(Ĺ L), with one RL rule and no mistakes.

4.5 Weak local parsing

Hammond (1990a, 1990b) and Hayes (1995) developed the insight that what had been thought of previously as ternary feet was an illusion. They proposed that ternary stress intervals were the result of gapped binary feet. That poses the question: What determines when gaps appear between binary feet? Hayes proposed that there is a special footing algorithm which groups beats into feet on the basis of a language specific "foot inventory" and choices for various parameters. The algorithm works directionally, gathering beats into well-formed feet. The algorithm is parametrized; for one setting feet are abutted, for the other light syllables are skipped. A secondary parameter controls whether skipping is obligatory, or only if possible. The restriction to skipping light syllables was justified as a locality effect. Feet could not be too far apart, with heaviness causing them to be too far apart. If it is supposed that either setting can be chosen in Estonian, the binary/ternary variation discussed in Section 3 is nicely accounted for.

The problem with this proposal is that while "skip a light syllable if possible" correctly describes ternary footing in Estonian, other languages have other criteria. In Finnish, see Section 2, the correct description is "skip a beat if alignment is improved by skipping". In order for alignment to be improved, the skipped beat will necessarily be a light beat followed by a nonfinal heavy beat. In Sentani (Section 4) the correct description is "skip a beat unless not skipping improves alignment". The skipped beat can be light or heavy, but will necessarily be preceded by a noninitial heavy beat. More flexibility is needed than that the choice between abutting and skipping is determined by the weight of the potentially skipped beat. In Estonian, a better description is "skip a beat unless not skipping aligns a heavy syllable" (i.e., puts it in stress position). The common thread is that what controls abutting versus gapping is pressure to align inherent heavy syllable stress with metrical stress.

Aside from empirical adequacy, there is a conceptual problem in the whole idea of a 'footing algorithm'. Phonology already has the category of rules, directional iterative rules. The introduction of a new category of rules needs substantial justification to show that the well-known characteristics of iterative rules are inadequate to carry out footing. A major consequence of Idsardi's idea of one-sided delimiters is that it allows footing by a standard iterative rule operating directionally on a line (tier) of phonological items (beats).[11]

11. This idea was not taken full advantage of by Idsardi; his footing rules were of the form $\times\times \rightarrow \times\times\rangle$, for example, although there is no line of $\times\times$-items. This is a vestige of the idea of a parsing algorithm. It applies to groups of beats, not to individual beats.

Section 5. Tripura Bangla

The thesis of Das (2001) presents an OT analysis of the stress system of Tripura Bangla (TB), a dialect of Bengali. Das provides an extensive and very useful wordlist (pp. 200–203) from which the examples in (55), (56), and (60) are taken. (C)V syllables are light, all others are heavy. The stress patterns of a majority of the examples, including all the examples in (54), are predicted by the basic ternary system (53), with non-persistent GB. Non-persistence is the restriction of GB application to beats away from the far edge, as in the Cayuvava and Sentani footing systems.

(53)
$$\left.\begin{array}{l} \mathsf{x} \rightarrow \langle \mathsf{x} \;/\; \#\_\_ \\ \left[\begin{array}{l} \mathsf{x} \rightarrow \mathsf{x}\rangle \;/\; \_\_\mathsf{x} \\ \mathsf{x} \rightarrow \mathsf{x}\langle \end{array}\right]_{\mathrm{LR}} \end{array}\right\} ;\ {*}\textsc{UnaryT} \qquad \begin{array}{l} (\mathrm{GF}_{\#}) \\ (\mathrm{GB}) \\ (\mathrm{GF}^{\mathrm{x}}) \end{array}$$

(54)

(54)	a.	*gó.ra*	(Ĺ L	‘root’
	b.	*bá.ta.ʃa*	(Ĺ L) L	‘type of candy’
	c.	*kɛ́.ra.mo.ti*	(Ĺ L) L L	‘ingenuity’
	d.	*ɸó.ri.sa.lò.na*	(Ĺ L) L (Ĺ L	‘direction’
	e.	*ɸró.yo.zo.nì.yɔ.ta*	(Ĺ L) L (Ĺ L) L	‘necessity’
	f.	*ó.no.nu.ʃɔ̀.ro.ni.yɔ*	(Ĺ L) L (Ĺ L) L L	‘unfollowable’
	g.	*aít.na*	(H́ L	‘veranda’
	h.	*ʃɔ́r.kar*	(H́ H)	‘government’
	i.	*ɸá.til*	(Ĺ H)	‘earthen pot’
	j.	*ɸák.na.mi*	(H́ L) L	‘precocity’
	k.	*ʃɔ́m.pot.ti*	(H́ H) L	‘wealth
	l.	*dúr.gɔ.ʈɔ.na*	(H́ L) L L	‘accident’
	m.	*ʃɔ́m.por.ki.tɔ*	(H́ H) L L	‘related’
	n.	*ɔ́.ma.no.ʃìk*	(Ĺ L) L (H̀)	‘inhuman’
	o.	*ʃán.bi.da.nìk*	(H́ H) L (H̀)	‘constitutional’,
	p.	*dúr.bit.ta.yɔ̀n*	(H́ L) L (H̀)	‘criminalization’
	q.	*ɸɔ́dʒ.dʒa.lɔ.sɔ̀.na*	(H́ L) L (L̀ L)	‘deliberation’
	r.	*ɸɔ́k.kɔ.ɸa.tìt.tɔ*	(H́ L) L (H̀ L)	‘partisanship’
	s.	*ɔ́.ɸo.ri.hàidʒ.dʒɔ*	(Ĺ L) L (H̀ L)	‘inevitable’
	t.	*ɔ́.nɔ.bɔ.lɔ̀m.bɔn*	(Ĺ L) L (H̀ H)	‘partisanship’
	u.	*ɔ́.ɸo.ri.bɔ̀t.ti.tɔ*	(Ĺ L) L (H̀ L) L	‘unchanged’
	v.	*ɔ́.ɸo.ri.bɔ̀t.to.ni.yɔ*	(Ĺ L) L (H̀ L) L L	‘unchangeable’

