RENÉ KAGER

ALTERNATIVES TO THE IAMBIC-TROCHAIC LAW*

This article seeks to develop alternatives to recent theories (Hayes 1985, 1987, 1991; McCarthy and Prince 1986, 1990; Prince 1991) that explain quantitative asymmetries between iambic and trochaic systems on the basis of a rhythmic *iambic-trochaic law*. The theory proposed here derives such asymmetries from two different rhythmic factors: moraic prominence-relations internal to heavy syllables, and avoidance of clash and lapse in sequences of moras. Firstly, it argues for a distinction between parsing feet and surface feet. Parsing feet draw from a symmetric foot inventory, based on two parameters: *stressable element* (mora vs. syllable), and *headedness* (iambic vs. trochaic). That is, the basic foot inventory is no longer governed by the iambic-trochaic law. Secondly, parsing feet are mapped into surface feet by rules that impose quantitative changes, or by stray adjunction, induced by strict prosodic layering. Thirdly, a rhythmic sub-theory defines filters that rule out clashes and lapses in sequences of moras or syllables, depending on the type of stressable element. It explains iambic-trochaic asymmetries with respect to lengthening and shortening, and an asymmetry with respect to directionality of iambic parsing. Evidence will be presented from Tübatulabal, Yidin^y, Araucanian, Chugach Alutiiq Yupik, Cayuga, Latin, and English.

1. The Iambic-Trochaic Law

Hayes (1985) has demonstrated a fundamental durational asymmetry between iambic and trochaic systems. Trochaic systems (those whose feet have initial prominence) are characterized by evenness of duration between the elements of the foot. In contrast, iambic systems (those whose feet have final prominence) typically display uneven feet of the form $[\sigma_\mu\ \sigma_{\mu\mu}]$, reinforced by vowel lengthening, consonant gemination, vowel reduction, etc. Hayes suggests that this asymmetry is grounded in a general principle of rhythmic grouping, extra-linguistic evidence for which was established in perception experiments by Woodrow (1951). Woodrow presented his subjects with rhythmically alternating stimuli in which promin-

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ence was marked either by intensity or duration. He found that intensity marking resulted in trochaic perception, and duration marking in iambic perception.[1] Hayes (1991) summarizes these results in the iambic-trochaic law:

(1) **Iambic-Trochaic Law** (Hayes 1991 p. 71)
  a. Elements contrasting in intensity naturally form groupings with initial prominence.
  b. Elements contrasting in duration naturally form groupings with final prominence.

Hayes points out that the iambic-trochaic law is reflected in the typology of rhythmic alternation in word stress systems. That is, systems which lack durational contrasts between syllables (where all syllables are equally light) are predominantly trochaic, while systems that have durational contrasts between syllables (where heavy and light syllables contrast) tend towards iambic rhythm.[2] In its strongest form, the iambic-trochaic law excludes quantity-insensitive iambic systems as well as quantity-sensitive trochaic systems. This formulation is obviously too strong, since trochaic systems are attested which display a syllable weight contrast. Hayes points out, however, that these are based on the durationally even quantitative trochee: $[\sigma_\mu\ \sigma_\mu]$ and $[\sigma_{\mu\mu}]$. It seems that the key factor in the iambic-trochaic law is not so much the presence of a durational contrast within the system, but rather a durational contrast within the foot. A restatement of the law in accordance with this revision would read as follows:

(2) a. Trochaic systems have durationally even feet.
  b. Iambic systems have durationally uneven feet.

Hayes (1987, 1991) reflects the iambic-trochaic law in the basic foot inventory (3), which contains *even* syllabic and moraic trochees, and *uneven* iambs:

[1] Studies on rhythmic perception are not in complete agreement on this issue. See for an overview Bell (1977).

[2] As a working hypothesis, such a typological relationship had already been suggested by Allen (1975, p. 78).

(3) Asymmetric metrical foot inventory (Hayes 1987, 1991)[3]

```
a. Syllabic Trochee   (* .)
                      σ σ

b. Moraic Trochee     (* .)    or    (*)
                      σ σ             σ
                      | |             |\
                      μ μ             μ μ

c. Iamb               (. * )   or    (. * )   or   (* )
                      σ σ            σ σ            σ
                      | |\           | |            |\
                      μ μ μ          μ μ            μ μ
```

In Hayes's view, the members of this foot inventory are primitives of linguistic theory, whose raison d'être is an extra-linguistic principle, the rhythmic iambic-trochaic law. The feet, as well as the principle on which they are grounded, are reinforced by rules that aspire towards the rhythmic ideal. For example, many iambic systems have rhythmic lengthening rules that produce durationally uneven feet at the surface. The second syllable in an even iamb $[\sigma_{\mu}\ \sigma_{\mu}]$ may be lengthened by vowel lengthening or by gemination of the following consonant, or the first syllable may undergo vowel reduction. All of these iambic processes lead to increased durational contrasts. In contrast, moraic trochee systems tend not to exhibit processes that rhythmically lengthen the first syllable in a foot, because these would introduce durational unevenness. Rather, some moraic trochee systems have rules that shorten a heavy syllable that is adjacent to an *unparsed* (stray) light syllable, so as to produce an even bimoraic foot (cf. Prince 1991, Mester 1991). Thus foot structure seems to be persistent throughout the phonology, in the sense that the effects of the iambic-trochaic law are maximized both by foot parsing and by quantitative processes at the surface level. This phenomenon has been called *metrical coherence* by Dresher and Lahiri (1991). The key feature of this theory is that it explains asymmetries between iambs and trochees by a rhythmic law governing foot shapes in the basic foot inventory.

McCarthy and Prince (1986) and Prince (1991) represent a somewhat different approach. They reformulate the iambic-trochaic law as a *linguistic* principle that governs the quantitative balance inside feet of different

[3] The foot inventory of Hayes (1991) differs from that originally proposed in Hayes (1987) in that it omits *stressless degenerate feet* (i.e. monosyllabic syllabic trochees, and monomoraic moraic trochees and iambs), a move proposed earlier by McCarthy and Prince (1986), Kager (1989) and Hayes (1989).

headedness. McCarthy and Prince (1986) propose a *Quantity/Prominence Homology*, by which feet whose members are quantitatively unbalanced have prominence on the heavier element (i.e. $[\sigma_{\mu}\ \sigma_{\mu\mu}]$ is iambic). They add a *Trochaic Default* principle, by which feet whose members are quantitatively balanced (i.e. $[\sigma_{\mu}\ \sigma_{\mu}]$) are trochaic by default.[4] However, a language may require that all feet have the same labelling everywhere (by the *Uniformity Parameter*), in which case both $[\sigma_{\mu}\ \sigma_{\mu\mu}]$ and $[\sigma_{\mu}\ \sigma_{\mu}]$ are iambic.

Prince (1991) integrates McCarthy and Prince's principles into a single *Grouping Harmony* principle, which expresses relative foot well-formedness as a function (the ratio) of the moraic weight of the second and the first element. This produces a well-formedness hierarchy of trochaic and iambic feet:

(4) a. Trochees: $[\sigma_{\mu\mu}], [\sigma_{\mu}\ \sigma_{\mu}] > [\sigma_{\mu\mu}\ \sigma_{\mu}] > [\sigma_{\mu}]$

b. Iambs: $[\sigma_{\mu}\ \sigma_{\mu\mu}] > [\sigma_{\mu\mu}], [\sigma_{\mu}\ \sigma_{\mu}] > [\sigma_{\mu}]$

In directional foot parsing, the optimal foot is built. Both the uneven quantitative trochee $[\sigma_{\mu\mu}\ \sigma_{\mu}]$ and the mono-moraic foot $[\sigma_{\mu}]$ are allowed, but these occupy low positions on the scale.

2. Rhythmic Asymmetries Without an iambic-Throchaic Law

The asymmetric theory sketched above makes two claims. Firstly, all asymmetries between iambic and trochaic systems derive from the iambic-trochaic law, which states the asymmetric relationship between patterns of prominence and durational contrasts. The law may well be rooted in an extra-linguistic perceptual principle of rhythmic organization. Secondly, the iambic-trochaic law governs the basic foot inventory, which consequently becomes asymmetric.

With respect to the first claim, that rhythmic asymmetries in stress systems derive from the iambic-trochaic law, we argue that an alternative source of asymmetries can be identified in principles of rhythmic organization operative at the moraic level, in particular (a) the syllable-internal sonority decline between the two moras of a heavy syllable, projected outside as prominence (Prince 1983), and (b) independently motivated rhythmic notions such as clash and lapse avoidance (Prince 1983, Selkirk

[4] It is thus predicted that iambs $[\sigma_{\mu}\ \sigma_{\mu\mu}]$ and trochees $[\sigma_{\mu}\ \sigma_{\mu}]$ may occur in the same system, an example of which may be Cairene Arabic (McCarthy 1979).

1984), which we apply to moras as stressable elements. We claim that a significant portion of the iambic-trochaic asymmetry in iterative stress systems is due to these linguistic rhythmic principles, rather than to the iambic-trochaic law. We do not intend to deny generally that extra-linguistic principles (i.e. the perceptual iambic-trochaic law of rhythmic organization) can be relevant to linguistic phenomena (i.e. rhythmic stress). However, we believe that the first goal of linguistic theory should be to investigate a purely linguistic basis of observed phenomena, before turning to the extra-linguistic domain.

Let us preview the key results here. Under our theory, quantitative processes are guided by various rhythmic goals, in particular avoidance of clash and lapse on the level of the stressable element. Unbalanced feet are the surface forms of parsing feet, which arise by (rhythmically conditioned) adjunction or lengthening. For example, iambic lengthening is an expansion of the bimoraic parsing foot $[\sigma_{\mu}\ \sigma_{\mu}]$ into a trimoraic surface foot $[\sigma_{\mu}\ \sigma_{\mu\mu}]$. Assuming a moraic sonority decline in heavy syllables, the internal prominence of the lengthened syllable must be falling. Thus, lengthening of the stressed syllable of an iamb produces an uneven iamb $[\sigma_{\mu}\ \sigma_{\mu\mu}]$ (5a). In contrast, trochaic lengthening would produce an uneven trochee $[\sigma_{\mu\mu}\ \sigma_{\mu}]$ (5b):

```
(5)a.  (. *)   ⇒   (. * .)   b.  (* .)   ⇒   (* . .)
       μ μ         μ μμ          μ μ         μμ μ
       | |         | |/          | |         |/  |
       σ σ         σ σ           σ σ         σ   σ
```

The explanation for the relative ill-formed status of the uneven trochee (5b) is the *mora lapse* which it contains (Selkirk 1984), i.e. a sequence of two stressless moras. Thus, the unnaturalness of rules of trochaic lengthening follows from lapse avoidance. In contrast, iambic lengthening (5a) is natural since it produces a rhythmically perfect uneven iamb (which might be called a moraic *amphibrach*, cf. Weeda 1989). For the same reason, rules that shorten the head of an uneven trochee are natural (by resolving a foot-internal lapse), while rules that shorten the head of an uneven iamb have no rhythmic bonus, and are unnatural. Thus, our theory attempts to deduce one phonological asymmetry (the iambic-trochaic one) from another (the sonority asymmetry of bimoraic syllables), rather than setting up both as primitives. These rhythmic principles are persistent in our theory, much as the iambic-trochaic law (or the basic foot inventory) is persistent in asymmetric theory.

We will also take issue with the second claim of the asymmetric theory, i.e. that the basic foot inventory must be asymmetric as a result of the iambic-trochaic law. Instead we propose a rhythm-free symmetric basic foot inventory, in the spirit of recent work by Hammond (1990a) and Jacobs (1990). Crucially, we deviate from these proposals in two respects. Firstly, as pointed out earlier, we explain iambic-trochaic asymmetries by principles of rhythmic organization which cannot be reduced to the iambic-trochaic law. In contrast, both Hammond and Jacobs identify some version of the iambic-trochaic law as the origin of asymmetries, either as an extra-linguistic principle of rhythmic perception (Hammond), or as a markedness principle on foot typology (Jacobs). Secondly, as we will see below, our foot inventory is not only symmetric, but *strictly binary* as well. Every foot may contain minimally and maximally two elements of identical status, either two moras or two syllables. In contrast, basic feet can be durationally unbalanced in both Hammond's and Jacobs's proposals.

Summarizing, we claim that a fully symmetric parametric inventory is preferable to an asymmetric non-parametric inventory, since an independent explanation is available for rhythmic asymmetries. This being the case, the simplest possible foot inventory should be adhered to. In the next sections, we will discuss further aspects of our theory: the fully symmetric parsing foot inventory (2.1), quantity-sensitivity (2.2), the distinction between parsing feet and surface feet (2.3), the sub-theory of rhythm (2.4), and directional foot parsing (2.5).

2.1. *A Fully Symmetric Parsing Foot Inventory*

Defining rhythmic well-formedness of feet by a factor that is external to the basic foot inventory allows a radical simplification of the latter. In (6) we introduce the fully symmetric foot inventory,[5] which results from variation of two parameters: *headedness* (trochaic vs. iambic), and *stressable element* (moraic vs. syllabic):

[5] Symmetric foot inventories have been explored by Hammond (1990a) and Jacobs (1990), although strict binarity of basic feet is not assumed in these works (i.e., basic feet can be unbalanced). Both view the iambic-trochaic law as the single source of asymmetries, either as an extra-linguistic principle of rhythmic perception, which filters out anti-rhythmic *iterative* (but not non-iterative) applications of feet (Hammond), or as a markedness principle that favors certain feet over others (Jacobs).

(6)		Moraic	Syllabic
	Trochee	(* .)	(* .)
		$\mu\ \mu$	$\sigma\ \sigma$
	Iamb	(. *)	(. *)
		$\mu\ \mu$	$\sigma\ \sigma$

As in earlier versions of parametric metrical theory (Hayes 1980, Halle and Vergnaud 1987), the *headedness* parameter governs the side of the foot where the head is located. The setting of this parameter is generally consistent throughout the phonology of a single language, but as we will see shortly, important deviations from consistency arise from the internal moraic sonority of heavy syllables in iambic systems. This asymmetric factor will be the key in explaining rhythmic quantitative asymmetries.

