The Moraic Iamb

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1 Introduction

Hayes (1985, 1987) points out a fundamental asymmetry between trochaic and iambic stress systems. Trochaic systems are characterized by even durations between the syllables in feet. In contrast, iambic systems strongly tend towards uneven durations, reflected by rules that lengthen stressed vowels or reduce stressless vowels, etc. Hayes (1987, 1991) reflects the durational asymmetry between trochaic and iambic systems directly in the foot inventory, which contains "even" syllabic and moraic trochees, and "uneven" iambs:

(1) Asymmetrical foot inventory (Hayes 1987, McCarthy and Prince 1986)

```
a. Syllabic trochee  (* .)
                      s s

b. Moraic trochee    (* .)  or  (*)
                      s s        s
                      | |        |\
                      m m        m m

c. Iamb              (. *)  or  (. *)  or  (*)
                      s s        s s        s
                      | |\       | |        |\
                      m m m      m m        m m
```

This paper supports Prince's (1985) distinction between *parsing* feet and *surface* feet, and will drastically simplify the parsing foot inventory. As elsewhere in phonology (or syntax, morphology, etc.), distinct levels of representation are motivated by the increased ability to make generalizations. Parsing feet are part of the universal foot inventory, while their assignment is subject to parameters such as iterativity and directionality. They are mapped into surface feet by various rhythmically governed mechanisms, among which are stray adjunction and quantitative processes such as iambic lengthening. My proposal is a fully symmetrical *parsing* foot inventory, based on two parameters: stress-bearing unit (*moraic* vs. *syllabic*), and dominance (*trochaic* vs. *iambic*):

(2) Symmetrical strictly binary parsing foot inventory

```
             Moraic  Syllabic
             (* .)    (* .)
Trochee       m m      s s

             (. *)    (. *)
Iamb          m m      s s
```

The symmetrical foot inventory (2) matches the asymmetrical inventory (1) with respect to trochaic feet, but it deviates for iambic feet. In particular, I will argue for the *even* moraic iamb as a member of the foot inventory. The moraic iamb will be argued for as an adequate replacement of the standard iamb as the parsing foot in systems with underlying weight contrasts, as an explanation of the *lack of right-to-left* iterative iambic systems, and as the foot type crucially required for the prosody of Chugach Alutiiq Yupik.

I will concentrate on the function of the moraic iamb as a parsing foot, and I refer to Kager (1991) for a more complete theory of quantitative processes and prosodic morphology, based on the distinction between parsing and surface feet. This paper is organized as follows. In section 2, I will sketch the principles and parameters that govern the symmetrical foot inventory. I then set out to show that standard iambs can be replaced by even parsing iambs in section 3. The central arguments for the moraic iamb will be made in section 4, where I will show that it leads to an explanation for a directional asymmetry between iambs and trochees, and in section 5, where I will motivate the moraic iamb as the most adequate parsing foot for Chugach. Finally, section 6 sketches the way in which quantitative asymmetries between surface iambs and trochees can be viewed from a rhythmic perspective.

2 Deriving the symmetrical inventory

The symmetrical parsing foot inventory (2) derives from two principles: the Strict Binarity Hypothesis (Kager 1989, 1990), and Syllable Integrity (Rice 1988). By strict binarity, all feet have exactly two elements, a property already true of both the syllabic and moraic trochee of Hayes (1987, 1991).

(3) **Strict Binarity Hypothesis** (Kager 1989)
Metrical constituency is strictly binary.

More formally, a parsing foot is a bracketed pair of identical stress-bearing units (moras, syllables). Quantity-sensitive systems select the mora as SBU, and quantity-insensitive systems the syllable. Strict binarity excludes degenerate and amphibrachic parsing feet, as well as uneven parsing feet: the iamb ($\sigma_{\mu}\sigma_{\mu\mu}$) and the trochee ($\sigma_{\mu\mu}\sigma_{\mu}$):

(4) Some ill-formed parsing feet

```
    a. (s)   b. (s s s)   c. s    d.  s  s   d.  s s    e.  s s s
                             |        |\ |       | |\       | | |
                            (m)     (mm m)     (m mm)     (m m m)
```

The second principle is Syllable Integrity:

(5) **Syllable Integrity** (Rice 1988)
The moras of a bi-moraic syllable must belong to the same metrical constituent.