There are two other groups of examples which show that (54) must be amended. The first is (55).

(55)	a.	*ʃɔ́ŋ.rɔk.kɔ̀n*	(H́ H)(H̀)	'reservation'
	b.	*ɸó.ri.bɛ̀ʃ*	(Ĺ L)(H̀)	'environment'
	c.	*ó.nu.kɔ̀m.pa*	(Ĺ L)(H̀ L	'compassion'
	d.	*ó.β'i.nɔ̀n.dɔn*	(Ĺ L)(H̀ H)	'congratulations'
	e.	*ó.nu.bɔ̀t.ti.ta*	(Ĺ L)(H̀ L) L	'obedience'
	f.	*ɸá.rɔ.dɔ̀ʃ.ʃi.kɔ.ta*	(Ĺ L)(H̀ L) L L	'expertness'

One is tempted to think that the mechanism that accounts for (55) is the same as the mechanism that produces similar results for the ternary option in Estonian; restricting GF^x to apply to light syllables only. Examples like those in (55b,c) would be footed in the Estonian ternary variation as in (56).

(56) a. ⟪ Ĺ L ⟩ H̀ L ⟩
$GF_\#$ GB GB

b. ⟪ Ĺ L ⟩ H̀ ⟩
$GF_\#$ GB GB

But this cannot be the case in Tripura Bangla; GB is not applicable to the final beat.

The most direct way for the language learner to modify (53) is to simply add a subrule to the iterative rule so that it makes every heavy beat which it targets foot-initial, subject to the derivational constraints. This is the way the Finnish iterative scheme (25) works. (57) results.

(57)
X → ⟨ X / # __ $(GF_\#)$
H → ⟨ H (GF_H)
X → X ⟩ / __ X (GB)
X → X ⟨ (GF^x)
$[\ldots]_{LR}$; *UnaryT

(57) accounts for all of the examples in (55). Here are a few derivation summaries.

(58) [55a] *ʃɔ́ŋ.rɔk.kɔ̀n*
⟪ H́ H ⟩⟨ H̀
$GF_\#$ GB GF_H

[55c] *ó.nu.kɔ̀m.pa*
⟪ Ĺ L ⟩⟨ H̀ L
$GF_\#$ GB GF_H

[54d] *ɸó.ri.sa.lɔ̀.na*
⟪ Ĺ L ⟩ L ⟨ L̀ L
$GF_\#$ GB GF^x

[55f] *ɸá.rɔ.dɔ̀ʃ.ʃi.kɔ.ta*
⟪ Ĺ L ⟩⟨ H̀ L ⟩ L L †
$GF_\#$ GB GF_H GB

† GB is not persistent.

The other group of words that are not accounted for by (57) are the words of the form LHX···. They are footed L(HX)···. This clearly is a heaviness effect, a light beat is skipped over so that a heavy beat can be made foot initial.

(59) #LHX··· words

a.	*ɸo.rík.ka*	L(H́ L)	‘examination’
b.	*bi.ʃɔ́j.jɔn*	L(H́ H)	‘immersion’
c.	*a.bɔ́r.zɔ.na*	L(H́ L)L	‘garbage’
d.	*ɔ.ʃáb.da.nɔ.ta*	L(H́ L)L L	‘carelessness’
e.	*ɔ.ʃɔ́ŋ.rok.ki.tɔ*	L(H́ H)L L	‘unreserved’
f.	*o.ʃɔ́ŋ.zu.zo.nì.yə*	L(H́ L)L(Ĺ L)	‘unattachable’

An additional marking rule is needed; L → L⟨ / #__H ; *Unary. It is constrained by *Unary. *ɸá.til*, (54i), shows that it does not apply to LH words. It takes precedence over GF$_{\#}$ when it is applicable. Call the rule GF$^{\#}_{\text{LH}}$. The order of GF$_{\#}$ and GF$^{\#}_{\text{LH}}$ is intrinsic; the more specialized rule is ranked more highly.

The fully modified system is (60). The modifications are outlined. All of them are straightforward steps to improve alignment.