The second parameter governing the symmetric foot inventory is the *stressable element* parameter. We assume two types of stressable elements, the syllable and the mora (cf. Halle 1990, Halle and Kenstowicz 1991). Languages typically select *one* type of stressable element for all foot parsing. Feet are formally represented as constituents by a pair of brackets enclosing two stressable elements of the same type. The stressable element parameter replaces the traditional quantity-sensitivity parameter of Hayes (1980). Three types of system are predicted. Firstly, quantity-sensitive systems, whose quantitative distinctions are relevant to foot parsing, employ the mora as stressable element. These are *moraic trochee* systems, and *moraic iamb* systems, the latter corresponding to *standard iambs* in the asymmetric theory (cf. Section 3). Secondly, systems that lack syllable weight distinctions, where every syllable measures one mora, are ambiguous with respect to choice of stressable element. Thirdly, systems whose quantity distinctions are ignored by foot construction employ the syllable as stressable element. We will address such 'truly quantity-insensitive' systems in Section 3.3.

Observe that all parsing feet of (6) are strictly binary, as they are composed of two elements, moras or syllables. Accordingly, we adopt the *Strict Binarity Hypothesis* from Kager (1989) as a significant narrowing down of the notion of *possible parsing foot*:[6]

(7) **Strict Binarity Hypothesis**
Metrical parsing produces strictly binary constituents.

[6] In a more general sense, strict binarity has featured in earlier versions of metrical theory that were based on binarily branching metrical trees, such as Liberman and Prince (1977) and Giegerich (1985). As will be clear from the discussion below, we interpret strict binarity more specifically, being a property of parsing foot structure.

By strict binarity, all of (8) are ruled out as parsing feet. Expelled feet include *degenerate* syllabic and moraic feet (8a, c), *ternary* feet (built on syllables (8b) or moras (8f), and *uneven* feet (the maximal uneven trochee (8d), and the maximal uneven iamb (8e):

(8)a. (σ)	b. $(\sigma\ \sigma\ \sigma)$	c. σ	d. $\sigma\ \sigma$	e. $\sigma\ \sigma$	f. $\sigma\ \sigma\ \sigma$
		(μ)	$(\mu\mu\ \mu)$	$(\mu\ \mu\mu)$	$(\mu\ \mu\ \mu)$

With Kager (1989) and Hayes (1991) we assume that degenerate feet are tolerated in initial foot parsing only when they are licensed by some prominence at a higher level. This may arise in mono-moraic domains (cf. English *sátìre*, where the final syllable is extrametrical), or where main stress is fixed without intermediary foot structure ('top-down' or 'main-stress-first' parsing; Van der Hulst 1984). Otherwise, degenerate feet are available only as rhythmic repair devices outside foot parsing proper, under narrow rhythmic conditions to be discussed in Section 3.2.

2.2. *Quantity-Sensitivity and the Moraic Headedness Asymmetry*

The generalization that heavy syllables attract stress has been expressed differently in succeeding versions of metrical theory, cf. Hayes (1980), Prince (1983), Halle and Vergnaud (1987), Hayes (1987), Halle (1990). We will argue that quantity-sensitivity is simply another instance of strictly binary foot structure that is automatically present in systems that have the mora as stressable element. Formally, both moras of a heavy syllable are obligatorly bracketed into a foot $[\sigma_{\mu\mu}]$. We derive this result in two steps. Firstly, we adopt *Syllable Integrity* from Prince (1976; 1980, p. 29). A recent formulation is presented by Rice (1988):

(9) **Syllable Integrity**
The moras of a bi-moraic syllable must belong to the same metrical constituent.

Syllable Integrity expresses the idea that tautosyllabic moras may not be split between feet. As has been observed by a variety of authors, foot construction based on moras might, in principle, lead to parsings that split bimoraic syllables between feet:[7]

[7] Theories that restrict stressable elements to syllables exclude such representations directly. If feet dominate moras through the intermediary level of the syllable (cf. McCarthy and Prince 1986), moras that belong to the same syllable must also belong to the same foot, improper bracketing being excluded.

```
(10)    σ    σ σ
        |   /\ |
        (μ μ)(μ μ)
```

But it is clear that most languages do not tolerate this situation, a conclusion reached independently for systems such as Cairene Arabic (McCarthy 1979; Harms 1981), Estonian (Prince 1980), and Chugach Yupik (Leer 1985a,b; Rice 1988, 1990). In fact, there seems to be every reason to assume a universal interpretation of Syllable Integrity.[8]

Secondly, we want to derive a stronger result, namely that in quantity-sensitive systems, all heavy syllables inherently attract stress, i.e. constitute a foot. This result follows naturally if we consider the heavy syllable as the bimoraic domain of a syllable-internal sonority contrast, which is projected into metrical structure as stress (cf. Prince 1983, pp. 58–60). Let us call this principle *Quantity-Sensitivity*. It has often been observed that, cross-linguistically, the relative prominence between both moras (or timing units) of long vowels tends to be falling. A declining prominence contour also characterizes closing diphthongs and closed syllables, by the inherent sonority differences between their constituent moras.[9] *Rising* prominence of complex nuclei, in contrast, represents the marked situation, one which seems largely restricted to opening diphthongs. Our theory naturally defines the domain in which to represent the syllable-internal sonority contours of moras as local grid prominences. Syllable Integrity and strict binarity already predict it, in the form of a monosyllabic bimoraic foot:

```
(11)a.  σ                            b.  σ
        |\    (closed syllables,        /|     (rarely, cf.
        μ μ   long vowels,              μ μ    rising
        (* .) falling diphthongs)       (. *)  diphthongs)
```

Notice that heavy syllables are represented as *moraic trochees* in the unmarked case, i.e. in languages lacking rising diphthongs. Summarizing, the headedness of foot-internal prominence in heavy syllables derives from sonority factors (whether universal or language-specific) that are independent from, and override, the setting of the headedness parameter

[8] Halle (1990) claims that Winnebago counts moras as if syllables boundaries were absent. We refer to Hayes (1991) for an alternative analysis that does not require splitting heavy syllables between feet. Southern Paiute, another alleged counter-example to syllable integrity, has hetero-syllabic sequences of short vowels underlyingly, which are mapped into long vowels at the surface, cf. Hayes (1980).

[9] Cf. relational metrical theories of syllable structure such as Kiparsky (1979) and Giegerich (1985).

for directional foot parsing. Essentially, we are claiming that heavy syllable stress has a source that is independent from directional foot parsing, much as Prince (1983) distinguishes QS from Perfect Gridding. In moraic stress systems where heavy syllable stress and rhythmic light syllable stress combine, the bimoraic foot has two possible sources, each with its internal headedness. We thus arrive at the representations in (12) for the typical moraic trochee and moraic iamb (that is, we abstract away from rising nuclei):

```
(12)a.  Moraic trochee              b.  Moraic iamb

        (* .)   vs.   (* .)             (. *)   vs.   (* .)
        μ μ           μ μ               μ μ           μ μ
        | |           | /               | |           | /
        σ σ           σ                 σ σ           σ
```

The key property of the moraic iamb is the *non-uniform* headedness between its two shapes. Its disyllabic form $[\sigma_{\mu}\,\sigma_{\mu}]$ is truly *iambic*, while its monosyllabic form (the heavy syllable $[\sigma_{\mu\mu}]$) is inherently *trochaic* by falling mora prominence. In contrast, both forms of the moraic trochee are truly trochaic. Non-uniform headedness in iambs has major rhythmic consequences for both foot parsing and quantitative processes, and unifies two asymmetries that have been noticed, but have never been related, in the literature. Firstly, it provides the explanation for an asymmetry of directionality in iambic parsing, to be discussed in Section 3. Secondly, it will be instrumental in our account of iambic-trochaic asymmetries of lengthening and shortening in Section 5.

2.3. *Parsing Feet Versus Surface Feet*

Prince (1985) argues that unbounded feet can be eliminated from the basic foot inventory, since these can be derived from bounded *parsing* feet, which expand into unbounded *surface* feet by stray adjunction. We will elaborate on Prince's reductionist strategy, and factor out constraints operative at different levels of representation, in order to arrive at a more constrained theory. More precisely, *strict binarity* governs foot parsing, while it is only at the surface foot level that words must be *exhaustively* composed of feet.[10] This strategy will reward us in the form of a strictly binary symmetric basic foot inventory.

As a consequence of a strictly binary basic foot inventory, we are forced to abandon Halle and Vergnaud's (1987) *Exhaustivity Condition* on foot parsing:

(13) **Exhaustivity Condition**
Rules constructing constituents apply exhaustively over the entire string.

Strictly binary foot parsing cannot meet this condition since in order to do so it takes non-binary feet: *unbounded* feet for cases where any number of stressless elements may appear between stresses, *ternary* feet where maximally two stressless elements may intervene, and *degenerate* feet where stress falls on elements that cannot form a binary foot on their own. Instead, foot parsing is only *maximally exhaustive*, within the limits of possible feet as defined by the system. However, we will opt for an alternative, *representational* form of metrical exhaustivity, which is based on the *prosodic hierarchy* (cf. Selkirk 1980, Itô 1986, Nespor and Vogel 1986, Zec 1988, Inkelas 1989), of which we reproduce the lowest portion below:

(14) **Prosodic hierarchy**

M (*Prosodic Word*)
|
F (*Foot*)
|
σ (*Syllable*)
|
μ (*Mora*)

By the *Strict Layer Hypothesis* (Selkirk 1984, Nespor and Vogel 1986), each constituent of level n must be immediately dominated by a constituent of level $n + 1$, while each constituent of level n must immediately dominate only constituents of level $n - 1$. This constraint takes a more general form in Prosodic Licensing (Itô 1986), which requires that all phonological elements belong to higher prosodic structure: segments to syllables, syllables to metrical feet, and metrical feet to phonological

[10] A separate level of surface feet has been *empirically* motivated by segmental processes whose domains are feet that are not part of the basic foot inventory, such as flapping in English, cf. Kiparsky (1979), Nespor and Vogel (1986).

words or phrases. Under this view, exhaustivity is a formal property of representations rather than (parsing) rules. Exhaustivity may be satisfied by various types of operation mapping parsing units into surface units.

Thus, a distinction is in order between exhaustivity as a condition on foot parsing, and as a condition on prosodic representations. Interestingly, it is precisely the former interpretation of exhaustivity which seems to be too strong. Firstly, Prince (1985) has shown that parametric theory can be simplified by eliminating *unbounded* feet as primitives of stress theory. Unbounded feet are derived from non-exhaustive construction of bounded feet, plus stray adjunction. Secondly, as shown in Levin (1988, 1989), exhaustive parsing meets problems in systems with non-iterative foot construction rules (or even two non-iterative rules), applying at both ends of the word (cf. Stoney Dakota, Shaw 1985), but see Halle (1990) for a reply. Thirdly, Hayes (1991) argues for a non-exhaustive Weak Local Parsing mode to account for ternary systems, such as Cayuvava and Estonian. This mode finds solid support in the analysis of Chugach Alutiiq Yupik, to be presented in Section 4.

Thus, we adopt the interpretation of exhaustivity as a condition on metrical representations, which is induced by prosodic theory. Under this representational view, it is natural that languages select different mechanisms to achieve surface exhaustivity after initial foot parsing. These include *persistent footing* (Hayes 1991), assignment of *degenerate feet* (motivated in Section 3.2), *mora addition* to stray light syllables (motivated in Section 4), and *deletion* of stray light syllables (Hayes 1991, Mester 1991). However, *stray adjunction* is the default mechanism for satisfying surface exhaustivity, one that applies when the system does not include any specific rules to deal with unparsed material. It is independently motivated for adjunction of material arising from other sources, most notably destressing rules, and loss of extrametricality.

Stray adjunction must be able to apply in a non-structure-preserving way, since the resulting surface feet are not governed by strict binarity. Observe how a stray light syllable adjoins to a bimoraic parsing foot to create a surface uneven iamb (15a), or a surface amphibrach (15b):

```
(15)a.  . (* .)       (. * .)  b.  (. *) .      (. * .)
        μ μ μ   ⇒     μ μ μ        μ μ μ   ⇒    μ μ μ
        |  |/         |  |/        |  |  |      |  |  |
        σ  σ          σ  σ         σ  σ  σ      σ  σ  σ
```

We have already seen a second way to derive surface uneven iambs, i.e. iambic lengthening of [$\sigma_{\mu}\, \sigma_{\mu}$], in Section 2. Thus our theory derives uneven iambs from even parsing iambs, whereas the asymmetric theory sets up uneven iambs as primitives. This enables us to restrict parsing feet by strict binarity. This argument is fully parallel to Prince's (1985) argument for deriving surface unbounded feet from basic bounded feet in order to eliminate the boundedness parameter.

Our claim that moras can be stressable elements seems to contradict the Strict Layer Hypothesis, which precludes direct domination of moras by feet. To meet this, we propose that moraic feet are automatically copied as syllabic feet – if a string of moras forms a foot, then the syllable(s) dominating these moras must also be bracketed as a foot. In effect, this renders the syllable level transparent to moraic foot construction. For discussion of the principles involved, see Kager (1992).

2.4. *The Sub-theory of Rhythm*

In this section, we will develop a sub-theory of rhythm that will account for the iambic-trochaic asymmetries discussed in Section 1. We will apply such well-established rhythmic principles as clash and lapse avoidance to the mora level. This is a natural consequence of the mora's status as the stressable element in quantity-sensitive systems. Further evidence for rhythmic filters as conditions on quantitative rules will be presented in Section 5.

The notion of rhythmic filters presupposes an understanding of what constitutes rhythmically ill-formed configurations. Let us first define the well-established key notions of *clash* (after Prince 1983) and *lapse* (after Selkirk 1984):

(16) a. **Clash:** two adjacent stressed elements.
b. **Lapse:** two adjacent stressless elements.