The weak version of the principle prohibits heavy syllables from being split between feet (Rice 1988, 1990), excluding moraic parsing such as (6a). I propose a stronger interpretation of (5), according to which heavy syllables *must* form feet on their own (i.e. are stressed), excluding (6b):

```
(6)a. *s s     s        b. *s     s s
       | | \   |            |\    | |
      (m m)(m m)            m m  (m m)
```

In moraic systems, each bimoraic syllable forms a foot ($\sigma_{\mu\mu}$) on its own, so that *quantity-sensitivity* and *heavy syllable integrity* follow from the same principle.

A major point of difference between the moraic feet in the foot inventories is that (2) selects the mora, not the syllable, as the stress-bearing unit. Accordingly, syllable-internal mora prominence is represented in monosyllabic bimoraic feet. Internal prominence of heavy syllables is sonority-governed (Kiparsky 1979, Prince 1983), and typically *falling*, as can be observed in closed syllables, long vowels, and falling diphthongs. Rising sonority occurs only in rising diphthongs. Strict binarity and syllable integrity provide the binary matrix to represent syllable-internal mora prominence in:

```
(7)a.  s                                b.   s
       |\    (closed syllables,             /|  (rising diphthongs)
       m m    long vowels,                 m m
      (* .)   falling diphthongs)         (. *)
```

This is the basis of the explanation of the rhythmic asymmetries between iambs and trochees in later sections. While moraic trochees are units with uniform trochaic dominance in both their disyllabic and monosyllabic expansion, moraic iambs are inherently non-uniform. Their disyllabic form ($\sigma_\mu \sigma_\mu$) is truly iambic, but their monosyllabic form (the heavy syllable $\sigma_{\mu\mu}$) is inherently *trochaic* reflecting the typical internal prominence of heavy syllables:

```
(8) Moraic trochee        Moraic iamb
    a.  s s    b.  s      a.  s s    b.  s
        | |        |\         | |        |\
        m m        m m        m m        m m
       (* .)      (* .)      (. *)      (* .)
```

3 Replacing the standard iamb

3.1 The syllabic iamb

The syllabic iamb is arguably the parsing foot for systems that completely lack quantitative distinctions (such as Weri), and for systems that introduce these only at the surface by iambic lengthening (such as Cayuga). These systems motivate the syllabic iamb in much the same way as trochaic systems lacking quantity-distinctions (such as Pintupi) motivate the syllabic trochee. Although such systems could be called quantity-insensitive, this qualification applies more to the lack of quantitative contrasts than to the insensitivity of foot construction to any weight distinction.

Truly quantity-insensitive systems (which ignore weight distinctions in stress assignment) are quite rare, even among trochaic systems. Hayes (1991) mentions trochaic systems such as Czech, Estonian, Finnish, Hungarian, Piro, Vogul, and Votic, although most of these systems show hidden quantity-sensitivity, typically by optional variation in secondary stresses much in the favor of heavy syllables. Truly quantity-insensitive iambic systems are claimed to lack universally, as expressed by the absence of the syllabic trochee in the foot inventory in (1). However, as Kager (1991) shows, Yidiɲand Araucanian come close to match the excluded foot type. Briefly, Hayes (1982) shows that Yidiɲ, where foot parsing is iambic, has a vowel shortening rule applying to weak syllables in iambic feet, assigned from left to right, cf. */barganda-:ɟi-ɲu/* → *(bargá)(ndaɟí:)ɲu* "pass by (antipassive-past)". In order to place the vowels to be shortened in weak positions, iambic foot assignment must be able to ignore their quantity in the first place, and thus be truly quantity-insensitive.

3.2 The equivalence of standard and moraic iambs under rightward parsing

Moraic iambs yield the same stress output as standard iambs in *left-to-right* iterative parsing (cf. Prince 1991). The bracketings are nearly identical except for a sequence of a light followed by a heavy syllable, which is bracketed as a single foot under standard iambs, but as a stray syllable followed by a monosyllabic heavy foot by moraic iambs:

```
(9)a. (*) (. *) (*) (. *) (.  *) (. *) (. *) (*) (. *) (. *) (.  *)  standard
   b. (*.)(. *) (*.)(. *)  . (*.)(. *) (. *) (*.)(. *) (. *)  . (*.) moraic
      mm   m m  mm   m m   m mm   m m   m m  mm   m m   m m   m mm
      |/   | |  |/   | |   | |/   | |   | |  |/   | |   | |   | |/
      s    s s  s    s s   s s    s s   s s  s    s s   s s   s s
```

I will illustrate the parsing equivalence with the placement of tonal accent in Creek, a standard example of rightward iambic parsing in the literature (Hayes 1981, Halle and Vergnaud 1987).