(60)

$$\left.\begin{array}{l}\boxed{\mathsf{L} \rightarrow \mathsf{L}\langle\ /\ \#\_\_\mathsf{H}} \\ \mathsf{X} \rightarrow \langle\mathsf{X}\ /\ \#\_\_\end{array}\right\}\ ;\ {}^{*}\textsc{Unary} \qquad \begin{array}{l}(\mathrm{GF}^{\#}_{\mathrm{LH}}) \\ (\mathrm{GF}_{\#})\end{array}$$

$$\left[\begin{array}{l}\boxed{\mathsf{H} \rightarrow \langle\mathsf{H}} \\ \mathsf{X} \rightarrow \mathsf{X}\rangle\ /\ \_\_\mathsf{X} \\ \mathsf{X} \rightarrow \mathsf{X}\langle\end{array}\right]_{\mathrm{LR}}\ ;\ \boxed{{}^{*}\textsc{Unary}\mathrm{T}} \qquad \begin{array}{l}(\mathrm{GF}_{\mathrm{H}}) \\ (\mathrm{GB}) \\ (\mathrm{GF})\end{array}$$

Here are some examples.

(61)

[59a] *ɸo.rík.ka*
L《H́ L
GF$^{\#}_{\text{LH}}$

[59e] *ɔ.ʃɔ́ŋ.rok.ki.tɔ*
L《H́ H⟩L L
GF$^{\#}_{\text{LH}}$ GB

[55e] *ó.nu.bòt.ti.ta*
《Ĺ L⟩⟨H̀ L⟩L
GF$_{\#}$ GB GB$_{\text{H}}$ GB

[54i] *ɸá.til*
《Ĺ H†
GF$_{\#}$

[54t] *ɔ́.nɔ.bɔ.lɔ̀m.bɔn*
《Ĺ L⟩L⟨H̀ H
GF$_{\#}$ GB GF^{x}

[54o] *ʃán.bi.da.nìk*
《H́ H⟩L⟨H̀
GF$_{\#}$ GB GF^{x}

† GF$^{\#}_{\text{LH}}$ is blocked by *Unary, so GF$_{\#}$ can apply.

5.1 Short-sighted alignment

There are a few more examples from Das (p.c.) that are instructive.

(62) a. *ɸɔ́ɟ.ɟa.lʊ.sɔ̀.nar* 《 $\underset{\mathrm{GF}_\#}{\underset{<}{\acute{\mathrm{H}}}}$ $\underset{\mathrm{GB}}{\underset{>}{\mathrm{L}}}$ 〉 $\underset{\mathrm{GF}^x}{\underset{>}{\mathrm{L}}}$ 〈 L̀ H ‘of deliberation’

b. *ʃá.rɔ.ma.nʊ̀.bɪk* 《 $\underset{\mathrm{GF}_\#}{\underset{<}{\acute{\mathrm{L}}}}$ $\underset{\mathrm{GB}}{\underset{>}{\mathrm{L}}}$ 〉 $\underset{\mathrm{GF}^x}{\underset{>}{\mathrm{L}}}$ 〈 L̀ H ‘atomic’

c. *ʃɔ́.ma.lʊ.sɔ̀.nar* 《 $\underset{\mathrm{GF}_\#}{\underset{<}{\acute{\mathrm{L}}}}$ $\underset{\mathrm{GB}}{\underset{>}{\mathrm{L}}}$ 〉 $\underset{\mathrm{GF}^x}{\underset{>}{\mathrm{L}}}$ 〈 L̀ H ‘of criticism’

In each example, there is a foot-final unstressed heavy syllable. Compare (62a–c) with (54n,o).

(L L)(L L)(H) is a different footing which has better alignment than the observed (L L) L(L H) footing. But GF^x, X → X〈, is short-sighted; it does not consider the long-term consequence of its application. A rule could be formulated with more look-ahead (in the form of a derivational constraint) which would avoid the (62) examples;, GF^x ; * / 〈_L H . But, as noted in fn. 9, the derivational constraint is a highly marked. Further, it would be a more complex and less computationally efficient rule with only a minor overall effect in improving alignment. The effect in a few cases would be improved alignment, but overall the effect would be minor. In the *design of the system*, computational efficiency can overrule alignment.

Das’ analysis is set in global OT theory. It fails to predict the correct stress patterns in (62). Its constraint WSP (‘heavy syllables are stressed’) outranks the competing constraints. The consequence is that

(Ĺ L)(L̀ L)(H̀) $\gg_{\mathrm{WSP}}$ (Ĺ L) L(L̀ H)

Das did not consider these particular examples in his thesis and subject them to ‘trial by tableau’. We will see later that the failure to test the predictions of OT analyses on a sufficiently extensive set of examples is a common source of errors in verifying OT analyses. See Section 7 for further discussion of this issue.

The examples (62) also have implications for the Halle and Idsardi (1995) Syllable Boundary Projection (SBP) proposal. They proposed that heavy syllable effects could be explained by a marking rule (SBP) which applied to prior to iterative footing. This cannot be the case in Tripura Bangla. Some examples from (54), (55), and (62) are given below.

(63) [55b] *ɸó.ri.bɛ̀ʃ* [54n] *ɔ́.ma.no.ʃìk* [62c] *ʃɔ́.ma.lʊ.sɔ̀.nar*

SBP must distinguish between L L H and L L L H on the one hand, where H → ⟨H applies, and L L L L H, where it does not. This requires counting light syllables to the left of the heavy syllable. This is something the iterative rule can do, but SBP cannot.

The footing system (57) foots these examples as shown below.