Elements in (16) may be syllables or moras, and languages seem to vary in their tolerance with respect to clashes and lapses along this dimension, call it *rhythmic unit*. Let us adopt the strongest hypothesis here, which is that in every stress system, there must be a match between rhythmic units, in terms of which clash and lapse are defined, and parsing units (type of stressable element, cf. mora or syllable). Typologically, this *Rhythmic Uniformity Hypothesis* seems to be confirmed by the observation that moraic trochee systems tend to avoid mora clashes, but tolerate syllable clashes, while syllabic trochee systems usually avoid both types, see Kager (1992).

Clash and lapse figure in rhythmic filters to be discussed below. As elsewhere in phonology, the definition of the ill-formedness conditions itself does not strictly determine the actual avoidance strategy, which may be (a) blocking rules where they would introduce some violation of a filter, or (b) repairing the output of a rule when this violates a filter. Usually, the choice of the repair cannot be predicted. Repairs for clash include *destressing*, and *pretonic lengthening*, and for lapse, *persistent footing*, *degenerate feet*, and *shortening*. Discussion of these rhythmic repairs is postponed to Section 5. However, it is clear that in every rhythmic system, the quantitative rules conspire towards minimizing rhythmic ill-formedness. In its most general form, this may be formulated as a principle that evaluates prosodic processes in terms of their rhythmic output:

(17) **Eurhythmy Principle**
A process is evaluated higher to the extent that it minimizes rhythmic ill-formedness.

Another dimension of rhythmic structure is the *domain* in which it is measured. The domain of an ill-formedness condition is the prosodic category that contains every element that is mentioned in the condition. Natural candidates for rhythmic domains are the foot, being the primary domain in which stressable elements are organized, and the prosodic word (or phrase), being the domain of iterative foot parsing. Since, for independent reasons, feet contain a single head, the prosodic word (or phrase) is the natural domain in which clashes may be measured. In contrast, there is no inherent maximum of *stressless* elements within the foot. Consequently, lapse may be measured within the foot, which seems to be the domain of lapse avoidance in rhythmic stress systems. Let us formulate this as a foot-domain *Anti-Lapse Filter*:

(18) **Anti-Lapse Filter** (domain: foot)
No lapse is allowed within the foot.

Another way of phrasing the filter is to require that within feet non-head elements be adjacent to the head (cf. Halle and Vergnaud 1987).

Naturally, the Anti-Lapse Filter is respected in the parsing foot inventory, which contains only strictly binary feet with a single stressless element. At the surface level, where the strict binarity requirement is relaxed, the filter allows for the ternary moraic amphibrach (19a,b), while it excludes the ternary moraic dactylus (19c) and moraic anapest (19d):

```
(19)a. (. * .)   b. (. * .)   c. (* . .)   d. (. . *)
        μ μ μ       μ μμ        μμ μ        μ μ μ
        | | |       | |/        |/ |        | | |
        σ σ σ       σ σ         σ  σ        σ σ σ
```

Observe that the Anti-Lapse Filter characterizes the basic foot inventory of the asymmetric theory. That is, the moraic trochee $[\sigma_\mu\, \sigma_\mu]/[\sigma_{\mu\mu}]$ as well as the iamb $[\sigma_\mu\, \sigma_\mu]/[\sigma_\mu]/[\sigma_\mu\, \sigma_{\mu\mu}]$ obey the filter on the mora level, and no feet occur in the inventory that do not obey it.

To the extent that the Anti-Lapse Filter is language-specific, it seems to characterize precisely the set of systems with iterative foot assignment. Interestingly, one might construe iterativity of foot parsing in such '*rhythmic*' systems as a consequence of the Anti-Lapse Filter. The evidence for the Anti-Lapse Filter in iterative stress systems is extensive. Firstly, many syllabic systems tend to avoid stressless syllables that are not adjacent to a stressed syllable. Secondly, Hayes (1980) observes that extrametricality strongly prefers right-peripheral positions, regardless of directionality of foot parsing and headedness of feet. We find a corresponding skewed distribution in tolerance with respect to lapses, as cross-linguistically final ternarity (*double offbeats*) is much more common than initial ternarity (*double upbeats*). These observations can be related if extrametrical elements are invisible not only for foot parsing (and Prosodic Licensing), but also for rhythmic conditions. We will further motivate this assumption in Section 5. Whatever relationship may hold between extrametricality and foot-internal lapse avoidance, it seems clear that *domain edges*, in particular the right edge, allow for some invisibility of elements for foot parsing, as well as for rhythmic conditions. Thirdly, rhythmic systems that diverge from rhythmic binarity display ternary, but never quaternary alternation. Significantly, surface feet in ternary systems may be construed as amphibrachs, i.e. feet that respect the Anti-Lapse Filter, with hardly any exceptions.[11] We will return to ternarity in Section 4. Fourthly, the Anti-Lapse Filter explains the non-lengthening of stressed syllables in moraic trochees, along the lines of the account sketched in Section 2 (cf. 5b).

We assume that stray adjunction works in accordance with the Eurhythmy Principle, creating rhythmically optimal surface feet wherever it can. In particular, the Anti-Lapse Filter determines the *direction* of adjunction (leftward vs. rightward to an adjacent foot) on a purely *rhythmic* basis. In symmetric cases, where the Anti-Lapse Filter under-determines the direction of adjunction, as in a stray mora between footed stressed moras, adjunction prefers to produce surface feet whose headedness matches the specification of the parsing feet (cf. Hayes 1980) – let us call this the *Uniform Headedness Principle* (UHP). Thus, everything else being equal, iambic systems prefer rightward adjunction, and trochaic systems leftward adjunction.

[11] Cayuvava (Key 1961, Halle and Vergnaud 1987, Hammond 1990a, Hayes 1991) has initial double upbeats.

2.5. *The Sub-theory of Directional Foot Parsing*

A plausible incremental interpretation of directional foot parsing is the assignment of stressable elements to a *parsing window*, with automatic structure assignment to the window after a new element has been added. That is, the two sub-routines of (20) apply iteratively in a directional way, until all elements have been parsed:

(20) a. Add element n to the parsing window.
 b. Assign foot structure to the parsing window.

Parsing applies under strict binarity, i.e. excluding degenerate, ternary, and unbounded feet. Parsing always respects the *Free Element Condition* (Prince 1985), so that it cannot apply so as to organize elements into feet that have already been parsed into feet. Below we illustrate a fragment of a rightward parsing into moraic trochees:

(21)	Add mora n	Assign foot structure	
a.	$[\mu_1]\ \mu_2\ \mu_3\ \mu_4\ \mu_5$	$[\mu_1]\ \mu_2\ \mu_3\ \mu_4\ \mu_5$	(degenerate foot μ_1 excluded)
b.	$[\mu_1\ \mu_2]\ \mu_3\ \mu_4\ \mu_5$	(* .) $[\mu_1\ \mu_2]\ \mu_3\ \mu_4\ \mu_5$	(trochee μ_1–μ_2 formed)
c.	(* .) $[\mu_1\ \mu_2\ \mu_3]\ \mu_4\ \mu_5$	(* .) $[\mu_1\ \mu_2\ \mu_3]\ \mu_4\ \mu_5$	(degenerate foot μ_3 excluded)
d.	(* .) $[\mu_1\ \mu_2\ \mu_3\ \mu_4]\ \mu_5$	(* .)(* .) $[\mu_1\ \mu_2\ \ \mu_3\ \mu_4]\ \mu_5$	(trochee μ_3–μ_4 formed)

In a theory in which exhaustivity is representational, rather than a condition on foot parsing, *incremental* parsing guarantees that binary feet are assigned under strict adjacency.

A major consequence of this view is that clash avoidance during parsing must be restricted to the parsing window – parsing has no rhythmic *look-ahead*. We predict that a bimoraic foot over a heavy syllable (i.e. one which is due to *Quantity-Sensitivity*, not to directional foot parsing) is rhythmically invisible when parsing iterates towards that heavy syllable. In (22a) moraic iambs are parsed rightward. The inherent prominence on μ_3, the first mora of a bimoraic syllable, is still outside the window when directional parsing promotes, μ_2, by an iamb over μ_1–μ_2. In (22b), iambic parsing is leftward. Here, the inherent prominence on μ_2 falls inside the window when directional parsing promotes μ_3 by an iamb over $\mu_3 - \mu_4$, thus introducing a clash in the window.

```
(22)a.           (*  .)                   (*  .)     (.   *)   (*  .)
       [μ1]  μ2   μ3 μ4 ⇒ [μ1   μ2]  μ3 μ4 ⇒ [μ1   μ2]  μ3 μ4
        |    |     \ /     |    |     \ /     |    |     \ /
        σ    σ      σ      σ    σ      σ      σ    σ      σ

    b.           (*  .)                   (*  .)     (.   *)   (*  .)
       μ4   [μ3   μ2 μ1] ⇒ [μ4   μ3   μ2 μ1] ⇒ [μ4   μ3     μ2 μ1]
        |    |     \ /      |    |     \ /      |    |       \ /
        σ    σ      σ       σ    σ      σ       σ    σ        σ
```

Both directions produce mora clashes when the second, strong mora of a disyllabic foot is installed immediately before the initial, strong mora of a monosyllabic heavy foot: $[\sigma_{\mu}\ \sigma_{\mu}][\sigma_{\mu\mu}]$. But there is a crucial difference in the way these clashes arise. According to the theory of directional parsing, the initial prominent mora of a heavy syllable is still invisible when parsing approaches it from the left, whereas it is already part of the parsing window when leftward parsing resumes after it from the right. We thus predict a different status of clashes, depending on whether they are introduced inside or outside the parsing window.

This prediction is corroborated by Prince's observation (1983, pp. 61–62) that parsing generally avoids introducing clashes in *backward* direction. The notion *backward* is relativized to the direction of the parsing process. That is, leftward parsing cannot introduce a prominence that clashes with another prominence to the right, and rightward parsing cannot introduce a prominence that clashes with another prominence to the left. Our theory is able to distinguish (the equivalents of) forward and backward clash in much the same way as Prince's (who distinguishes 'QS' from Perfect Gridding), by factoring out heavy syllable stress from light syllable stress (the former inherently takes precedence over the latter, by *Syllable Integrity*). Given these observations, we hypothesize that, universally, foot parsing may not apply so as to introduce a clash in the parsing domain:

(23) **Anti-Clash Filter** (directional foot parsing)
Directional foot parsing cannot introduce a clash in the window.

Crucially, this does not rule out resumption of stress on a light syllable following a heavy syllable in a rightward moraic trochee system such as Cairene, cf. $[\sigma_{\mu\mu}][\sigma_{\mu}\ \sigma_{\mu}]$. The clash is introduced in the window at the syllable level, whereas the relevant parsing unit is the mora.

In situations where normal 'back-to-back' parsing would produce a clash, two kinds of reactions are (logically) possible. Firstly, the directional parsing process stops whenever a clash cannot be avoided. This would imply that specific strings of stressable elements have no possible analysis under a given mode of parsing, hence, under a standard view of linguistic parsing processes, are marked as ungrammatical. Alternatively, a stressable element may be *skipped* if parsing that element into a foot would otherwise cause a clash. Below, this is shown for a leftward iambic parsing. After μ_3 and μ_4 have been assigned to the window, no iamb can be built over these moras, as this would produce a clash (μ_2 and μ_1 have already been assigned into the window).

(24)

```
                (* .)                        (* .)     (.  *)  .  (* .)
μ5  [μ4  μ3  μ2 μ1] ⇒ [μ5  μ4  μ3  μ2 μ1] ⇒ [μ5  μ4  μ3  μ2 μ1]
|    |    |    \/        |    |    |    \/        |    |    |    \/
σ    σ    σ    σ         σ    σ    σ    σ         σ    σ    σ    σ
```

Following Prince (1983), we will tentatively assume that *skipping* is the correct strategy. Further motivation of this claim will be postponed to Section 3.2.

The remainder of this article is organized as follows. In Section 3, we will demonstrate that the standard iamb can be replaced in all its parsing functions by the even iambs of our symmetric foot inventory. Section 4 will make a positive argument for the moraic iamb (and against the standard iamb) on the basis of the metrical phonology of Chugach Alutiiq Yupik. Section 5 demonstrates the relevance of the rhythmic sub-theory for quantitative processes in a number of systems such as Cayuga, English, and Latin.

3. Replacing the Standard Iamb as a Parsing Unit

A point-by-point comparison between the asymmetric inventory and ours shows that the inventories agree on trochaic feet (syllabic and moraic). However, with respect to iambic feet, the inventories differ. Our foot inventory eliminates the uneven *standard iamb*, while introducing two even iambs, cf. the *moraic iamb* and the *syllabic iamb*. Here, we will show that these parsing feet may adequately replace the standard iamb.

This section is organized as follows. In sub-section 3.1, we will demonstrate the fairly trivial equivalence of moraic and standard iambs under rightward parsing, the mode relevant for the majority of iambic systems. Sub-section 3.2 shows that such an equivalence extends to leftward iambic systems, under conditions that follow from the theories of rhythm and directional parsing. We will show that these theories provide an explanation for the markedness of leftward iambic systems, which does not straightforwardly extend to the asymmetric theory. Finally, sub-sections 3.3 and 3.4 address syllabic iambs and trochees as parsing feet.

3.1. *Equivalence of Standard and Moraic Iambs Under Rightward Parsing*

The moraic iamb $[\sigma_{\mu}\, \sigma_{\mu}]$ and $[\sigma_{\mu\mu}]$ has been motivated as a unit of metrical parsing for Yupik prosodic systems by Leer (1985a, b) and Woodbury (1987). We will show here that it is fully equivalent to the standard iamb under rightward parsing, with only slight differences in bracketing. This conclusion has been reached independently by Prince (1991), who provides formal proof of the equivalence.[12] The demonstration is straightforward, and can be given without actual examples.