(10) Tonal accent in Creek (Haas 1977)

I. *Sequences of light (CV) syllables*

a. ifá "dog"
b. ifóci "puppy"
c. amifocí "my puppy"
d. imahicíta "one to look after for"
e. isimahicitá "one to sight at one"
f. itiwanayipíta "to tie to one another"

II. *Sequences of light and heavy (CVV, CVC) syllables*

g. cálo "trout"
h. sókwo "sack"
i. pocóswa "axe"
j. hoktakí "woman"
k. waakocí "calf"
l. alpatóci "baby alligator"
m. iŋkosapitá "one to implore"
n. yakaphoyíta "two to walk"

The tonal accent is placed on the rightmost even-numbered syllable, counting from the nearest heavy syllable, or else from the word begin. Rightward standard iambic parsing yields the feet among which End Rule Final selects the accent:

```
(11)a.          *    b.            *     c.    *      d.          *
         (.  *)(.  *)    (.  *)(.  *) .    (.  *)  .    (.  *) (.  *) .
          m  m  m  m      m  m  m  m  m     m  mm  m     m  mm  m  m  m
          a mi fo ci      i ma hi ci ta    po cos wa    ya kap ho yi ta
```

But moraic iambs achieve this result equally well, with only a slight and irrelevant difference of bracketing occurring in (12c,d):

```
(12)a.          *    b.            *     c.    *      d.          *
         (.  *)(.  *)    (.  *)(.  *) .     . (*.)  .     . (*.)(.  *) .
          m  m  m  m      m  m  m  m  m     m  mm  m     m  mm  m  m  m
          a mi fo ci      i ma hi ci ta    po cos wa    ya kap ho yi ta
```

3.3 The iambic directionality asymmetry: reanalyzing leftward iambs

Having shown that moraic iambs can replace standard iambs in rightward parsing, I now turn to leftward quantity-sensitive iambic systems. Actually, leftward iambic systems are extremely rare as compared to rightward systems, an important observation due to Hayes (1991). Hayes mentions a large number of rightward systems, such diverse as Asheninca, Cayuga, Choctaw, Hixkaryana, Macushi, Menomini, Munsee, Odawa, Onondaga, Passamaquoddy, Potowatomi, Winnebago, Yupik, etc. In contrast, only three systems have been analyzed as leftward iambic: Tübatulabal (Wheeler 1979), Aklan (Hayes 1981), and Tiberian Hebrew (McCarthy 1979).

Consider the data below from Tübatulabal (Voegelin 1935):

(13)a. tcíŋiyál "the red thistle"
b. tiŋíyaláap "on the red thistle"
c. wɪtáŋhatál "the Tejon Indians"
d. wítaŋhátaláabatsú "away from the Tejon Indians"
e. táahávilá "the summer (obj.)"
f. haníilá "the house (obj.)"

The final syllable is always stressed. Voegelin calls it the *main stress*, although all stresses appear to be equally strong. In words with only light (short-voweled) syllables (13a,c), stress alternates leftward from the "main stress". In words with heavy syllables (13b,d,e,f) every other light syllable preceding a heavy syllable is stressed. The standard iambic analysis produces the following outputs:

```
(14)a. (*)(.  *)(.  *) (.  *)   b. (*) (*)(.  *)   c. (.  *) (*)
        m  m   m  m  mm  m  m       mm  m  m  m        m  mm  m
       wi tan ha ta laa ba cu      taa ha wi la       ha nii la
```

This result crucially depends on the degenerate foot, an expansion of the iamb of Hayes (1981). But since degenerate feet are excluded from the foot inventory (1), standard iambs no longer produce the correct results:

```
(15)a.  . (.  *)(.  *) (.  *)   b. (*)  . (.  *)   c. (.  *)  .
        m  m   m  m  mm  m  m       mm  m  m  m        m  mm  m
       wi tan ha ta laa ba cu      taa ha wi la       ha nii la
```

The results of applying *moraic* iambs from right to left are even worse:

```
(16)a. (.  *) (.  *)(*.)(.  *)   b. (*.) . (.  *)   c.  . (*.) .
        m  m   m  m  mm  m  m        mm  m  m  m        m  mm  m
       wi tan ha ta laa ba cu       taa ha wi la       ha nii la
```

But, as Kager (1989) shows, Tübatulabal can be reanalysed trochaically. The End Rule Final is applied before foot assignment:

(17) a. End Rule Final.
b. Moraic trochees, right to left.