(64) a. ⟪ $\underset{\prec}{\acute{\text{L}}}$ $\underset{\succ}{\text{L}}$ ⟩⟨ $\underset{\prec}{\grave{\text{H}}}$ b. ⟪ $\underset{\prec}{\acute{\text{L}}}$ $\underset{\succ}{\text{L}}$ ⟩ $\underset{\succ}{\text{L}}$ ⟨ $\grave{\text{H}}$ c. ⟪ $\underset{\prec}{\acute{\text{L}}}$ $\underset{\succ}{\text{L}}$ ⟩ $\underset{\succ}{\text{L}}$ ⟨ $\grave{\text{L}}$ H

$GB_{\#}$ GB GF_{H} $GB_{\#}$ GB GF^{x} $GB_{\#}$ GB GF^{x}

There is no way to avoid an iterative rule which is sensitive to both beat count and weight.

Section 6. Overlong syllables in Estonian

The basic idea for analyzing the prosodic properties of so-called overlong syllables in Estonian was developed in Prince (1980), based on the description by Hint (1973), and further developed in Hayes (1995). Such syllables impressionistically sound heavier than heavy syllables, and are associated with particular prosodic effects. Prince's idea was that overlong syllables can (optionally) act like disyllabic sequences, reflecting a diachronic origin. The consequence is that there is an option of (V) or (V X) feet, using V to denote an extra-heavy beat, one which is projected from an overlong syllable. The data is from Hayes (1995), taken from Hint (1973).[12] It will be presented in 3 groups. The first consists of those examples which are consistent with a (V)/(V X) option. The latter 2 groups deal with some complications. The overlong syllables are boldfaced.

12. For typographic reasons, the page references to the source of the examples are omitted in this section. They can be found by consulting the wordlist on p. 319 in Hayes.

(65) (V) or (V X)

a. ***árs****.ti*	(V́)L	(V́ L)
b. ***yǽl****.kè.test/****yǽl****.ke.tèst*	(V́)(L̀ H)	(V́ L)(H̀)
c. ***hái****.kùs.test/****hái****.kus.tèst*	(V́)(H̀ H)	(V́ H)(H̀)
d. ***káu****.kè.le/****káu****.ke.le*	(V́)(L̀ L)	(V́ L)L
e. ***tö̋ös****.tù.se.le/****tö̋ös****.tu.sè.le*	(V́)(L̀ L)L	(V́ L)(L̀ L)
f. ***tö̋ös****.tùs.te.le/****tö̋ös****.tus.tè.le*	(V́)(H̀ L)L	(V́ H)(L̀ L)
g. ***tö̋ös****.tùs.tes.se/****tö̋ös****.tus.tès.se*	(V́)(H̀ H)L	(V́ H)(H̀ L)
h. ***áu****.sài.mat.tèks/****áu****.sai.màt.teks*	(V́)(H̀ H)(H̀)	(V́ H)(H̀ H)
i. ***káu****.kèt.tes.sè.ki/****káu****.ket.tès.se.ki*	(V́)(H̀ H)(L̀ L)	(V́ H)(H̀ L)L
j. ***tɣ́es****.tù.set.tà.ki/****tɣ́es****.tu.sèt.ta.ki*	(V́)(L̀ H)(L̀ L)	(V́ L)(H̀ L)L

k. ***trúu****.tù.se.lè.ki/****trúu****.tu.sè.le.ki* , ***trúu****.tu.se.lè.ki*

(V́)(L̀ L)L̀ L)/(V́ L)(L̀ L)L,(V́ L)L(L̀ L)

l. ***kín****.tlùs.te.lè.ki/****kín****.tlus.tè.le.ki* , ***kín****.tlus.te.lé.ki*

(V́)(H̀ L)(L̀ L)/(V́ H)(L̀ L)L,(V́ H)L(L̀ L)

Suppose we interpret Prince's idea that there is an option between (V) and (V X) feet as the option to treat the sequel to V as a prosodic word in its own right. This can be realized as the option to mark not only initial V but the following X as word-initial beats. Let *UnaryV be the constraint which accepts beats which are overlong or accepted by *UnaryT. The system (34) is modified in two ways, highlighted in (66).

$$\text{(66)}\quad \begin{array}{ll} \mathsf{X} \to \langle \mathsf{X} / \#\_\_ ;\ {*}\textsc{Unary} & (\mathrm{GF}_{\#}) \\ \left.\begin{array}{l} \boxed{\mathsf{X} \to \langle \mathsf{X} / \mathsf{V}\_\_\dagger} \\ \left[\begin{array}{l} \mathsf{X} \to \mathsf{X}\rangle \\ \mathsf{L} \to \mathsf{L}\langle\dagger \end{array}\right]_{\mathrm{LR}} \end{array}\right\} \boxed{;\ {*}\textsc{UnaryV}} & \begin{array}{l} (\mathrm{GF}_{\mathrm{V}}) \\ (\mathrm{GB}) \\ (\mathrm{GF}) \end{array} \end{array}$$

(66) produces all the forms in (65), except for (65a). Because *Unary blocks the application of GF_{V}, Only (V L) is possible, not (V) L. But the stress is V́ L in either event, so (66) makes the correct prediction although it does not produce (V)L.

A few annotated derivation outcomes illustrate the effect of the added marking rule. GF_{V} is active (i.e. an available rule) in the first column, but not in the second column.