The adequacy of moraic iambs may be felt intuitively by realizing that rightward iambic systems stress all heavy syllables, and all even-numbered syllables in light-light sequences. Consider the fact that the only possible situation in which both parsing modes may produce different bracketings is where a light syllable is immediately followed by a heavy syllable, which sequence may be parsed as a standard iamb, but not as a moraic iamb. It occurs in words that begin with a light plus a heavy syllable, or more generally, wherever a heavy syllable is preceded by an odd-numbered sequence of light syllables. Parsing outputs of standard and moraic iambs are illustrated below for a single sequence of syllables, in which one up to four light syllables occur between heavy syllables:

```
(25)a.  (*)(. *)  (. *)(*)  (. *) (. *)  (. *)(. *)(*)   standard

    b.  (*.) .  (*.)(. *)(*.) (. *)  . (*.)  (. *)(. *)(*.)   moraic
        μμ μ   μμ  μ μ   μμ  μ μ   μ μμ   μ μ  μ μ  μμ
        |/ |   |/  | |   |/  | |   | |/   | |  | |  |/
        σ  σ   σ   σσ    σ   σ σ   σ σ    σσ   σ σ  σ
```

The difference of bracketing does not affect the output *stress* pattern, since the unbracketed light syllables in moraic iamb parsing always correspond to foot-initial stressless syllables in standard iambs. Moreover, every time after a heavy syllable has been passed, both parsing modes are 'synchronized' again, which excludes any possible long-distance transfer of local bracketing differences. Under our theory, the surface distribution of feet is predicted to be identical in both parsing modes, as the Anti-Lapse Filter and the Uniform Headedness Principle both predict rightward stray adjunction of stray moras, which produces uneven iambs.

[12] See for discussion also Van der Hulst (1991).

3.2. *The Leftward Moraic Iamb*

Equivalence of moraic iambs and standard iambs holds for parsing in the rightward direction. But what about leftward iambic systems? In unpublished classnotes (UCLA 1989–1990), B. Hayes draws attention to a puzzling *directionality* asymmetry in iambic parsing. Whereas syllabic and moraic trochees freely iterate in either direction,[13] quantitative iambs are intimately connected with *left to right* parsing.[14] Hayes (1991) mentions more than twenty rightward iambic systems, contrasted with only three leftward systems. The numerical superiority of rightward systems is somewhat flawed by the fact that several systems on the list are closely related (genetically and/or areally): Cayuga-Onondaga-Seneca (Lake-Ioquoian), Chickasaw-Choctaw-Creek-Seminole (Muskogean), Eastern Ojibwa-Menomini-Munsee-Passamaquoddy-Potowatomi-Unami (Algonquian), Carib-Hixkaryana-Macushi (Carib); but the typological diversity is restored by the presence of Asheninca (Arawakan), Madimadi (Australian), Negev and Cyrenaican Bedouin Arabic, Winnebago (Siouan), and various Yupik dialects.

In contrast, a leftward iambic analysis has been proposed for only three systems: Tübatulabal (Wheeler 1980, Hayes 1980), Aklan (Hayes 1980), and Tiberian Hebrew (Prince 1975, McCarthy 1979). Here we will demonstrate that an explanation of the markedness of leftward iambic systems derives from our theory of directional parsing and the rhythmic filters. Crucially, this explanation has no direct translation in the asymmetric theory under the iambic-trochaic law. But first, we intend to show that leftward iambic systems can in fact be analyzed by strictly binary feet. Having done so, we will have completed our demonstration that standard iambs can be replaced by feet from the strictly binary foot inventory. Our reanalysis of leftward iambic systems uses the moraic iamb in conjunction with mora skipping to avoid mora clash. This analysis captures the rhythmic complexity of leftward iambic systems by the need for degenerate feet to establish exhaustivity. Now consider the stress pattern of Tübatulabal (Voegelin 1935):

(26) a. tcíɳiyál — 'the red thistle'
b. tiɳíyaláap — 'on the red thistle'

---

[13] Leftward moraic trochee systems from Hayes (1991) are: Cahuilla (prefixes), Fijian, Hindi, Maithili, and Wargamay. Rightward moraic trochees occur in Cahuilla, Cairene Arabic, and Nunggubuyu (Kager 1990).

[14] Cross-linguistically, leftward parsing is marked as compared to rightward parsing for all foot types. But clearly, the absolute ban against leftward iambs cannot be reduced to this relative preference.

c.	wιtáŋhatál	'the Tejon Indians'
d.	wίtaŋhátaláabatsú	'away from the Tejon Indians'
e.	táahàwilá	'the summer (obj.)'
f.	táahàwiláap	'in the summer'
g.	wašáagáhajá	'it might flame up'
h.	ánaŋíinínɨmút	'he is crying wherever he goes (distr.)'
i.	ímbɨŋwíbaʔát	'he is wanting to roll string on his thigh'
j.	pɨtɨ́tpɨtɨ́ɨdinát	'he is turning it over repeatedly'
k.	haníilá	'the house (obj.)'

Stress falls on (a) final syllables, (b) long-voweled syllables, and (c) alternate short-voweled syllables counting backward from stresses defined by (a, b). According to Voegelin, "alternation of stress in general is oriented from the main stress, which is not acoustically more prominent than other stressed vowels, but merely serves as a convenient point of departure in describing the rhythmical pattern." This 'main stress' generally falls on the final syllable. Furthermore, stress always falls on the first mora of a long vowel, or stated otherwise, heavy syllables have a trochaic internal mora prominence. Observe how leftward standard iambs, supplemented with *degenerate feet*, produce the correct stresses:

(27)a. (*) (. *)(. *) (. *)
μ μ μ μ μμ μ μ
wί taŋ há ta láa ba tsú

b. (*) (*) (. *)
μ μ μ μ
táa há wi lá

c. (. *) (*)
μ μμ μ
ha níi lá

Degenerate feet are indispensable in three contexts: (28a) on the leftmost light syllable in an *even* sequence of light syllables to the left of a heavy syllable, (28b) on the leftmost light syllable of an *odd* sequence of light syllables lying to the left of the word end, and (28c) on a final light syllable, if it is directly preceded by a heavy syllable. The assumption that degenerate feet are generally excluded leads to incorrect predictions about the pattern of Tübatulabal:

(28)a. .(. *) (. *) (. *)
μ μ μ μ μμ μ μ
*wι taŋ há ta láa ba tsú

b. (*) . (. *)
μμ μ μ μ
*táa ha wi lá

c. (. *) .
μ μμ μ
*ha ní i la

This conclusion has considerable theoretical interest, since recent metrical theory (cf. Hayes 1991, Prince 1991, Kager 1989, Mester 1991) has established the marginal status of degenerate feet. As far as we know, *non-peripheral* degenerate feet (cf. 26h) have been motivated in the metrical literature exclusively for Tübatulabal, Aklan, and Tiberian Hebrew, i.e. precisely the set of leftward iambic systems.[15] Let us now place this puzzle in the perspective of our theories of directional parsing and rhythm.

It can be easily demonstrated that a moraic iamb analysis needs to be supplemented by skipping as a mechanism of clash avoidance. To see this, consider the rhythmic output of iambic parsing under the assumption that skipping is unavailable.

```
(29)a.  ( .*) ( .  * ) (* .) ( .  *)        b.  (*)  . ( .  *)
         μμ    μ  μ    μ μ   μ   μ               μμ  μ   μ  μ
        *wɩtáŋ ha tá   lá a  ba tsú             *táa ha wi lá

    c.  . (* . ) .
        μ  μμ    μ
      *ha ní i   la
```

Where moraic iambs are ‘synchronized’ with the quantity-sensitive iambs of (27), as in (29b, c), they cannot do without degenerate feet in both peripheral and medial positions. The distortion from the correct pattern is even more severe in (29a), where directional parsing is resumed after a heavy syllable *laa*, with long-distance leftward transfer of the mis-parsing effect.

Now consider the output of leftward moraic iambic parsing under a skipping theory. As suggested in Section 2.5, the Anti-Clash Filter automatically induces the skipping of one mora in order to avoid mora clash in the parsing window (skipped moras have been underlined):

```
(30)a.  (* .) . .  (* .) (. *) . (* .)     b.  .  (.    *) .(*.) (. *)
        μ μ  μ μ̲   μ μ   μ  μ  μ̲ μ μ           μ  μ    μ μ̲  μμ  μ  μ
        |/   | |   |/    |  |  | |/            wɩ taŋ  ha ta laa ba tsu
        σ    σ σ   σ     σ  σ  σ σ
```

As is clear from (30b), this skipping parsing mode in itself still fails to

[15] Degenerate feet occur systematically in similar positions in Aklan forms, cf. <u>*mà*</u>*tinàmarán* ‘being lazy’, *nagà:*<u>*pà*</u>*nabún* ‘go soaping (actor present)’ (Hayes 1980, p. 23), as well as in Tiberian Hebrew forms, where they are diagnosed by lack of reduction, cf. *màləkeehém* ‘their kings’ (McCarthy 1979).

produce the Tübatulabal stress pattern. However, notice that a pattern is produced that is identical to that of the leftward standard iamb (28). Where standard iambs produce $[\sigma_{\mu}\ \sigma_{\mu\mu}]$, moraic iambs produce $\underline{\sigma}_{\mu}\ [\sigma_{\mu\mu}]$, with a skipped mora, which will be adjoined rightward to produce an uneven iamb. In itself, this is an important result, since we have now demonstrated that leftward standard and moraic iambic parsing are equivalent. But of course, both theories still fail to produce the Tübatulabal pattern under the assumption that degenerate feet are ruled out.

Now the original problem can be reformulated as follows. If iambs can be assigned freely in both directions, and degenerate feet are highly marked, then why do we not find systems whose stress patterns minimally deviate from the Tübatulabal pattern in omitting degenerate feet? Logically, two types of answers may be tried out. Firstly, one may try to deny the existence of the problem, by showing that the Tübatulabal pattern simply does not require degenerate feet. This can be achieved by a reanalysis based on the moraic trochee, as has been proposed in Kager (1991), an earlier version of ideas presented here. Secondly, a potentially more interesting way of explaining the directionality asymmetry, which we will explore below, is to interpret the rarity of leftward iambic systems as a consequence of the fact that these require degenerate feet in the first place. There is much independent evidence suggesting that degenerate feet are highly marked (cf. Hayes 1991). We may avoid circularity of the argument if we can establish the following: (a) the conclusion that degenerate feet are the relevant means of achieving exhaustivity in Tübatulabal, which can be arrived at by demonstrating failure of alternatives, (b) a precise definition of the rhythmic contexts in which degenerate feet may occur.

Following this line of argument, let us try to reveal the correct generalization underlying the distribution of degenerate feet. In order to do so, we will have to look into the rhythmic properties of (30), the output of leftward moraic iambic parsing under clash avoidance by mora skipping. Clearly, clash avoidance by skipping leads to another kind of rhythmic ill-formedness in the form of sequences of unparsed elements, i.e. lapses. Ignoring degenerate feet for a moment, two solutions seem to be available to deal with these, and both fail as satisfactory repair strategies, for rhythmic reasons. Firstly, one may try reparsing, or *persistent footing* (Hayes 1991), by installing an iamb $[\sigma_{\mu}\ \sigma_{\mu}]$ over the unfooted sequence, as in (31a). But this illegally introduces clash in the parsing window. Secondly, one may try to incorporate both stray moras into adjacent feet by *stray adjunction*. Arguably, the righthand stray mora adjoins rightward without ill-formed effects as in (31b), but the leftward mora has no way of adjoining without violating the Anti-Lapse Filter since both of its neighbouring moras are stressless:

```
(31)a. (* .)(. *)(* .)   b. (* .) . (. * .)   c. (* .)(*)(. * .)
       μμ  μ  μ̲  μμ         μμ  μ  μ̲  μμ         μμ  μ  μ̲  μμ
       |/  |  |  |/         |/  |  |  |/         |/  |  |  |/
       σ   σ  σ  σ          σ   σ  σ  σ          σ   σ  σ  σ
```

Thirdly, structure (31b) may be repaired by applying a *degenerate* foot, cf. (31c), in order to achieve exhaustivity while avoiding a foot-internal lapse. This seems to be the actual repair strategy selected, considering the evidence available from Tübatulabal, Aklan and Tiberian Hebrew. We thus arrive at the proper generalization concerning the distribution of degenerate feet. Degenerate feet occur when exhaustivity cannot be met in other, less marked, ways without violating the rhythmic filters, the Anti-Lapse Filter[16] and the Anti-Clash Filter. Consequently, we derive the correct result that leftward iambic parsing is a highly complex parsing mode.[17]

Crucially, this generalization cannot be simply carried over to the asymmetric theory which contains the standard iamb. In order to see this, observe that the asymmetric theory takes the *syllable*, not the mora, as the stressable element. Suppose that one were to reject any relaxation of this point of view, and hold on to the syllable (not the mora) as a unit of rhythm. Then the complexity of leftward iambic parsing might be construed as an effect of two competing forces: the avoidance of degenerate feet, subordinated to the preference for exhaustive foot parsing. Rightward iambic parsing (32a) induces no conflict between these factors, as it accomplishes exhaustivity without mono-moraic feet (the single exception are final sequences of a heavy and a light syllable; however, most rightward iambic systems have final extrametricality). But leftward iambic parsing (32b) requires the degenerate foot as a means of accomplishing exhausitivity:

```
(32)a. (*) (. *) (*) (.  *) (. *)      b. (*)  (*) (. *) (. *) (. *)
       σ   σ  σ  σ   σ  σ  σ  σ           σ    σ   σ  σ  σ  σ  σ  σ
       |\  |  |  |\  |  |  |  |\          |\   |   |  |\ |  |  |  |\
       μμ  μ  μ  μμ  μ  μ  μ  μμ          μμ   μ   μ  μμ μ  μ  μ  μμ
```

[16] The idea that the assignment of degenerate feet is universally constrained by a no-clash prohibition has been expressed earlier in Jacobs (1990). Jacobs does not relativize this prohibition to units of parsing (mora or syllable), however.
[17] In terms of the theory of hierarchical constraints of Prince and Smolensky (1991), we find a hierarchy with the exhaustivity requirement at the top, followed by the two rhythmic filters, and avoidance of degenerate feet at the bottom end.