At the right periphery, word-level prominence now overrides foot parsing:

```
(18)a.                        *   b.             *   c.           *
       (*  .) (*  .)(*.) .    *      (*.)(*  .)  *        . (*.)  *
        m  m   m  m  mm  m    m       mm  m  m   m        m  mm   m
       wi tan ha ta laa ba   cu      taa ha wi  la       ha nii  la
```

Similar reanalyses are possible for Aklan and Tiberian Hebrew, but because of lack of space I cannot present these here.

A second reanalysis of Tübatulabal is possible, based on Kiparsky's (1991) idea of *anti-extrametricality*. Anti-extrametricality is the opposite situation of extrametricality: at edges, a mora may count for prosodic purposes without being segmentally linked. Under final mora anti-extrametricality, Tübatulabal stress can be derived by leftward moraic trochees and the End Rule Final. Below, anti-extrametrical moras appear in braces:

```
(19)a.                        *      b.               *     c.            *
       (*  .) (*  .)(*.) . (* .)      (*.)(*  .)(* .)        . (*.)(* .)
        m  m   m  m  mm  m m{m}        mm  m  m m{m}         m  mm m{m}
       wi tan ha ta laa ba cu         taa ha wi la          ha nii la
```

4 Explaining the directionality asymmetry

Let us summarize our results. We have substituted rightward standard iambs by moraic iambs, and reanalyzed the few leftward standard iambic systems by moraic trochees. By eliminating the entire category of leftward iambic systems, the directionality asymmetry in iambic systems has become *complete*. This immediately raises the question as to what causes the general absence of leftward (standard or moraic) iambic systems. My explanation will be a *rhythmic* one, and it will crucially depend on the non-uniform dominance of the moraic iamb. I will first define some ill-formed moraic rhythms:

(20)a. *Mora clash*: two adjacent stressed moras.
b. *Short mora lapse*: two adjacent stressless moras.
c. *Long mora lapse*: three adjacent stressless moras.

The lack of leftward quantity-sensitive iambic systems is explained by the *anti-rhythmic* results of leftward *moraic iamb* parsing. As shown in (21b), this parsing mode *consistently* produces *mora clash* after having footed a heavy syllable. It is also the only parsing mode to produce *long* lapses. In contrast, *left-to-right* moraic iamb parsing produces no such long lapses, and only occasional clashes, only of the "tolerable" *forward* kind, cf. Prince (1983:61-62). (Forward and backward clash are distinguishable as heavy syllable parsing, because of syllable integrity, takes precedence over light syllable parsing):

(21) **Rhythmic patterning of moraic iamb**
a. Left-to-right: MaxID: 2 moras; MinID: 0 mora (forward clash);
b. Right-to-left: MaxID: 3 moras; MinID: 0 mora (backward clash).

```
a. s     s s   s     s s   s   s     b. s     s s   s     s   s s   s
   |\    | |   |\    | |   |   |\       |\    | |   |\    |   | |   |\
   m m   m m   m m   m m   m   m m      m m   m m   m m   m   m m   m m
   (* .)(. *)(* .)(. *) .  (* .)      (* .)(. *)(* .) .  (. *)(* .)
```

Long lapse and backward clash constitute compelling rhythmic anti-pressure against leftward moraic iambic parsing.