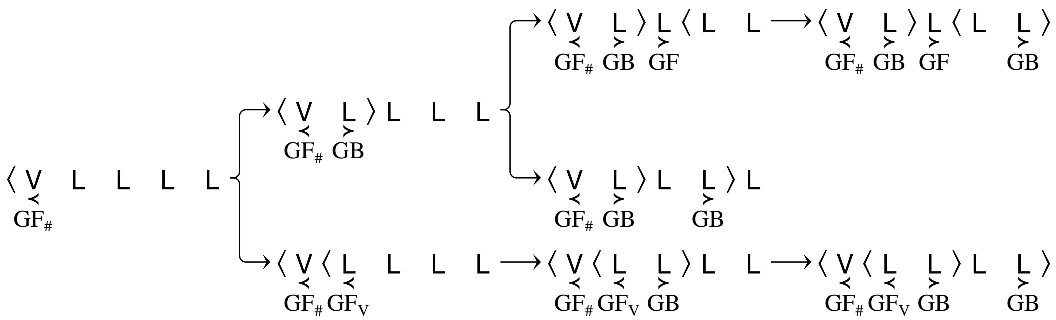
(67)

		GF_V active	GF_V not active
[65f]	***tő̋ös****.tù.se.le/****tő̋ös****.tu.sè.le*	⟪ V́ ⟪ L̀ L ⟩ L $GF_\#$ GF_V GB	⟪ V́ L ⟩ L̀ L ⟩ $GF_\#$ GB GB
[65c]	***hái****.kùs.test/****hái****.kus.tèst*	⟪ V́ ⟪ H̀ H ⟩ $GF_\#$ GF_V GB	⟪ V́ H ⟩ H̀ ⟩ $GF_\#$ GB GB
[65a]	***árs****.ti*	⟪ V́ L ⟩ $GF_\#$ GB	⟪ V́ L ⟩ $GF_\#$ GB

Even when GF_V is active in the last row, it cannot apply because it would produce a *Unary violation.

The 2 optionalities in the data (66) lead to 4 possible outcomes for suitable word shapes. There are no words in the data with a suitable shape to have 4 different stress patterns. But there are 2 examples which have 3 different stress patterns; (65k) and (65l). The derivation of (65k) is given below.

(68) **trúu***.tù.se.lè.ki/***trúu***.tu.sè.le.ki* , **trúu***.tu.se.lè.ki*



A form V L L L L L would yield 4 possible outcomes.

There are 2 groups of words in the data which are not explained by a (V)/(V X) alternation. There is no alternation,

(69) V L H X words

a.	***kýh****.tle.yàt.teks*	(V́ L)(H́ H)	*(V́)(Ĺ H)(H)
b.	***káh****.kle.vài.le*	(V́ L)(H́ L)	*(V́)(Ĺ H) L
c.	***káu****.ke.màt.tes.se*	(V́ L)(H́ H) L	*(V́)(Ĺ H)(H́ L)

But note that there is an alternation in V L H words.

d.	***yǽl:****.ke.tèst/****yǽl:****.kè.test*	(V́ L)(H́)	(V́)(Ĺ H)

V H L and V H words

e.	***yúl****.kèt.te*	*(V́ H) L	(V́)(H́ L)
f.	***vánkk****.rìtt*	*(V́ H)	(V́)(H́)

Both cases are heaviness effects

6.1 VLHX··· words

Recall that edge-marking in Tripura Bangla was exceptional for LHX··· word shapes; the initial light syllable was skipped over. Stress shifted from the light post-V beat to the following heavy beat. The heavy beat 'attracts' stress. The same edge marking is used in Estonian to mark the edge of the sequel to the overlong syllable. We need to revise (66) to (70).

(70)
$$\left.\begin{array}{l} \mathsf{X} \rightarrow \langle\, \mathsf{X} \,/\, \#\_\_ \\ \mathsf{L} \rightarrow \mathsf{L}\,\langle \,/\, \mathsf{V}\_\_\mathsf{H} \end{array}\right\}\text{; *U}\textsc{nary} \qquad \begin{array}{l}(\mathrm{GF}_{\#})\\(\mathrm{GF}_{\mathrm{VLH}})\end{array}$$
$$\left.\begin{array}{l} \mathsf{X} \rightarrow \langle\, \mathsf{X} \,/\, \mathsf{V}\_\_\dagger \\ \left[\begin{array}{l} \mathsf{X} \rightarrow \mathsf{X}\,\rangle \\ \mathsf{L} \rightarrow \mathsf{L}\,\langle\dagger \end{array}\right]_{\mathrm{LR}} \end{array}\right\}\text{; *U}\textsc{nary}\mathrm{V} \qquad \begin{array}{l}(\mathrm{GF}_{\mathrm{V}})\\(\mathrm{GB})\\(\mathrm{GF})\end{array}$$

If $\mathrm{GF}_{\mathrm{VLH}}$ applies, GF_{V} cannot apply. There are two reasons. In the first place, the FBC removes the light syllable as a potential target of later rules. In the second place, if it did apply, a *UNARY violation would result.

The *UNARY constraint on $\mathrm{GF}_{\mathrm{VLH}}$ is needed, otherwise there would be no alternation in (69d). $\mathrm{GF}_{\mathrm{VLH}}$ would apply and block GF_{V}. There is a similar restriction in Tripura Bangla. The use of $\mathrm{GF}_{\mathrm{VLH}}$ rather than $\mathrm{GF}_{\#}$ is a heaviness effect, allowing heavy/metrical alignment of the heavy syllable. Summaries of the derivations (one valid and one not invalid) which produce the the two (69b) forms are given below.