The appearance of stresses in Tübatulabal in positions that match the degenerate feet of (32b) strongly suggests that pressure towards exhaustivity *outweighs* avoidance of degenerate feet, even when this produces syllable-level *clashes* (between a degenerate foot and a heavy syllable to its left). But if Tübatulabal tolerates syllabic clashes in order to achieve exhaustivity (i.e. clash avoidance is dominated by the *stronger* constraint of exhaustivity), the next puzzle immediately arises. why do *trochaic* systems always avoid medial degenerate feet in similar contexts?

Firstly, syllabic trochee systems overwhelmingly avoid syllabic clashes. Secondly, as far as we are aware, moraic trochee systems do not tolerate degenerate feet in either of the contexts below, where (33a) represents rightward parsing, and (33b) leftward parsing:

(33)a. (. *) . (*)
σ σ σ σ
| | | |\
μ μ μ μμ

b. (*) . (* .)
σ σ σ σ
|\ | | |
μμ μ μ μ

We have checked this prediction, and found it to be correct, for all moraic trochee systems in Hayes (1991, Ch. 6), who lists Cairene and Palestinian Arabic, Cahuilla, Fijian, Hindi, Maithili, Turkish, and Wargamay. This comes as a complete mystery to the asymmetric theory, since iambic systems, such as Tübatulabal, assign degenerate feet in contexts that are similar to (33b) in every relevant aspect when looked at from the perspective of syllabic rhythm. In contrast, our mora-based theory makes the correct prediction: a degenerate foot may appear on a stranded mora only when no mora clash is introduced, while no alternative is available in the form of stray adjunction (i.e. when stray adjunction would violate the Anti-Lapse Filter). Mora-rhythmic theory thus reduces the directionality asymmetry to a simple representational asymmetry. We conclude that reference to the mora as a unit of rhythm is unavoidable.

These results can be carried over to the asymmetric theory only when reference to moraic rhythm is allowed, but not without severe theoretical problems. Consider the problem of how to measure the *moraic*-rhythmic effects of *syllable*-based foot parsing. Arguably, this can be achieved through the introduction of a separate moraic level of representation. In itself, this already constitutes a complication as compared to our mora-based theory, where parsing units and rhythmic units are equated by the Rhythmic Uniformity Hypothesis. Given a separate moraic level of representation, however, one may construe an explanation of the marginality of leftward iambic systems that is parallel to that of our mora-based theory. Observe that this explanation crucially assumes mora-rhythmic notions, such as syllable-internal trochaic prominence, and avoidance of mora clash and lapse. But these are precisely the notions that we have proposed as alternatives to the iambic-trochaic law. An appeal to these notions by the asymmetric theory would therefore undermine the very basis of that theory.

3.3. *The Syllabic Iamb*

Having demonstrated that the moraic iamb can do all the work of the standard iamb in foot parsing, we must now address the status of the quantity-insensitive syllabic iamb $[\sigma\ \sigma]$ as a member of the basic foot inventory. Let us first attempt to define what would constitute a syllabic iamb system. If we define quantity-sensitivity traditionally, as the irrelevance of underlying weight contrasts to stress rules, any iambic system that lacks underlying quantitative distinctions will be quantity-insensitive. Weri may serve as an example, which has final main stress and secondary stress on alternate syllables before it. Hayes (1980) analyzes it by leftward quantity-insensitive iambs. A rightward example is Southern Paiute, which has stress on even-numbered (non-final) syllables. Although these systems seem to defeat the uneven iambic spirit, they can still be formally analyzed within the asymmetric foot inventory, as has been argued by Hayes (1991). Even iambic systems may actually be based on the (quantity-sensitive) standard iamb, and deviate in that they lack weight contrasts. They lack the two iambic expansions $[\sigma_{\mu\mu}]$ and $[\sigma_{\mu}\ \sigma_{\mu\mu}]$ by accident, as it were. One might object that assigning iambic systems without a weight contrast to the quantity-sensitive iamb is inconsistent, since the theory assigns *trochaic* systems which lack underlying weight contrasts, such as Warao, to the quantity-insensitive syllabic trochee.[18] Keeping this issue open, it is clear that iambic systems that lack underlying weight contrasts can be analyzed by either foot inventory, symmetric or asymmetric.

By a stronger definition, the qualification 'quantity-insensitive' may be reserved for systems with underlying weight distinctions, which are ignored by foot parsing. 'Truly quantity-insensitive' iambic systems are extremely rare, and universally excluded under the asymmetric theory, by the iambic-trochaic law. This seems to be a major problem for our parsing foot inventory, which predicts truly quantity-insensitive feet of both kinds of headedness. However, below we will establish the syllabic iamb as a

[18] If the asymmetric theory were to accept the stronger definition of quantity-insensitivity, the large majority of syllabic trochee systems, those without weight contrasts, would be subsumed under the moraic trochee.

parsing foot for three systems (Yidin^y, Seneca, and Araucanian). This implies that the syllabic iamb cannot be universally excluded as a parsing foot, but must be marginal at least. Its marginality may be attributed to the convergence of two independent factors. Firstly, *true* quantity-insensitivity is a rather rare phenomenon in itself, even in trochaic systems (as will be shown in Section 3.4). Secondly, the fact that syllabic iambs are even rarer than their trochaic counterparts may be attributed to an independent factor: the relative lower frequency of occurrence of iambic systems, as compared to trochaic systems. Let us now turn to the empirical evidence for the syllabic iamb as a truly quantity-insensitive parsing foot.

Hayes (1982) analyses Yidin^y (based on data from Dixon 1977) by a rightward iambic foot construction rule whose output is subject to a relabeling into trochees in specific contexts. Yidin^y has an underlying vowel length contrast showing up in positions where it cannot be predicted by rule (cf. 34a, b). Another source of length that may be assumed to be available to foot parsing resides in pre-lengthening suffixes, such as (antipassive) *-:d^{y}i* (cf. 34c):

(34) a. galámbaráa 'march fly (absolutive)'
b. waráabugá 'white apple tree (absolutive)'
c. wúɻabá:+d^{y}i+ɻ 'hunt (antipassive present)'

Notice that suffix-induced length may be placed on odd-numbered syllables. The relevance of this observation will become clear in a moment.

The evidence for the iambic nature of initial foot parsing comes from a phenomenon of penultimate lengthening, which is restricted to syllables that are in *even*-numbered positions, as counted from the word-beginning. This rule can be understood as natural only if it is triggered by a *prominence* on the even-numbered syllable. The penult is lengthened in words of uneven length, i.e. where it is metrically *strong*:[19]

(35) a. gudá:ga 'dog (absolutive)'
b. gudágudá:ga 'dog (reduplicated absolutive)'

Words that have no long vowels in even-numbered syllables, i.e. in meically strong positions, surface with trochaic prominence. Hayes analyzes

[19] McCarthy and Prince (1986), Kiparsky (1991) and Crowhurst (1991) present alternative analyses, all of which are based on leaving the headedness of parsing (iambic vs. trochaic) unspecified, and specifying it on the basis of length. These analyses can no longer express penultimate lengthening as stress-based, however, and also run into problems with the shortening rule discussed below.

this by a rule relabeling iambic parsing feet into trochees (this rule may not affect feet whose head syllable contains a long vowel):

(36) a. gáliŋ 'go (present)'

b. gúdagágu 'dog (purposive)'

Observe that words with long vowels in odd-numbered syllables, cf. wúŋabá:d^{y}iŋ (34c), may also undergo trochaic relabeling, but if only long vowels are absent from even-numbered syllables. The evidence that foot parsing is truly quantity-sensitive comes from a rule of *Illicit Length Elimination* (Hayes 1980, p. 125) that shortens vowels in odd-numbered syllables, i.e. in the weak positions of iambic parsing feet. Long vowels that are shortened by this rule always result from pre-lengthening suffixes (underlyingly long vowels never occur in odd-numbered syllables):

(37) a. bargánda-d^{y}í:-n^y 'pass by (antipassive-past)'
/barganda:-d^{y}i-n^{y}u/

Under an iambic analysis the shortening rule is completely natural, since odd-numbered syllables match the weak positions of iambic parsing feet. In contrast, an analysis that leaves parsing feet initially unlabeled, makes it a complete coincidence that Yidin^y has both odd-numbered vowel shortening, and even-numbered penultimate vowel lengthening. But if we accept this, it becomes clear that iambic parsing must be truly quantity-insensitive, since in order for odd-numbered vowel shortening to be able to locate its targets, foot parsing must ignore length in the first place:

```
(38)                        (.  *)(.  *)  .     (.  *)(.  *)  .
       σ σ σ  σ  σ          σ σ σ  σ  σ        σ σ σ σ   σ
       | | |\ |  |    ⇒     | | |\ |  |   ⇒    | | | |\  |
       μ μ μμ μ  μ          μ μ μμ μ  μ        μ μ μ μμ  μ
       barganda:dʸinʸu      barganda:dʸinʸu    bargandadʸi:nʸu
```

Having established that parsing feet in Yidin^y are iambic as well as truly quantity-sensitive, we arrive at the conclusion that the syllabic iamb is a possible parsing foot.

Another well-known example of truly quantity-insensitive iambic parsing can be found in Seneca (Chafe 1977, Michelson 1988), where the position of the accent is calculated as follows: the accent is assigned to the last non-final even-numbered syllable that is either closed itself or followed by a non-final closed syllable. The distinction between open and closed syllables is interpreted in all analyses (Stowell 1979, Prince 1983, Halle and Vergnaud 1987) as one of syllable weight. Without going into the complexities of the analysis, it is clear that the rightward counting mechanism must be both iambic (since it locates an *even* syllable as the head of the foot) and truly quantity-insensitive (since the counted position, or evenness, of a syllable is determined strictly with respect to the word-beginning, not to a preceding heavy closed syllable).

A third iambic system that (partially) ignores syllable weight is Araucanian (Echeverría and Contreras 1965). Main stress is on the second syllable of a phonological word, and secondary stress alternates rightward:

(39) a.	wulé	'tomorrow'
b.	tipánto	'year'
c.	elúmuyù	'give us'
d.	elúaènew	'he will give me'
e.	kimúfalùwulày	'he pretended not to know'

Presence of a weight contrast based on the open-closed syllable distinction is suggested by two generalizations that conspire to place closed syllables in stressed positions. Firstly, disyllabic content words ending in a vowel may be stressed on either syllable, cf. *pu rúka~pu ruká* 'in the house'. That is, the final syllable is optionally extrametrical if it is *open*, but not if it is closed. Secondly, three-syllable words ending in a consonant have a secondary stress on the last syllable, cf. *θuŋúlàn* 'I do not speak'. These two special cases suggest that closed syllables count as heavier than open syllables. Yet, in the general case, closed syllables do occur in the weak positions of iambic feet cf. */incé/* 'I', */ilmén/* 'rich, noble'. In order to express the latter property, we have to assume that the parsing foot is truly quantity-insensitive, as it ignores the distinction between open and closed syllables. More formally, an analysis may be proposed which constructs syllabic iambs from left to right, but spells out the weight of closed syllables in degenerate feet:

```
(40)a.    *                b.     *           c.     *
       (. *) (*)             (. *) .             (. *)
       σ  σ  σ               σ  σ  σ             σ  σ
       |  |  |\              |  |\ |             |\ |\
       μ  μ  μμ              μ  μμ μ             μμ μμ
       θu ŋu lan             ti pan to           il men
```

The situation closely resembles that of *trochaic* systems such as Estonian (Prince 1980, Hayes 1991), and Wergaia, Madimadi, Wembawemba, and Ngarigu, all Victorian Australian languages discussed in Hercus (1986). Here, quantity-insensitive trochees are constructed from left to right, and in words with an odd number of syllables (whose final syllable cannot be footed), the final syllable's composition determines its stress value: it is stressed iff it is heavy. Hayes (1991) refers to this parsing mode as the *generalized trochee*. If this analysis of Araucanian is on the right track, it shows again that quantitative distinctions may be partly ignored in iambic parsing.

3.4. *A Note on 'Truly Quantity-Insensitive' Trochaic Systems*

The marginality of truly quantity-insensitive iambic systems has been put forward as strong support for the iambic-trochaic law by asymmetrists. However, this argument is only correct to the extent that truly quantity-insensitive trochaic systems have a much better attested empirical status. This turns out not to be the case, however, when we take a closer look at the trochaic systems claimed to be truly quantity-insensitive. Systems cited by Hayes (1991) as falling in this category include Czech, Dehu, Estonian, Finnish, Hungarian, Nengone, Piro, Vogul, and Votic. But upon closer inspection the number of well-established systems that completely ignore underlying quantitative contrasts shrinks considerably. Firstly, the source references for the majority of these systems (Dehu: Tryon 1967a, Nengone: Tryon 1967b, Piro: Matteson 1965, Vogul: Kálmán 1965, and Votic: Ariste 1969) are fairly sketchy, and do not establish quantity-insensitivity explicitly. Usually, underlying quantitative contrasts are not even mentioned in the description, while crucial examples are omitted. Secondly, four of the better-documented systems (Czech, and the Finno-Ugric languages) display some quantity-sensitivity. Secondary stresses in these systems are fairly weak and variable, but variability is always conditioned by syllable weight, cf. Kager (1992). In Finnish, for example, main stress is strictly initial and the second syllable is stressless regardless of its weight, but secondary stresses in the remainder of the word depend on weight (Carlson 1978, Kiparsky 1991): if the third syllable is light and the fourth syllable heavy, the preferred pattern is for the third syllable to be stressless, and a secondary stress to fall on the fourth syllable. Estonian (Hint 1973), Hungarian (Kerek 1971, pp. 39–40) and Czech (Jakobson 1962, p. 615) seem to display similar phenomena.[20]

Summarizing, quantity-insensitive trochaic systems are much rarer than expected under a strong definition of quantity-insensitivity. This observation tells us that the presence of a quantity distinction in a language is strongly correlated with its having quantity-sensitive stress. But if this

[20] English secondary stress has been claimed to be truly quantity-insensitive, but Kager (1989) shows that it is more complex, and at least partly quantity-sensitive.

correlation holds, the lack of truly quantity-insensitive iambic systems is part of a much wider generalization, which itself goes unexplained by the iambic-trochaic law.