Moraic *trochees* are rhythmically ideal parsing feet in both directions, which never produce mora clashes, nor long lapses. This property is a result of the uniform dominance of their disyllabic and monosyllabic expansion (cf. 8a):

(22) **Rhythmic patterning of moraic trochee**
a. Left-to-right: MaxID: 2 moras; MinID: 1 mora;
b. Right-to-left: MaxID: 2 moras; MinID: 1 mora.

```
a. s     s s   s     s s   s   s     b. s     s s   s     s   s s   s
   |\    | |   |\    | |   |   |\       |\    | |   |\    |   | |   |\
   m m   m m   m m   m m   m   m m      m m   m m   m m   m   m m   m m
   (* .)(* .)(* .)(* .) .  (* .)      (* .)(* .)(* .) .  (* .)(* .)
```

Indeed, moraic trochee systems, although less numerous than either syllabic trochee systems or iambic systems, display free variety in direction of assignment, as can be verified by the systems discussed in Hayes (1991). Leftward moraic trochee systems include Cahuilla (prefixes), Fijian, Hindi, Maithili, and Wargamay. Rightward moraic trochees occur in Cahuilla (stems), Cairene Arabic, and Nunggubuyu (Kager 1990).

Crucially, the rhythmic explanation of the iambic directionality asymmetry cannot be carried over to the asymmetrical inventory (1), which makes it an argument for the inventory (2). Firstly, the syllable, not the mora is the stress-bearing unit in (1), making moraic rhythm hard to measure. Secondly, the rhythmic effect of leftward parsing is not notably worse than that of rightward parsing. Leftward parsing (23b) does not even produce mora clashes:

(23) **Rhythmic patterning of standard iamb** (measured in moras)
a. Left-to-right: MaxID: 2 moras; MinID: 0 moras (clash);
b. Right-to-left: MaxID: 3 moras (long lapse); MinID: 1 mora.

```
a. (*.)(. *)(*.)(. *)(.  *.)  b. (*.) . (.  *.)(.  *)(.  *.)
   s   s s  s   s s  s   s      s   s   s  s   s  s  s   s
   |\  | |  |\  | |  |   |\     |\  |   |  |\  |  |  |   |\
   m m m m  m m m m  m   m m    m m m   m  m m m  m  m   m m
```

We now turn to the second argument for the moraic iamb as a parsing foot.

5 A ternary iambic system: Chugach Alutiiq Yupik

Although (as shown above) standard and moraic iambs produce identical results in regular rightward parsing, and although they cannot be compared in leftward parsing (due to the asymmetry), there is still one type of system that can provide a fairly direct empirical testing ground. *Ternary* iambic systems qualify as such, if Hayes (1991) is correct in claiming that ternarity does not involve ternary feet, but simply binary feet applied in a special parsing mode, called *weak local parsing*. Under normal (strong local) parsing, feet are constructed adjacently, but in ternary systems, a light syllable is skipped after every application of foot construction. At domain edges, a skipped stray mora may end up next to another stray mora, which cannot form a (degenerate) foot on its own (see 24a). Dependent on language-specific choice, such sequences of *free elements* can be left as they are (as in Cayuvava), or be bracketed into well-formed feet when foot construction is *persistent* (see 24b):

(24)a. Weak local parsing (leftward trochee) b. By persistent footing:

```
[ . . (* .) . (* .) . (* .)        (* .)(* . ) . (* .) . (* .)
```

The best known (and as far as I know only) example of a ternary iambic system is Chugach Alutiiq Yupik (Leer 1985a,b, Rice 1988, Halle 1990, Hayes 1991). Chugach has the following distribution of stresses:

(25) I. *Sequences of light (CV, non-initial CVC) syllables*
a. pa.lá.yaq "rectangular skiff"
b. a.kú.ta.mə́k *akutaq* (a food), abl.sg.
c. ta.qú.ma.lu.ní "apparently getting done"
d. a.kú.taχ.tu.níχ.tuq "he stopped eating *akutaq*"
e. ma.ŋáχ.su.qu.tá.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. taá.taá "her father"
j. taá.ta.qá "my father"
k. naá.qu.ma.lú.ku "apparently reading it"
l. náa.ma.cí.quá "I will suffice"
m. úl.luq "it flooded"
n. án.ci.qu.kút "we'll go out"
o. án.ci.quá "I'll go out"
p. úm.yuáχ.tə.qu.tə́.ka.qá "I'm thinking about it"
q. áχ.ku.táχ.tuá.ŋa "I'm going to go"
r. áɣ.ŋuá.qu.táχ.tuá.ŋa "I'm going to dance"

The syllable weight distinction in Chugach almost coincides with the vowel length contrast. Heavy syllables contain long vowels or diphthongs, which may be *rising* (/ia/, /ua/, etc.) or *falling* (/au/ and /ai/). Stress has been marked on the strong mora, following Leer's transcription. *Initial closed* syllables are always stressed, and may be considered to undergo a mora addition rule, which makes them heavy (Hayes 1991).