(71) ***káh**.kle.vài.le* / ***káh**.klè.vai.le* $\quad \underset{\mathrm{GF}_{\#}}{\langle\!\langle\, \acute{\mathsf{V}}}\ \underset{\mathrm{GF}_{\mathrm{VLH}}}{\mathsf{L}}\,\langle\!\langle\, \grave{\mathsf{H}}\ \underset{\mathrm{GB}}{\mathsf{L}}\,\rangle \qquad {}^{*}\underset{\mathrm{GF}_{\#}}{\langle\!\langle\, \acute{\mathsf{V}}}\ \underset{\mathrm{GF}_{\mathrm{V}}}{\langle\!\langle\, \grave{\mathsf{L}}}\ \underset{\mathrm{GB}}{\mathsf{H}}\,\rangle\, \mathsf{L}$

The derivation summarized on the right is not valid because $\mathrm{GF}_{\mathrm{VLH}}$ is applicable and ordered before GF_{V}. (65j) and (69c) are analyzed in the same way. There is alternation in (69d) because *UNARY blocks $\mathrm{GF}_{\mathrm{VLH}}$, so GF_{V} can optionally apply. Unfortunately, there is one casualty of introducing $\mathrm{GF}_{\mathrm{VLH}}$; if it applies in (65j), *tʸ̆es.tù.set.tà.ki* is no longer produced. I see no way to make the correct prediction in both (69c) and (65j). I must assume that the latter is marked as an exception to $\mathrm{GF}_{\mathrm{LH}}$.

6.2 V H and V H X words

There are two examples in which the disyllabic persona of the overlong syllable is obligatory.

(72) VH# and VHL# words.

a. ***yúl***.*kèt.te* (V́)(H́ L) *(V́ H) L

b. ***vánkk***.*rìtt* (V́)(H́) *(V́ H)

In both cases there is a heaviness effect, stressing the heavy syllable is obligatory

Comparison of the (72) examples with examples from (65), repeated below, show that the effect is limited to VH and VHL words.

(73)	a.	***hái***.*kùs.test*/***hái***.*kus.tèst*	(V́)(H́ H)	(V́ H)(H)	(65c)
	b.	***káu***.*kè.le*/***káu***.*ke.le*	(V́)(Ĺ L)	(V́ L)(L)	(65d)
	c.	***tő̈ös***.*tùs.te.le*/***tő̈ös***.*tus.tè.le*	(V́)(H́ L) L	(V́ H)(Ĺ L)	(65f)

It is easy to write the necessary marking rule: H → ⟨H / V__(L)#, with the parentheses here indicating optionality. If this rule applies before the optional rule X → ⟨ X / V __, it accounts for why there is no optionality in these examples. It is hard to see why the rule does not extend to all V H ··· words. I do not see any honest option other than undisguised stipulation. The best that can be said is that it is a single local rule, with no lexical listing needed.

6.3 Summary

We arrive finally to the fully elaborated footing system (74).

$$
(74)\quad
\left.\begin{array}{l}
\mathsf{X} \rightarrow \langle\, \mathsf{X} \,/\, \#\_\_ \\
\mathsf{L} \rightarrow \mathsf{L}\,\langle \,/\, \mathsf{V}\_\_\mathsf{H}
\end{array}\right\}\ ;\ {}^{*}\textsc{Unary}
\qquad
\begin{array}{l}
(\mathrm{GF}_{\#}) \\
(\mathrm{GF}_{\mathrm{VLH}})
\end{array}
$$

$$
\left.\begin{array}{l}
\mathsf{H} \rightarrow \langle\, \mathsf{H} \,/\, /\, \mathsf{V}\_\_(\mathsf{L})\# \\
\mathsf{X} \rightarrow \langle\, \mathsf{X} \,/\, \mathsf{V}\_\_{}^{\dagger} \\
\left[\begin{array}{l}
\mathsf{X} \rightarrow \mathsf{X}\,\rangle \\
\mathsf{L} \rightarrow \mathsf{L}\,\langle\,{}^{\dagger}
\end{array}\right]_{\mathrm{LR}}
\end{array}\right\}\ ;\ {}^{*}\textsc{Unary}\mathrm{V}
\qquad
\begin{array}{l}
(\mathrm{GF}_{\mathrm{HL}}) \\
(\mathrm{GF}_{\mathrm{V}}) \\
(\mathrm{GB}) \\
(\mathrm{GF})
\end{array}
$$

Except that it must somehow be listed that $\mathrm{GF}_{\mathrm{VLH}}$ does not apply in *tÿ́es.tù.set.tà.ki*, (65j), the system (74) accounts for *all* of the data.

One of the arguments favoring RBG phonology over OT phonology is the way that quirks and irregularities, diachronic baggage, can be accounted for by amending more basic rules. This section is not elegant. It's purpose is to show how a sequence of amendments can lead to a rule system which accounts for virtually all the examples in an extensive data set (i.e., the examples in Hayes, 1995). It is plausible that language learners go through a similar sequence of amendments as the data set to be accounted for expands.

Section 7. The verification problem

In an important paper, Karttunen (2006) makes the important point that there is reason to be cautious in verifying the correctness of OT analyses of stress systems. He justifies this caution by examining the OT analyses of Finnish word prosody in Elenbaas (1999), Elenbaas and Kager (1999), and Kiparsky (2003). He computed the optimal candidate using their proposed constraint lists for the words in a fairly large data set, using very large candidate sets.