4. The Moraic Iamb as a Parsing Foot in a Ternary System

We have shown above that standard iambs and moraic iambs, when applied from left to right, produce identical stress patterns, with only some irrelevant differences in bracketing. However, in one case rightward standard and moraic iambs potentially produce different results: in *ternary* systems, under assumptions about ternarity made by Hayes (1991). Hayes proposes that ternary systems draw from the universal foot inventory (3), but minimally deviate from binary systems in the way feet are assigned. Binary systems go by the unmarked *Strong Local Parsing* mode, which produces sequences of adjacent feet. In contrast, under the marked *Weak Local Parsing* mode, parsing leaves one mora (the *Minimal Prosodic Distance*) unbracketed after a foot has been completed, and before the next is constructed. Furthermore, on a language-specific basis, sequences of stray elements may be reparsed into proper feet, a condition that Hayes calls *persistent footing*. Persistence effects can be observed best in languages with ternary rhythms, such as Estonian (cf. Hayes 1991, pp. 264–278). We now turn to a ternary system with persistent footing, *Chugach Alutiiq Yupik*, which (as far as we know) is the only *iambic* ternary system.

Chugach is a dialect of Alaskan Yupik, spoken on the Kenai Peninsula and Prince William Sound. In recent literature, it has received considerable attention (Rice 1988, 1990; Halle 1990; Hammond 1990a; Hayes 1991; Kager 1991), after a detailed description by J. Leer (1985a,b), to whom many of the key ideas in later analyses, including ours, can be attributed. We follow Leer's analysis particularly in the insight that each heavy syllable constitutes a foot on its own. This analysis will be shown to be both simpler and more adequate than alternatives based on standard iambs and amphibrachs.

4.1. *The Stress Data and a Moraic Iamb Analysis*

The stress pattern of Chugach is illustrated below. Syllables boundaries have been indicated by dots, and underlying gemination by consonant sequences (*l.l* etc.):[21]

(41)	I. *Sequences of light (CV, non-initial CVC) syllables*	
a.	pa.lá.yaq	'rectangular skiff'
b.	a.kú.ta.mék	*akutaq* (a food), abl.sg.
c.	ta.qú.ma.lu.ní	'apparently getting done'
d.	a.kú.tar.tu.nír.tuq	'he stopped eating akutaq'
e.	ma.ŋár.su.qu.ṭá.qu.ní	'if he (refl.) is going to hunt porpoise'
	II. *Sequences of light and heavy (CVV, initial CVC) syllables*	
f.	mu.lú.kuút	'if you take a long time'
g.	pi.lú.liá.qa	'the fish pie I'm making'
h.	waá.muq	'she's playing'
i.	úl.luq	'it flooded'
j.	taá.ta.qá	'my father'
k.	án.ci.qu.kút	'we'll go out'
l.	naá.qu.ma.lú.ku	'apparently reading it'
m.	át.sar.su.qú.ta.qu.ní	'if he (refl.) is going to get berries'
n.	tán.neg.lig.sú.qu.ta.qú.ni	'if he (refl.) is going to hunt'
o.	naá.ma.cí.quá	'I will suffice'
p.	án.ci.quá	'I'll go out'
q.	ág.ku.tár.tuá.ŋa	'I'm going to go'
r.	taá.taá	'her father'
s.	úm.yuár.te.qu.té.ka.qá	'I'm thinking about it'
t.	ág.ŋuá.qu.tár.tuá.ŋa	'I'm going to dance'

Following Leer, we transcribe underlyingly long vowels as diphthongs or geminates, with stress marked on the righthand mora, cf. *aá*, *uú*, *uá*, *iá*, etc. Although Leer does not explicitly address the internal mora prominence of heavy syllables, there is *tonal* evidence from other Yupik dialects which suggests that it is indeed right-headed. For Central Alaskan Yupik, Miyaoka (1985, p. 54) observes that underlyingly heavy syllables have a "markedly rising tone", and accordingly he analyzes underlyingly heavy syllables as iambic feet (in contrast, lengthened vowels have a level tone).

The stress pattern of words containing only light syllables can be summarized as follows. Every syllable in position $3n - 2$ is stressed, and every

[21] We use Central Yupik Orthography, but replace 'ng' by 'ŋ' in (41).

final syllable in words of length $3n + 1$ syllables. The counting is obviously ternary, and starts at word beginning. This invites an analysis based on rightward construction of iambs under Weak Local Parsing and persistent footing:[22]

```
(42)a.  (.  *)  .   .   b. (.  *)   . (.  *)
         μ  μ  μ  μ         μ  μ     μ  μ  μ
         a ku  ta meq       ta qu  ma lu n i
        (.  *)(.   *)      (persistent
         μ  μ   μ  μ          footing
         a ku  ta meq         inapplicable)

    c.  (.  *) . (.  *) .
         μ  μ  μ  μ  μ  μ
         a ku  tar tu n i rt uq
        (persistent footing inapplicable)
```

Observe that in (42b,c) persistent footing need not come into effect, since after directional footing no adjacent unparsed moras are available. We will return to such cases below.

Only one additional assumption is required for words that contain heavy syllables. The class of heavy syllables consists of underlyingly long-voweled and diphthongal syllables, and word-initial short-voweled closed syllables. In order to account for the latter, we assume with Hayes (1989, 1991) that the moraic weight of closed syllables is position-dependent, and formally express this by a rule of mora-addition to initial closed syllables. Assuming this definition of heavy syllables, the stress pattern of the words in (41f-t) can be described as follows. Every heavy syllable is stressed, and so is every light syllable in position $3n$ following a heavy syllable. In addition, light syllables in position $3n - 1$ following a heavy syllable are stressed if they are word-final, or directly precede a heavy syllable. Persistent footing applies to sequences of unparsed moras lying at word end, and in between heavy syllables, cf. (43b,c):

[22] The feet of Leer's analysis in most respects coincide with our moraic iambs, although they are derived in a somewhat different way, for which we refer the reader to Leer's work. Our analysis is similar to, but developed independently from, that of Hammond (1990b).

(43)a. (. *) . (. *) .
μμ μ μ μ μ
naa.qu.ma.lu.ku

(footing
inapplicable)

b. (* .)(. *) . (. *) . .
μμ μμ μ μ μ μ μ
um.yuar.te.qu.te.ka.qa
(* .)(. *) . (. *)(. *)
μμ μμ μ μ μ μ μ
um.yua_r.te.qu.te.ka.qa

c. (* .) (. *) . . (. *) .
μμ μμ μ μ μμ μ
ag.ngua.qu.tar.tua.nga
(* ,) (. *)(. *) (. *) .
μμ μμ μ μ μμ μ
ag.ngua.qu.tar.tua.nga

One final aspect of Chugach stress has to be discussed, i.e. the fact that word-initial light syllables are always stressed before heavy syllables, and that the onset consonant of the following heavy syllable is geminated, closing the initial light syllable, cf. *át.tií* (*/atii/*) 'his father', *qáy.yaá* (*/qayaal/*) 'his boat'. Leer (1985a) interprets initial gemination as basic, and stress as its result. An interesting change of perspective is possible, however, if we follow Woodbury (1987) and interpret gemination as the addition of a mora to a degenerate foot. Let us first discuss the contexts where degenerate feet would arise. Under strict binarity, an initial light syllable preceding a heavy syllable cannot form a bimoraic foot by directional parsing, and is 'trapped' (Mester 1991). Surface exhaustivity can, theoretically at least, be achieved in two ways. Firstly, stray adjunction may adjoin the light syllable rightward to the heavy syllable. However, if underlyingly long vowels are indeed right-headed, as implied by Leer's transcription, this would produce a foot-initial mora lapse. Secondly, a degenerate foot may be assigned, precisely under the conditions found relevant for Tübatulabal. Gemination may then be interpreted as a rescue strategy to assure bimoraicity of the degenerate foot (see Woodbury 1987 for a similar proposal for Central Alaskan Yupik). With Hayes (1991), we assume that gemination involves mora addition to the initial syllable, and that the onset consonant of the following syllable spreads to fill it:

(44) . (. *) ⇒ (*) (. *) ⇒ (* .) (. *)
μ μ μ ⇒ μ μ μ ⇒ μ μ μ μ
| /\/ | /\ / | \/\/
a t i a t i a t i

Strong evidence for this analysis comes from the fact that the foot boundaries it provides are independently required to account for a consonant strengthening rule which, according to Leer (1985a), has the foot as its domain. Foot boundaries in Chugach are signalled by the presence of fortis consonants in foot-initial position. According to Leer, two major characteristics of fortis consonants are complete lack of voicing with voiceless consonants (stops and voiceless fricatives), and preclosure. Preclosure leads to extra length of fortis consonants as compared to their lenis counterparts. Leer describes Fortition as a foot-initial process associated with all types of 'accented' feet, including the disyllabic iambic foot composed of two light syllables. Even though no phonetic contrast holds between fortis and lenis initially, Leer describes all word-initial consonants as fortis. The distribution of fortis consonants is illustrated below, where foot boundaries are indicated by brackets, and fortis consonants are printed bold-face.

(45)a.	(alí)(**k**aá)	'she's afraid of it'
b.	(**m**íng)(**q**iú)	'sew it'
c.	(án)ci(**q**uá)	'I'll go out'
d.	(án)ci(**q**ukút)	'we'll go out'
e.	(akú)(**t**amék)	'a food' (abl. sg.)
f.	(**n**aá)(**m**ací)(**q**uá)	'I will suffice'
g.	(**n**aá)ma(**c**iqúq)	'it will suffice'
h.	(**t**aá)(**t**aqá)	'my father'
i	(**t**aá)(**t**aá)	'her father'
j.	(akú)tar(**t**unír)tuq	'he stopped eating *akutaq*'
k.	(**n**aá)qu(**m**alú)ku	'apparantly getting done'

As will be clear, the distribution of fortis consonants is captured directly by the parsing foot boundaries derived under a moraic iamb analysis. Interestingly, surface foot boundaries seem to do equally well, as we have a principled way of excluding the adjunction of stray syllables to the righthand foot. Observe that such adjunction would produce ternary head-final feet, violating the Anti-Lapse Filter: **(án)(ciquá)*, **(án)(ciqukút)*. This result provides additional support for Leer's transcribing underlyingly heavy syllables in Chugach as right-headed. We return to the role of stray syllables in the next section.

Chugach, as most other Yupik dialects, has a process of iambic lengthening, affecting the stressed syllable of a disyllabic iamb if it is open. An interesting interaction occurs between iambic lengthening and ternarity. Final vowels are never lengthened, as long vowels are excluded in final position. We transcribe rule-derived length by diacritics (*a:* etc.):

(46)a.	(alí:)(kaá)	'she's afraid of it'
b.	(akú:)taq	*akutaq* (a food)
c.	(akú:)(tamék)	*akutaq* (abl. sg.)
d.	(taqú:)ma(luní)	'apparently getting done'
e.	(akú:)tar(tunír)tuq	'he stopped eating *akutaq*'
f.	(naá)(mací:)(quá)	'I will suffice'
g.	(naá)qu(malú:)ku	'apparently getting done'

Lengthening adds a mora to the stressed syllable in a disyllabic iamb, cf. $[\sigma_\mu\, \sigma_\mu] \Rightarrow [\sigma_\mu\, \sigma_{\mu\mu}]$.[23] There is tonal evidence from other Yupik dialects that lengthening produces long vowels whose initial mora is strong. As observed by Miyaoka (1985) for Central Alaskan Yupik, vowels whose length is due to (iambic) lengthening contrast with underlyingly long vowels in having a level tone, instead of a rising tone. This has several consequences, to be explored below.

As can be seen in *(taqú:)ma(luní)*, a light syllable skipped by Weak Local Parsing fails to block iambic lengthening of the preceding light syllable. This fact deserves attention, since the stray syllable might be expected to readjoin to the preceding foot. If this were the case, iambic lengthening would be expected to ruled out by the Anti-Lapse Filter, since it would introduce a foot-internal mora lapse: *(taqú:ma)(luní)*. The fact that lengthening applies uninhibited indicates that the foot structure at the surface must be different, and that a stray syllable does not automatically adjoin leftward. This is corroborated by Leer's (1985b) observation that light syllables immediately following bimoraic feet, which in our analysis are skipped by Weak Local Parsing, actually surface with some weak degree of stress (Leer 1985b: 163): "[. . .] it has become increasingly apparent that, unlike the rest of Yupik, Alutiiq has three degrees of stress – zero stress, weak stress, and strong stress. [. . .] I argue here that in Alutiiq, residual light syllables [. . .] remain unassigned at the foot level, and adjoin the foot to the left at a higher level, the superfoot level". In order to account for this, we propose that a degenerate foot is assigned to stray skipped syllables in order to fulfill exhaustivity. Essentially, Chugach seems to assign a higher priority to iambic lengthening than to the avoidance of degenerate feet:

[23] In syllables containing schwa, lengthening occurs in the form of gemination of the onset of the following syllable, as schwa cannot be long: *úm.yuár.te.qu.ték.ka.qá* 'I'm thinking about it'.

```
(47)  (. *) . (.  *)     ⇒            (. * .) (*) (.  *)
      μ μ   μ  μ μ     (Iambic        μ μμ   μ  μ  μ
      /| /| /| /| /|   lengthening,   /| /|/  /| /| /|
      ta qu ma lu ni   refooting)     ta qu   ma lu ni
```

This degenerate foot has a degree of stress lesser than that of a bimoraic foot, and fails to trigger foot-initial fortition, which is clearly restricted to feet with 'strong' stress. Observe that the consonant that follows the weakly stressed degenerate foot is always fortis, as it is foot-initial. Interestingly, Hayes (1991) represents fortis consonants as sharing a mora with the preceding vowel (see the discussion in Section 4.5). If correct, fortition has the additional function of supporting the degenerate foot by contributing to its moraic weight.