In words containing only light syllables, every syllable in position *3n - 1* is stressed, and every final syllable in words of length *3n + 1* syllables. The counting is obviously ternary, and starts at word begin. This invites the following analysis based on rightward moraic iambs:

(26) Construct moraic iambs from left to right, weak local parsing, persistent.

The feet that Leer refers to essentially coincide with moraic iambs, but are derived in a somewhat different way, for which I refer the reader to Leer (1985a,b). This produces the derivations of (27):

```
(27)a. (.  *) .  .    b. (.  *) . (.  *)   c. (.  *) .  (.  *)  .
        m  m  m  m        m  m  m  m  m        m  m  m   m  m   m
        a ku ta meq      ta qu ma lu ni        a ku tar tu nir tuq

       (.  *)(.  *)
        m  m  m  m     (persistent footing   (persistent footing
        a ku ta meq     inapplicable)         inapplicable)
```

In words containing heavy syllables, every heavy syllable is stressed, and so is every light syllable in position *3n* following a heavy syllable (cf. 28a). In addition, light syllables in position *3n - 1* following a heavy syllable are stressed if they are word-final (cf. 28b), or directly precede a heavy syllable (cf. 28c). The parsing definition of (26) produces the following derivations:

```
(28)a. (.*) . (.  *) .  b.(*.)(.*)  . (.  *) .  .  c.(*.) (.*) .  .  (.*)  .
       mm  m  m  m  m     mm  mm    m  m  m  m  m    mm   mm  m  m   mm   m
       naa qu ma lu ku    um yuar te qu te ka qa     ag.ngua.qu.tar.tua.nga

                          (*.)(.*)  . (.  *)(.  *)   (*.) (.*)(.  *) (.*)  .
      (persistent footing mm  mm    m  m  m  m  m    mm   mm  m  m   mm   m
       inapplicable)      um yuar te qu te ka qa     ag.ngua.qu.tar.tua.nga
```

One special case needs to be dealt with. In words where an initial underlyingly light syllable is immediately followed by a heavy syllable, the onset consonant of the heavy syllable is geminated, and the initial syllable surfaces with stress, cf. *át.tíi* (/atii/) "his father", or *qáy.yáa* (/qayaa/) "his boat". I assume a rule of mora addition along the lines of Hayes (1991):

(29) **Initial Pre-Long Strengthening**

```
                       s     s
                       |     |\
     0 -> m /   [Wd    m ___ m m
```

By gemination, the initial syllable becomes closed, hence heavy, and will be automatically stressed (because of Syllable Integrity):

```
(30)   . (. *)  IPLS  . . (. *)     (* .)(. *)
       m  m m    =>   m m  m m   => m m  m m
       | /\ /         |   /\ /      | \ /\ /
       a t i          a  t  i       a  t  i
```

Chugach has an "iambic" lengthening rule applying to all metrically strong vowels in non-final open syllables, cf. *(taqú:)ma(luni)* "apparently getting done", *(naá)(mací:)(quá)* "I will suffice". Since I will present my general view of iambic lengthening in section 6 below, here it suffices to say that the rule refers to precisely the feet produced by (26).

Let us now turn to the process of *consonant fortition*, which provides strong additional evidence for the analysis presented above. Foot boundaries in Chugach are signalled by the presence of fortis consonants in foot-initial position. According to Leer (1985a), 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. Even though there is no phonetic contrast between fortis and lenis initially, Leer describes all word-initial consonants as fortis, since these always begin a foot. The distribution of fortis consonants is shown below, where foot boundaries are indicated by brackets, and fortis consonants are printed bold-face:

(31) 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. (**p**isú)qu(**t**aqú)ni "if he (refl.) is going to hunt"
k. (**n**aá)qu(**m**alú)ku "apparently getting done"

Moraic iambs assigned under weak local parsing and persistent footing directly produce the correct foot boundaries required for fortition of foot-initial consonants. Moraic iambs work so well in Chugach mainly because each foot is minimally and maximally bimoraic, so that each heavy syllable will form a foot on its own. The other successful ingredients of the analysis are weak local parsing and persistent footing. Let us now consider alternative analyses based on amphibrachs and standard iambs, respectively.