The data set consists of a set D of input-output pairs. The theoretical analysis gives a function f from inputs to outputs. The analysis is verified by the data if $f(x) = y$ for all (x, y) in D. In practice, f is verified on only a subset D_0 of D. There are two kinds of problems that can arise in verification.

1. *Insufficient testing.* It is verified that $f(x) = y$ for all (x, y) in D_0, but there are other (x, y) which are in D but not in D_0 for which $f(x) \neq y$.
2. *False positives.* It appears that $f(x) = y$ for all (x, y) in D_0, but there is no actual verification because $f(x)$ is not actually what the analysis predicts.

Both OT and RBG (rule-based grammar) can fall prey to false positives. An OT account can fail to consider a sufficiently large set of competing outputs for some inputs because they are influenced by knowing what the output should be. An RBG account can make a mistake in some derivations because they also are influenced by knowing what the result should be. Below I will have something to say about how RBG accounts can shield against the false positive problem, as well of the insufficient testing problem. First, we consider the problems in verifying OT accounts.

Kartunnen convincinly demonstrates that although an analysis can be verified for $D_0 \subset D$ which is seemingly sufficiently large, there can be unexpected (x, y) in D which are not in D_0 for which $f(x) \neq y$. He concludes that one can go wrong in this way "even if one is a native speaker of the language and an expert in the field."

There is an example in Section 5.1 in in Das' analysis of Tripura Bangla in which shows that the D_0 he relied on to verify his proposals was not sufficiently extensive. The result was that there were data points (x, y) in the data D, not in D_0, for which $f(x) \neq y$. I should add that I cannot vouch for the fact that f gave the correct result for all $x \in D_0$ that were considered since Das only considered candidate sets with only 2 or 3 alternatives, with no argument given that this candidate set was sufficient to accurately determine $f(x)$. Effectively, he assumes that the reader will trust him that there are no other candidates that should be considered.

Karttunen's main point was not to condemn OT analyses, but simply to argue that it is very difficult to verify that OT analyses are correct without computational support. A extensive data set D_0 is needed. Let I_0 be the set of x for which there is a y such that (x, y) is in D_0. For each x in I_0, a sufficently large set of candidates C_x is needed in order to have confidence that the optimum in $\{(x, y)$ in $C_x\}$ if in fact the optimum among all the possibilities. This requires a great deal of computation. He tested the proposals for Finnish by choosing D_0 to be all the examples given in the papers, which was more extensive than the examples actually analyzed. The candidates sets were extravagantly extensive. The computation of $f(x)$ for all the x in I_0 required a non-trivial program and computational power to find, for each (x, y) in D_0 the optimal candidate in C_x and checking to see if it was in fact y. He found that for several x the optimal candidate was not in the proposed C_x. His conclusion of his investigation is the title of the paper, "The Insufficiency of Paper-and-Pencil Linguistics: the Case of Finnish Prosody".[13]

The analysis of Finnish word prosody in Section 2 is much easier to verify. It is not difficult to show that (75) follows from the proposed stress system (25). And it is not difficult to verify (75) on a large dataset without computational support. Paper-and-pencil linguistics is quite sufficient in the case of Finnish word prosody.

(75) σ_1 is stressed in multisyllabic words. If σ_n is stressed, then σ_{n+3} is stressed if σ_{n+2} is light and σ_{n+3} is heavy and nonfinal, otherwise σ_{n+2} is stressed if it is nonfinal.

Verifying the analysis yields the observed stress patterns reduces to verifying that (75) is a valid generalization over the data. OT analyses could avoid Karttunen's criticism if the constraint system proposed could be shown to imply (75). On the other hand, if it cannot be shown that (75) follows from the analysis, it would confirm Karttunen's claim. This poses a challenge to OT theories of footing and stress.

Each of the other 3 systems studied in this paper have descriptive algorithms similar to (75) which follow from the footing systems which were proposed for them.

13. Although Karttunen does not come to this conclusion, the difficulty in verifying OT analyses should be taken as an argument against the OT framework.

(76) a. Estonian:
σ_1 is stressed in multisyllabic words.
If σ_1 if overlong, then:
1. σ_2 is stressed if it is heavy and either final or followed by final light syllable. otherwise
2. σ_3 is stressed if it it is nonfinal and σ_2 is light; otherwise
3. σ_2 is optionally stressed if it is nonfinal.

If σ_n is stressed by the rules above, then σ_{n+3} is optionally stressed if σ_{n+2} is light and σ_{n+3} is heavy or nonfinal, otherwise σ_{n+2} is stressed if it is heavy or nonfinal.

b. Sentani: The antepenult is stressed if it is heavy, the penult is extra-light, and final syllable is light; otherwise the final syllable is stressed if it is heavy or the word is monosyllabic; otherwise the penult is stressed. If σ_n is stressed then σ_{n+3} is stressed if σ_{n+2} is light, otherwise σ_{n+2} is stressed if it is nonfinal. (Numbering is from right to left in RL systems.)

c. Tripura Bangla: σ_2 is stressed if it is heavy and nonfinal and σ_1 is light, otherwise σ_1 is stressed if is nonfinal. If σ_n is stressed, then σ_{n+3} is stressed if it is heavy or nonfinal and σ_{n+2} is light, otherwise σ_{n+2} is stressed if it is heavy.