Summarizing, Chugach presents a strong argument for the moraic iamb over the standard iamb, especially since it is the single attested ternary iambic system. Ternary iambic systems constitute a rare potential source of differences between standard and moraic iambs, for reasons explained above. Moreover, the Chugach data, as reported in Leer (1985a,b) are crystal-clear. For both uniqueness and clarity, the fact that the Chugach data firmly support the moraic iamb is significant. Let us now discuss alternative analyses of the Chugach data based on standard iambs and amphibrachs.

4.2. *A Standard Iambic Analysis of Chugach*

If we were to simply replace the moraic iamb of our analysis with the uneven standard iamb, while preserving Weak Local Parsing and persistent footing, the results would be crucially different. Although such an analysis yields identical results for words that have light syllables only, it produces incorrect results in words with strings of light syllables of length $3n - 1$ that are surrounded by heavy syllables. The key problem is that there is no principled way to block light syllables from grouping with a following heavy syllable into a maximal iamb:

```
(48)a. (*)  . (.  *)    b. (*)  . (.  *)  .
       μμ   μ  μ  μμ       μμ   μ  μ  μμ  μ
       naá ma cí quá       ág ku tár tuá nga

    c. (*)  (*)  . (.  *)    .
       μμ   μμ   μ  μ  μμ    μ
       ág nguá qu tártu á nga
```

In order to produce the correct stresses and the foot boundaries required for fortition, this analysis has to be supplemented by a rule of foot reanalysis:

(49) **Foot Reanalysis**

```
. (. *)        (. *) (*)
μ  μ μμ   ⇒    μ μ   μμ
```

Ironically, this rule functions to cancel the canonical iamb, so that its weak initial syllable becomes available for persistent footing (otherwise persistent footing would violate the Free Element Condition). Although such an analysis is descriptively adequate, the type of reanalysis rules it involves is powerful, and thus goes at the expense of explanatory adequacy of metrical theory. Hayes (1991) takes a different track, while preserving Weak Local Parsing and persistent footing. He avoids part of the problem signalled above by attributing the stress on light syllables before heavy syllables (cf. *naámac̲íquá*) to *Pre-Long Strengthening*. The same rule accounts for stress on initial light syllables preceding heavy ones in words such as *át.tíi* (cf. (44)):

(50) **Pre-Long Strengthening** (Hayes 1991, p. 285)

```
                 σ
                 |\
∅ → μi  /  ___   μ μ
                 /\ |
         α       β [-cons]
```

This rule performs two operations simultaneously: it strengthens the initial consonant of a heavy syllable (fortition), and lengthens the preceding vowel to some degree. Its output undergoes directional footing and persistent footing:

```
(51)                             (*) . (*) (*)       (*) (.  *) (*)
        σ σ σ  σ    PLS,         σ σ  σ   σ    PF   σ σ  σ   σ
        /\ | |  /\  footing      /\ |  /\  /\        /\ |  /\  /\
        μμ μ μ  μ μ              μμ μ  μμ  μμ        μμ μ  μμ  μμ
        /\/ /| /| /||            /\/ /| /|/\/||      /\/ /| /|/\/||
        n a maci qua             n a maci qua        n a maci qua
```

Observe that this analysis breaks up fortition into two different processes, one of Pre-Long Strengthening, and a second fortition process, which we may call *Fortition II*, and whose effects can be seen in words such as (*akú*)(*tamék*). Fortition II is left unformulated by Hayes, but it is clear that on every plausible account, it must apply foot-initially. Hayes argues that breaking up fortition precisely reflects Leer's (1985, p. 86) observation that fortition in mono-syllabic heavy feet $[\sigma_{\mu\mu}]$ is slightly more phonetically apparent than in disyllabic 'double-light' feet $[\sigma_{\mu}\,\sigma_{\mu}]$. Yet, this is somewhat to be expected, since only in the former case does fortition have the additional, phonetically natural, function of strengthening a stressed syllable.

Light pre-long syllables surface as stressless and light in one context: where a stressed syllable immediately precedes it, cf. *án.ci.quá*. For these cases, Hayes adds a rule of destressing which removes the initial mora from CVC in ("double clash", i.e. when it is surrounded by stresses. The resulting sequence of a light followed by a heavy syllable is automatically adjusted by persistent footing into a canonical iamb $[\sigma_{\mu}\,\sigma_{\mu\mu}]$:

```
(52) (*)  (*)  (*)       (*)  .   (*)       (*)  (.   *)       (*)  (.   *)
      σ    σ    σ         σ    σ    σ         σ    σ    σ         σ    σ    σ
     /\   /\   /\        /\    |   /\   PF   /\    |   /\        /\    |   /\
     μμ   μμ   μμ   ⇒    μμ    μ   μμ   ⇒    μμ    μ   μμ   ⇒    μμ    μ   μμ
     | |  /|/V| |        | |  /|\/| |        | |  /|\/| |        | |\ /|\/| |
     an   ci  qua        an   ci qua         an   ci qua        *an   ci qua
```

But now it is incorrectly predicted that the onset consonant of the destressed syllable *ci*, which has become foot-initial, is strengthened by foot-initial Fortition II, as shown in (52). Elsewhere, foot-initial consonants derived by persistent footing are fortis, cf. *t* in (*akú*)(*tamék*) and *m* in (*naá*)(*mací·*)(*quá*), and so are initial consonants of canonical iambs derived by regular footing, cf. *m* in (*mulú·*)(*kuút*). Clearly, the distinction between (*náa*)(*mací·*)(*quá*) and (*án*)(*ciquá*) cannot reside in the way persistent footing applies, as both contain a stray light syllable followed by a footed heavy syllable at some point in their derivation, compare (51) and (52). If footing is indeed persistent in the intended sense, reapplying whenever it can to produce canonical iambs, Fortition II must have global power in order to distinguish iambs derived by persistent footing after destressing from all other iambs.

Much as fortition is split between two processes, so is rhythmic vowel lengthening: in addition to Pre-Long Strengthening (which assigns vocalic half-length), a rule of *Iambic Lengthening* has to be assumed. Naively, it may appear that splitting up lengthening is reflected in two different degrees of length. Indeed, rhythmic vowel lengthening is somewhat inhibited before fortis consonants. Contrasting *akú:taq* and *akú·tamék*, Leer (1985b, p. 164) observes that, "The syllable *ku* is lengthened in both cases, but *u* is longer in *akutaq* (where *t* is lenis) than in *akutamek* (where *t* is fortis)". Hayes relates this inhibition to the fact that fortis consonants are somewhat *longer* than lenis consonants, taking up part of the space otherwise available for lengthening. Arguably, this length contrast need not be phonologically represented, as the inhibited length before fortis consonants may be explained purely *phonetically* in much the same way as the lesser duration of vowels before voiceless consonants, a well-known phenomenon. Both fortis and lenis consonants are characterized by increased duration. But even if the length contrast were moraic, the data would still show that it is simply due to the mere presence of a fortis consonant. In both examples (*akú:taq* and *akú:tamék*), the lengthened vowel precedes a light syllable, excluding Pre-Long Strengthening as a possible source of the observed contrast.

We conclude that Hayes's standard iambic analysis accounts for the distribution of stress and fortition in Chugach, but only at the expense of some globality and fragmentation of what appear to be unified processes.

4.3. *An Amphibrach Analysis of Chugach*

The second metrical analysis of Chugach that we will discuss is the one proposed in Rice (1988, 1990), which in essential aspects has been adopted by Halle (1990). This analysis is based on the *amphibrach*, a foot type of the inventory of Halle and Vergnaud (1987), which is defined as a ternary line-0 constituent with a medial head: (.*.). Non-maximal amphibrachs include (.*), (*.), and (*). For Chugach, amphibrachs are constructed over moras from left to right. In order to effectuate the foot-initial status of heavy syllables, a left foot boundary is pre-assigned to all heavy syllables (indicated below with '[', cf. (53b–f)). Initial closed syllables acquire a pre-marked stress (indicated with '#', cf. (53c,e,f)), and are subsequently footed as heads of disyllabic amphibrachs. This analysis correctly assigns stresses, as is shown below.

```
(53)a. (.  * . )(.  *)      b. [ .*   .) ( .  *   .)
        μ  μ μ   μ  μ           μμ  μ   μ  μ  μ
       ta qú ma  lu n í         naá qu  ma lú ku

   c. (#) [ .*   . ( .  *   .) (*)        d. [ .*   .) (*) [ .*)
       μ     μμ  μ  μ  μ  μ   μ              μμ   μ   μ    μμ
      úm yu ár te qu té  ka  qá             naá ma  cí   quá
```

e. (# .)(*)[.* .)
$\mu \quad \mu \quad \mu \quad \mu\mu \quad \mu$
ág ku tár tu á nga

f. (#) [.* .)(*)[.* .)
$\mu \quad \mu\mu \quad \mu \quad \mu \quad \mu\mu \quad \mu$
ág ngu á qu tár tu á nga

But much as the initial standard iambic analysis discussed above, this parsing fails to provide the proper foot boundaries required for a uniform characterization of Fortition. More specifically, it fails where a non-initial mono-moraic foot is produced, cf. (53c,d,e,f). For this reason, both Rice and Halle supplement their analysis with a restructuring rule (restated below in our notation):

(54) **Foot Reanalysis** (Halle 1990)

line 0 $\quad$ * .) (*) $\rightarrow$ *) (. *)

Foot Reanalysis performs a rebracketing on constituent structure, a very powerful type of operation, which for familiar reasons of restrictiveness should rather be banned universally. Even worse, it only serves the purpose of deriving the foot boundaries that are *directly* produced in a moraic iamb analysis. For these reasons, we claim that this analysis is less adequate than a moraic iamb analysis. This concludes our discussion of Chugach.

5. Iambic-Trochaic Asymmetries in Quantitative Processes

In this section, we will discuss quantitative processes, such as lengthening, shortening, and reduction, from the perspective of the rhythmic sub-theory developed in Section 2.4. Our goal is to demonstrate that this theory is equally successful, as compared to the asymmetric theory, in explaining the iambic-trochaic asymmetries that have been observed to characterize quantitative processes, and furthermore, that it is more adequate than the asymmetric theory in dealing with various other phenomena.

5.1. *Iambic Lengthening and Trochaic Non-Lengthening*

Hayes (1985) observes that many iambic systems display processes that increase the quantitative contrast between the syllables of the foot, by lengthening or gemination of the second syllable. The general name for such processes is *iambic lengthening*. The uneven iamb of the asymmetric foot inventory (3) suggests an attractive interpretation of iambic lengthening, namely as satisfaction of the *canonical* iamb $[\sigma_{\mu}\, \sigma_{\mu\mu}]$. Hayes (1991) points out that lengthening of stressed syllables, in itself a natural tendency observed in stress systems, is found in the form of alternating rules that lengthen every other syllable only in *iambic* systems.

Our first goal is to explain why stressed vowel lengthening, although a phonetically natural phenomenon, is so common in iambic systems, and so rare in trochaic systems. The first key is the mora prominence contour in long vowels, the second the Anti-Lapse Filter. Languages with moraic feet measure rhythmic well-formedness in terms of *mora clash* and *lapse*. The effects of stressed vowel lengthening in moraic iambs and moraic trochees are represented below:

```
(55)a.  (. *)       (. * .)  b.   (* .)       (* .  .)
        μ μ    ⇒    μ μμ          μ μ    ⇒    μμ  μ
        | |         | |/          | |         |/  |
        σ σ         σ σ           σ σ         σ   σ
```

Although both types of parsing feet are expanded into trimoraic surface feet, the rhythmic effects are very much different. Rhythmic well-formedness being measured within feet, it is clear that moraic iambs expand into rhythmically well-formed surface feet, whereas moraic trochees expand into surface feet that contain a *mora lapse*. Hence, from a rhythmic point of view, stressed vowel lengthening is much more likely to occur in an iambic system than in a trochaic system. This explanation for the iamb-trochee asymmetry needs no appeal to an asymmetric foot inventory as defined by the iambic-trochaic law.

This perspective naturally extends to another iambic lengthening process, that of pretonic lengthening. The following data from Cayuga are taken from Foster (1982):

(56)a.	/hoyaneˀ/	hoyá:neˀ	'chief'
b.	/ęhęnatowat/	ęhę̀nató:wat	'they will hunt'
c.	/teyakotkwęh/	teyákotkwęh	'she's dancing'
d.	/tewakatawęnyeˀ/	tewàkatáwęnyeˀ	'I'm moving about'
e.	/akekahaˀ/	akékahaˀ	'my eye'
f.	/akyęthoˀ/	akyę́:thoˀ	'I planted it'
g.	/tękatawęnyeˀ/	tękàtawę́:nyeˀ	'I'll move about'
h.	/ękatatǫkwˀetǫnyęˀ/	ękàtatǫ̀kwˀetǫ́:nyęˀ	'I will make some people for myself'
i.	/hęnatowas/	hęnà:tó:was	'they're hunting'
j.	/akekhǫniˀ/	akè:khǫ́:niˀ	'I cooked a meal'

The pattern can be described as follows:[24] Every open penult is long and

[24] We abstract away from the effects of glottals on syllabification and stress, and from the two definitions of 'open syllable', a more restricted Proto-Northern-Iroquoian definition and

has main stress, cf. (56a–b,i–j). In words with closed penults, main stress is on the rightmost non-final even-numbered syllable, cf. (56c–h), which is lengthened if it is penultimate, cf. (56f–h). Secondary stresses are on even-numbered syllables, the rightmost of which is lengthened if it directly precedes the main stress (this can only be the case when the main stressed syllable is a lengthened open penult), cf. (56i–j). Our analysis is below:

(57)a. Mark final syllables extrametrical.
b. Open Penult Lengthening.
c. Assign moraic iambs from left to right.
d. End Rule Final.
e. Penultimate Main Stress Lengthening.
f. Pretonic Lengthening.