The *amphibrach* analyses of Rice (1988) and Halle (1990) form attempts to do without weak local parsing. Amphibrachs are ternary feet with medial heads, which in the case of Chugach are constructed over moras. Non-maximal amphibrachs include degenerate monomoraic feet. In order to guarantee that every long-voweled syllable starts a foot, Halle (1990) pre-assigns left foot boundaries to heavy syllables, indicated below with square brackets. Accents (marked by "#") are pre-assigned to initial closed syllables. This analysis correctly assigns stresses, as is shown below.

```
(32)a. (.  *  .)(.  *)  b. [.*  .)(.  *  .)      c. (#) [.*   .)(.  *  .)(*)
        m  m  m  m  m       mm  m  m  m  m           m   mm   m  m  m  m  m
        ta qu ma lu ni      naa qu ma lu ku          um yuar te qu te ka qa

    d. [.*  .)(*)[.*)   e. (#   .)(*) [.*   .)  f. (#)  [.*  .)(*) [.*   .)
        mm  m  m  mm        m   m  m   mm   m       m    mm  m  m   mm   m
        naa ma ci qua       ag ku tar tua nga       ag ngua qu tar tua nga
```

But parsing fails to provide the proper foot boundaries required for a uniform characterization of Fortition. More specifically, it fails where a non-initial monomoraic foot is produced, cf. (32c,d,e,f). To repair this, Rice and Halle add a powerful restructuring rule (restated below in our notation):

(33) **Foot Reanalysis** (Halle 1990)

```
line 0      * .)(*)  ->  *)(. *)
```

This rule only serves the purpose of deriving the foot boundaries that are *directly* produced in a moraic iamb analysis:

```
(34)a. (.  *   .)(*) RE (.  *)(.  *)  b. [.*  .)(*) RE [.*)(.  *)
        m  m  m  m  =>  m  m  m  m       mm  m  m  =>  mm  m  m
        a ku ta mek     a ku Ta mek      taa ta qa     Taa Ta qa

    c. [.*  .)(*)[.*)  RE  [.*)(.  *)[.*)
        mm  m  m  mm   =>   mm  m  m  mm
       naa ma ci qua        Naa Ma ci Qua
```

Because of its additional power required for foot reanalysis, this analysis is arguably less adequate than a moraic iamb analysis.

Next, let us consider a standard iambic analysis based on weak local parsing and persistent footing. Such an analysis immediately fails in locating the proper stresses, as well as the foot boundaries required for fortition:

```
(35)a. (*)  . (.  *)    b. (*)  . (.   *)   .    c. (*)  (*)  . (.   *)   .
        mm  m  m  mm       mm   m  m   mm   m       mm   mm   m  m   mm   m
       naa ma ci qua       ag ku tar tua nga        ag ngua qu tar tua nga
```

The problem for a standard iambic analysis is to guarantee that a foot starts at every heavy syllable. Again, correction of the output requires a powerful restructuring rule, whose function is essentially to replace standard iambs by moraic iambs:

(36) **Foot Reanalysis**

```
. (. *)     (. *)(*)
m  m mm  =>  m m  mm
```

An improvement is suggested in an ingenious unpublished analysis by Hayes (1991). Hayes' central idea is that consonant fortition before long vowels is a "pale version" of initial pre-long strengthening, which (unlike rule 29) does not result in consonant gemination, but shares its effects between consonant length and partial lengthening of the preceding vowel. The rule is stated below:

(37) **Pre-Long Strengthening** (Hayes 1991:285)

```
                      s     Conditions:(a) If a = V of initial CV,
                      |\                   mi links to b.
0 -> mi  /  ___      m m               (b) Otherwise, mi links to
                    / \|                   both a and b.
                  a    b  [-cons]
```

In non-initial sequences of a light and a heavy syllable, the added mora will be shared between the light syllable's vowel (which undergoes partial iambic lengthening) and the heavy syllable's onset (which becomes "fortis"). Evidence for partial iambic lengthening comes from Leer (1985a), who observes that fortis consonants somewhat inhibit vowel lengthening before them. Pre-Long Strengthening feeds construction of standard iambs under weak local parsing and persistent footing:

```
(38)
                                                               (*) (.     *) (*)
     s   s   s    s          s   s    s   s          s   s     s   s
    / \  |   |   / \        / \  |   / \ / \        / \  |    / \ / \
    m m  m   m   m m   =>   m m  m   m m m m   =>   m m  m    m m m m
   /\ / /|  /|  /| |       /\ / /|  /|/\/| |       /\ / /|   /|/\/| |
   n a m a c i q u a       n a m a c i Q u a       N a M a c i Q u a
```