7.1 Lookahead

It will be convenient below to number syllables. Numbers are consecutive LR or RL; σ_1 has the INITIAL property in LR systems and the FINAL property in RL systems.

(77) Say that an LR syllable-counting system has k-lookahead if stress on σ_n in

$$\sigma_1 \cdots \sigma_n \sigma_{n+1} \cdots \sigma_{n+k} \cdots$$

depends only on the properties of $\sigma_1, \ldots, \sigma_{n+k}$ and k is the smallest integer with this property.

The reader can deduce the corresponding definition for RL syllable-counting systems.

Finnish, Estonian, Sentani, and Tripura Bangla all are 1-lookahead. All of the footing systems proposed for Finnish that Karttunen critiqued were at least 3-lookahead. Consider our analysis (78) of *ká.las.tè.le.mì.nen* ‘fishing’ (Nom. Sg.). The correct stress pattern is predicted.

(78) *(ka.las)(te.le)(mi.nen)*

$\langle\!\langle\, \underset{<}{\mathrm{L}} \;\; \underset{>}{\mathrm{H}}\, \rangle\; \mathrm{L} \;\; \underset{>}{\mathrm{L}}\, \rangle\; \mathrm{L} \;\; \underset{>}{\mathrm{H}}\, \rangle$

$\mathrm{GF}_{\#}$ GB GB GB

The proposals of Elenbaas and Kiparsky both incorrectly predict the footing (79a), but would correctly predict (79b) if it were tested on a word with that particular syllable weight sequence.[14] A property of σ_6 affects stress on σ_3.

(79) a. $*(\underset{1}{\acute{\mathrm{L}}}\;\; \underset{2}{\mathrm{H}})\; \underset{3}{\mathrm{L}}\; (\underset{4}{\grave{\mathrm{L}}}\;\; \underset{5}{\mathrm{L}})\; \underset{6}{\mathrm{H}}$

b. $(\acute{\mathrm{L}}\;\; \mathrm{H})(\grave{\mathrm{L}}\;\; \mathrm{L})(\grave{\mathrm{L}}\;\; \mathrm{L})$

The reason that (79a) is produced is the high rank of the constraint StressToWeight in their systems; *(ká.las)te(lè.mi)nen* has one fewer StressToWeight violations than *(ká.las)(tè.le)(mì.nen)*.

I do not intend this to simply criticize these particular analyses. I am sure that they can be fixed up to produce that correct result. I suspect that OT practitioners would judge the list of constraints (80) as ‘parochial’, but the valid forms are characterized by these 5 inviolable conditions.

14. The analysis of the error is given in §1.5 of Karttunen’s paper.

(80) a. Feet are binary.
b. Stress is trochaic.
c. Main stress is initial.
d. (L H) feet occur only at the edges.
e. Unfooted beats are light and followed by a stressed heavy beat.

Characterizing the Finish stress patterns is a very easy problem.

Rather than criticize particular analyses, the intention is to criticize the OT conception of stress as a global maximization problem. It is not global, it is local and directional, with very limited lookahead. A satisfactory theory of footing and stress would have made the analyses of Elenbaas and Kiparsky transparently deficient. The fact that the framework so easily accommodates such analyses belies its claims to superior typological predictions.

The whole notion of lookahead is alien to the OT framework. The idea of the graded constraint AllFeetLeft already conspicuously wears on its sleeve its origin in left-to-right iteration.[15] Hopefully, trying to also incorporate the idea of lookahead will induce some linguists who have learned to live with AllFeetLeft to see that directional iteration cannot be avoided. It is not sufficient to deny the problem by saying that lookahead is not involved in the computation of stress. The notion ‘k-lookahead’ defined in (77) is *not theory dependent*. It is *an empirical fact* of some interest that all of the languages analyzed in this paper are at most 1-lookahead. It calls for an explanation.

15. Das’ thesis uses the term ‘iteration’ 24 times in explicating his OT analysis of Tripura Bangla. It is used in such expressions as “direction of iteration” (p. 97) and “the starting edge of iteration” (p. 138).

Section 8. Conclusion

Although the theory developed in this paper differs in significant ways from Halle and Idsardi (1995), the differences are secondary and it should be seen as support for the insight of Idsardi (1992). The core proposal in this paper is that DIRs are focused on a single beat. The rest of the paper consists of various consequences of the focused DIR proposal and empirical evidence supporting it. The main consequence is that several DIRs can be organized in a scheme, with the action at each stage in the derivation determined by the local conditions. This makes relatively straightforward analysis of the full spectrum of ternary systems possible as well as rhythmic footing which is weight sensitive.

A notion of k-lookahead was defined in a way that it can said to be true of a data set, independent of whatever theory is used to analyze that data set. All of the languages studied in this paper have a 1-lookahead word-stress system. This is easily explained in the framework of rhythmic footing carried out by schemes of focused DIRs. It is posed as a challenge to the OT framework to explain why lookahead is so limited in word prosody. Finding suitable system of constraints for particular languages is not an explanation. It must be shown that the architecture of the theory leads to limited lookahead.

A related challenge is an explanatory OT account of the partition of rhythmic footing into binary and gapped binary footing. Frampton (2023) shows how this follows from the same natural locality conditions on DIRs that account for limited lookahead.

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