Final syllables are extrametrical: they can neither be stressed, nor be lengthened, and do not rhythmically inhibit the lengthening of the open penult. Rightward iambic parsing is motivated both by secondary stress and the odd-even count in locating the main stress in words with closed penults. Open Penult Lengthening precedes foot parsing because it blocks the iambic stress rule, and cannot be seen as a natural stressed vowel lengthening rule, given the fact Cayuga has rightward iambs. Historically, OPL is a remnant of the Proto-Northern-Iroquoian penultimate accent rule plus stressed open syllable lengthening. Cayuga has reanalyzed this situation by reordering OPL before its rightward iambic stress rule, an innovation that it shares with Onondaga and Seneca (cf. Foster 1982, Michelson 1988).

Cayuga perfectly illustrates the rhythmic nature of vowel lengthening. Firstly, the only vowels with secondary stress that lengthen are those which directly precede the main stress, hence the name Pretonic Lengthening. Prince (1983) observes that PTL functions to resolve a clash:[25]

```
(58)a.  (.  *) (* .)        (. * .) (* .)
        μ  μ   μ μ    ⇒    μ  μμ   μμ
        |  |   |/           |  |/    |/
        σ  σ   σ            σ  σ     σ

   b.   (.  *) (* .)            (.  * .) (* .)
        μ  μ   μ μ <μ>   ⇒    μ  μμ   μμ <μ>
        hęna   too  was         hęna:   too  was
```

Pretonic Lengthening clearly demonstrates the moraic iamb's non-uniform

---

a less restricted contemporary definition. cf. Foster (1982), Michelson (1988). In (56), /ę, ǫ/ indicate nasalized vowels.

[25] See also Benger (1984).

headedness, which may lead to 'forward' clashes (clashes outside the parsing window) in directional foot parsing. Secondly, only penultimate vowels ever lengthen under primary stress, a fact that had puzzled earlier analysts. Foster (1982, pp. 63–64): "It can be shown that when odd-numbered penults give up the accent, the even-numbered antepenult does not undergo vowel lengthening, even when that syllable is open. This comes as something of a surprise." From our point of view, the absence of lengthening in the antepenult does not come as a surprise, since it would create a *lapse* internal to the foot after the stray penult has been adjoined to it by stray adjunction. In other words, the adjoined stray penult takes all the rhythmic space left in the foot that otherwise could have been taken by lengthening the stressed vowel.

(59)a. (. *.)
μ μμ ⟨μ⟩
akyę:thoʔ

b. (. *)(. * .) NOT (. *)(. * . .)
μ μ μ μ μ ⟨μ⟩ μ μ μ μμ μ ⟨μ⟩
tewa katawęnyeʔ tewa kata:węnyeʔ

Observe that the invisibility of extrametrical moras to rhythmic conditions is crucial to our account. As said earlier in Section 2.4, we take the position that extrametricality affects both foot parsing and rhythmic conditions. Moreover, it turns out that the extrametricality persists to surface foot structure, at least for Cayuga. Summarizing, we see that both stress-related lengthening processes in Cayuga are strictly governed by mora-level rhythmic constraints. Cross-linguistically, rules of penultimate lengthening are much more frequent than rules of antepenultimate lengthening. This has also been observed for trochaic systems, see Prince (1991) for discussion of antepenultimate non-lengthening in Chamorro and Italian.[26] Under final extrametricality this can be understood as an instance of lapse-avoidance.

An issue that requires further discussion is what happens when an iamb is followed by a stray mora at the end of the domain. As the exhaustivity requirement would predict, such a mora would adjoin leftward to the preceding iamb, where the Anti-Lapse Filter would block lengthening. As we have just seen, this prediction is borne out by Cayuga. However, cases are also known where lengthening is uninhibited by the presence of a

[26] On Italian, see also Sluyters (1990).

stray mora in the context, cf. Hixkaryana (Hayes 1991, p. 169). And we have seen earlier that in Chugach iambic lengthening prevails over the avoidance of degenerate feet in examples such as (46b, d, e, g). For final contexts, this is represented below:

```
(60)   (. *) .  #       (. *  .) .  #      (. *  .)(*)   #
       μ μ  μ     ⇒    μ μμ μ        ⇒    μ μμ   μ
       |  |  |          |  |/  |            |  |/    |
       σ σ  σ           σ  σ   σ            σ  σ     σ
```

Final degenerate feet may go unobserved for two reasons. Firstly, as in Chugach, their stress is weaker than that of bimoraic feet. Secondly, many iambic systems inhibit final prominences, as Hayes (1991) observes. Some restrict lengthening to non-final feet (cf. Chugach), others have final extrametricality (cf. Cayuga), while still others display (phrase-)final destressing (cf. Chugach). Summarizing, cases where iambic lengthening applies uninhibited by final stray moras may be attributed to independent (weakening) processes that are restricted to the final position. In next two sections we will demonstrate that the explanatory power of moraic rhythm naturally extends to shortening processes.

5.2. *Trochaic Shortening*

Recent literature (Myers 1987, Prince 1991) shows the relevance of quantitative trochees to vowel shortening in English. This lexical process, located at Level-1 by Kiparsky (1982), is illustrated by alternations between long and short vowels in pairs such as *divi:ne*~*divinity* and *co:ne*~*conic*. Myers (1987) has convincingly demonstrated that shortening applies to the stressed syllable of a quantitative trochee $[\sigma_{\mu\mu}\ \sigma_{\mu}]$, the type of foot identified by Hayes (1980) as the English main stress foot. Relevance of the main stress foot derives from the fact that the shortening behavior of level-1 suffixes is highly predictable from their stress placement properties. Non-extrametrical short-voweled suffixes, such as *-ic*, place stress directly before themselves, cf. *sa*(*tánic*), and usually shorten the preceding long syllable, with which they form a trochaic foot, cf. (*cónic*). In contrast, extrametrical suffixes, such as *-al*, *-ous*, *-ent*, which place stress on the antepenult if the penult is light, cf. *mu*(*níci*)*pal*, do not form a foot with the preceding long syllable. Accordingly, they fail to induce vowel shortening, as can be seen in (*fí:*)⟨*nal*⟩, *de*(*sí:*)⟨*rous*⟩, *o*(*ppó:*)⟨*nent*⟩. But the same extrametrical suffixes do so when they adjoin to a stem which itself has a long-voweled penult, cf. (*na:*)⟨*tion*⟩~(*natio*)⟨*n* + *al*⟩. Here the stem-final syllable loses its extrametricality as it is no longer peripheral after suffixation. It thus comes available for footing and is included in the domain for shortening. Finally, disyllabic suffixes such as *-ity* and *-ify*, with final extrametrical syllables, combine their first light syllable into a trochee with the stem's heavy syllable, inducing shortening of the latter, cf. *di(vi:ne)* ~ *di(víni)⟨ty⟩*, and *(sá:ne)* ~ *(sáni)⟨fy⟩*.

Prince (1991) points out that shortening is a fundamentally balanced trochaic process, fitting in with the iambic-trochaic law, since it establishes quantitative equality between the syllables of a trochaic foot: $[\sigma_{\mu\mu}\ \sigma_{\mu}] \Rightarrow [\sigma_{\mu}\ \sigma_{\mu}]$. Under our theory, trochaic shortening can be understood as a process that resolves a *foot-level lapse*. The exhaustivity requirement forces the stray to adjoin to the heavy trochee to its left, where it produces a mora lapse. The repair strategy is to shorten the stressed bimoraic syllable, removing the lapse:[27]

(61)					
	(* .) .		(* . .)		(* .)
	$\mu\mu\ \mu$	⇒	$\mu\mu\ \mu$	⇒	$\mu\ \mu$
	|/ |	Stray	|/ |	Trochaic	| |
	$\sigma\ \sigma$	Adjunction	$\sigma\ \sigma$	Shortening	$\sigma\ \sigma$

Formulated in terms of harmony theory (Prince 1991, Prince and Smolensky 1991), one may describe the situation by a hierarchy of constraints, in which the pressure towards exhaustivity (by stray adjunction) outweighs the anti-pressure against neutralizing an underlying quantitative contrast (by mora deletion). The same constraint hierarchy can be observed in Latin (Mester 1991), where an additional constraint seems to be present (at the top of the hierarchy), i.e. the pressure towards surface foot bimoraicity.

5.3. *'Iambic' Shortening*

Next, consider a second type of shortening process that has been observed in trochaic systems, the process of *Brevis Brevians* in Latin and the *Arab Rule* in English. Early Latin productively shortened long final syllables in disyllabic words whose first syllable is light, cf. *puta:* ⇒ *puta* 'believe (2sg. imperative)', but not in those whose first syllable is heavy, cf. *manda:* 'entrust (2sg. imperative)', *laudo:* 'praise (1sg. presens)'. The process is also known as *iambic shortening* (Allen 1973, p. 181), which reflects the fact that it applies to an anti-trochaic, iambic quantitative sequence:

[27] Alternatively, we may interpret vowel shortening as a means to achieve exhaustivity without foot-internal lapses, eliminating an intermediary stage of an uneven trochee. This possibility is more in the spirit of Mester's (1991) account of Latin.

$\sigma_{\mu}\,\sigma_{\mu\mu}$. English displays a similar process (the *Arab Rule*), which destresses closed short-voweled syllables after (stressed) light syllables (cf. Fidelholtz 1967, Ross 1972), as in *ǽrəb*, but not after heavy syllables, as in *éyræb*.

Prince (1991) and Mester (1991) point out that this shortening is a fundamentally trochaic process, as it establishes equality between the syllables of a moraic trochee: $\sigma_{\mu}\,\sigma_{\mu\mu} \Rightarrow [\sigma_{\mu}\,\sigma_{\mu}]$. But an alternative view of iambic shortening is possible, based on clash avoidance. Crucially, in both Latin and English, shortening affects an *initial* sequence of a light plus heavy syllable. With Kager (1989) and Hayes (1991), we assume that the light syllable, which is the only (metrical) available target in the domain for the End Rule, acquires main stress without having to constitute a bimoraic foot. The resulting *mora clash* is subsequently resolved by deleting a mora of the heavy syllable, followed by stray adjunction (or persistent footing):

```
(62)   *                    *                         *
       (*) (* .)    ⇒       (*) (* .)    ⇒            (*  .)
       μ   μμ     Loss of   μ   μμ     Iambic          μ  μ
       |   |/     e.m.      |   |/     Shortening      |  |
       σ<σ>                 σ   σ                      σ  σ
```

As a result, the heavy final syllable is *de-weighted* (cf. Kager 1989). As expected, shortening fails to apply to words with initial heavy syllables, cf. Latin *manda:* and English *éyræb*, with an additional mora in the first syllable, and no mora clash.[28]

5.4. *Vowel Reduction and the Iambic-trochaic Asymmetry*

Finally, consider *vowel reduction*, the process of reducing the vowel of every weak foot-initial syllable. In a number of iambic systems, reduction goes all the way to deletion, cf. Macushi (Hawkins 1950) and Odawa (Piggott 1980). Reduction is a typical *iambic* process from the perspective of Hayes (1985), as it enhances the durational contrasts between syllables. Still, it cannot be straightforwardly captured as a process driven by the

[28] Alan Prince has pointed out to me that *Cretic Shortening* in Latin (Mester 1991) is problematic to the view that trochaic shortening is uniformly clash-driven. Briefly, Cretic Shortening shortens a final heavy syllable where it follows a sequence of a heavy and a light syllable: *di:cito* 'say (imperative future)'. In Mester (1991), this is analyzed as the result of pressure towards exhaustive parsing into bimoraic trochees. Deleting a mora from a final heavy syllable makes it eligible for incorporation into a bimoraic trochee together with the preceding stray syllable: *(di:)ci(to:)*⇒*(di:)cito*⇒*(di:)(cito)*.

iambic-trochaic law, as it resists quantitative (i.e. mora-based) formalization. The obvious mora-based formalization of vowel reduction (and the only one possible for deletion), is *mora loss*. But mora loss produces *non-canonical* bimoraic iambs out of canonical ones, cf. $[\sigma_{\mu}\ \sigma_{\mu\mu}] \Rightarrow [\sigma_{\mu\mu}]$.

We see that vowel reduction cannot be analyzed as a direct result of the iambic-trochaic law. But should it be? Phonological vowel reduction is not restricted to iambic systems to the same extent that vowel lengthening is. English and Dutch (Kager 1989), for example, are clearly trochaic systems, and both have a strong tendency to reduce stressless syllables, which are even deleted as long as the output can be syllabified, cf. *myst*[ə]*ry*. Trochaic systems with vowel reduction include late Latin (Jacobs 1986) and Maithili (Hayes 1991). Alternating vowel deletion rules based on trochaic counting, dropping every vowel in even syllables counting from the beginning of a word, are reported for Indo-European (Lightner 1972, p. 318, Borgstrøm 1949), and for Old Irish (Lightner 1972, p. 318, Thurneysen 1961). This suggests that vowel reduction may not be a purely iambic phenomenon at all.

6. Conclusions

We have outlined a theory of foot structure whose main principles are a symmetric strictly binary basic foot inventory, directional foot parsing, and principles of rhythmic organization on the mora level. Our key result is the unification of asymmetries between iambs and trochees (quantitative processes, directionality) on the basis of two highly plausible assumptions: the moraic iamb's non-uniform headedness, rooted in syllable-internal sonority-governed moraic prominence, and avoidance of clash and lapse, the latter relativized to the foot. We believe that the resulting theory provides a promising new perspective[29] on a range of stress-related and quantitative phenomena.

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[29] As to the status of the uneven iamb in prosodic morphology, it seems too early to draw strong conclusions. Hammond (1990a) claims that it is never crucially referred to.

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Onderzoeksinstituut voor Taal en Spraak
Universiteit van Utrecht
Trans 10
3512 JK Utrecht
The Netherlands
kager@hutruu59.bitnet