In words such as *án.ci.quá* (cf.31c) an incorrect stress is produced on the syllable *ci*, one surrounded by heavy syllables. Hayes eliminates this stress by a rule deleting the first mora from a CVC-syllable in *double clash*. The resulting light syllable undergoes persistent footing, grouping with the following heavy syllable into a maximal iamb, cf. *(án)(cí)(*q*uá)* → *(án)ci(*q*uá)* → *(án)(ci*q*uá)*. But now it is incorrectly predicted that the foot-initial onset consonant of *ci* surfaces as fortis. Elsewhere, consonants derived by persistent footing indeed undergo a rule of foot-initial fortition, cf. *m* in *(*n*aá)(*m*ací)(*q*uá)*, see again (38). Since footing is persistent, the burden of distinguishing these cases must be on fortition, which must have global power to do so, as the contrast is purely derivational, and is not recoverable from surface foot structure.

Notice that this analysis splits up both fortition and iambic lengthening into two processes. In addition to the "half-length" from Pre-Long Strengthening, separate rules of foot-initial fortition and iambic lengthening rule must be assumed. Hayes argues that splitting up fortition precisely reflects Leer's (1985:86) observation that fortition in monosyllabic heavy feet is slightly more phonetically apparent than in disyllabic "double-light" feet. 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.

Splitting up *vowel lengthening* may seem to be reflected in different degrees of length, as Leer observes that iambic vowel lengthening is somewhat inhibited before fortis consonants. That is, *u* is longer in *akú:taq* than in *akú:*t*amə̄k*. 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 voiceless consonants are characterized by increased duration. But most importantly, the vowel length contrast is due to the mere presence of a fortis consonant, not to different rules, i.e. *sources* of vowel lengthening.

We thus find that Hayes' 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.

Summarizing, several alternatives to a moraic iamb analysis of Chugach, based on the amphibrach and the standard iamb, have been shown to be less adequate. The final section briefly addresses quantitative foot-based rules.

6 Mapping parsing feet into surface feet

Let us now address the question as to why rhythmic vowel lengthening seems to be so closely related to iambic foot parsing. While under the asymmetrical foot inventory (1), iambic lengthening can be expressed as template satisfaction $(\sigma_\mu\sigma_\mu) \rightarrow (\sigma_\mu\sigma_{\mu\mu})$, it will be clear that it no longer can under the symmetrical foot inventory (2). Interestingly, Hammond (1990) suggests that the iamb-trochee asymmetry characterizes *surface feet,* not parsing feet, and instantiates a general principle of rhythmic perception. Kager (1991) attributes the close relationship between iambic rhythm and vowel lengthening to a linguistic rhythmic factor: avoidance of clash and lapse within the surface foot:

(39) **Prosodic Domain Eurhythmy Principle**
Rhythmic wellformedness must be maximized at all prosodic levels.

I refer to Kager (1991) for extensive motivation of the principle, which governs the mapping from parsing feet into surface feet, which includes *stray adjunction* and foot-governed quantitative rules such as iambic lengthening and trochaic shortening (Prince 1991). Now, iambic lengthening becomes a non-structure-preserving expansion of the parsing foot $(\sigma_\mu\sigma_\mu)$ into the surface foot $(\sigma_\mu\sigma_{\mu\mu})$, the output of which is measured rhythmically. The rhythmic consequences of stressed vowel lengthening in iambs vs. trochees are very much different:

```
(40) a.  s s         s s          b.  s s         s   s
         | |   =>    | |\             | |   =>    |\  |
         m m         m m m            m m         m m m
        (. *)       (. * .)          (* .)       (* . .)
```

Vowel lengthening adds a mora to a stressed syllable, which (by 7a) translates into falling moraic prominence. Thus, while vowel lengthening creates a mora *lapse* in the trochee, it has no rhythmic disadvantages whatsoever in the iamb. Internal moraic prominence of heavy syllables turns out to be the unifying rhythmic factor in both quantitative asymmetries: the iambic directionality asymmetry, and the iamb-trochee asymmetry with respect to lengthening.

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