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Foot Harmony and Quantitative Adjustments*

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0 Introduction

Foot structure can affect syllable weight, as is well known from the analysis of minimal word effects (McCarthy & Prince 1986, 1993ab, 1994 *inter alia*). Other examples of lengthening or shortening processes that are sensitive to foot structure (henceforth, quantitative adjustments) are quite common as well. In Yupik, for instance, LL sequences lengthen when footed iambically to become (L **H**).[1] This process, known as IAMBIC LENGTHENING, is one of the cornerstone pieces of evidence for what I will here call "the standard theory" of foot typology, as exemplified by Hayes 1985, 1987, 1995 and McCarthy & Prince 1986.

(1) Iambic lengthening

L L		**(L H)**	
/qayani/	→	**[qayá:ni]**	'his own kayak'

The standard theory takes the asymmetric (L **H**) iamb to be the perfect iamb, and iambic lengthening is taken to be a rule that strives for this ideal. In Hayes 1995, iambic asymmetry is built into the universal foot inventory in accordance with the Iambic/Trochaic Law, which states that iambic groupings naturally contrast in duration while trochaic groupings naturally contrast in intensity. Without further elaboration, this type of approach cannot account for dialectal variation in the quantitative adjustment of LH sequences in Yupik. One dialect, Chaplinski, behaves as expected: LH sequences are not adjusted and are footed as (L **H**), as shown in (2a). Another dialect, St. Lawrence Island, foots LH sequences as (L **S**), as shown in (2b). Finally, Central Alaskan Yupik dialects unexpectedly foot LH sequences as (**H**) (**H**), as shown in (2c).

(2) Quantitative adjustments of LH in different Yupik dialects

a.	**L H**		**(L H)**		
	/qaya:ni/	→	**[qayá:ni]**	'in his (another's) kayak'	(Chaplinski)
b.	**L H**		**(L S)**		
	/qaya:ni/	→	**[qayá::ni]**	'in his (another's) kayak'	(St. Lawrence Island)
c.	**L H**		**(H)(H)**		
	/qaya:ni/	→	**[qáyyá:ni]**	'in his (another's) kayak'	(Central Alaskan Yupik)

To account more uniformly for all of the quantitative adjustments in (1) and (2), I adopt a slightly modified version of the theory of foot typology proposed in Prince 1990, recast within Optimality Theory (OT; Prince & Smolensky 1993). In Prince's theory, disyllabic feet are evaluated based on a function known as GROUPING HARMONY. Grouping Harmony assigns a numerical value to a disyllabic foot, calculated by dividing the size (in moras) of the second

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[1] L denotes a light (monomoraic) syllable, H denotes a heavy (bimoraic) syllable, and S denotes a superheavy (trimoraic) syllable. Stress on these symbols is indicated by **boldface**; parentheses denote foot boundaries. All data in this paper are from the various papers in Krauss 1985a and from Hayes 1995, §6.3.8.

syllable of the foot by the size of the first syllable. The greater the size of the second syllable relative to the first, the greater the numerical value, and hence the better the Harmony of the foot. The function, along with the evaluation of some disyllabic feet, is given in (3).

(3) Grouping Harmony

a. Let G be a disyllabic foot.
Let X be the first syllable of G.
Let Y be the second syllable of G.
Let |Z| be the size of Z in moras.
Harmony H of G: $H(G) = |Y| / |X|$.

b. *Harmony ratings*.

i. (L S) = [μ $\underline{\mu\mu\mu}$]. *Harmony* = 3.
ii. (L H) = [μ $\underline{\mu\mu}$]. *Harmony* = 2.
iii. (L L) = [μ $\underline{\mu}$]. *Harmony* = 1.
iv. (H L) = [$\mu\mu$ $\underline{\mu}$]. *Harmony* = $\frac{1}{2}$.

(The term Y contributing the numerator is underlined.)

This definition differs from Prince's in that G is "at most binary on syllables or moras" in Prince's definition. The "at most" part allows for the evaluation of degenerate (L) feet, giving them a Harmony rating of zero. I assume that the constraint Foot Binarity (FTBIN; Prince 1980, 1990) independently imposes binarity on feet and penalizes degenerate feet. The "or moras" part allows for the evaluation of monosyllabic (H) feet, giving them a Harmony rating of one. I assume here that Grouping Harmony is simply not defined on monosyllabic (H) feet. This particular assumption is crucial in the analyses that follow.

Grouping Harmony assigns higher value to end-heavier disyllabic feet (prototypical iambs), independent of trochaic vs. iambic prominence. A dependence on such prominence recognizes the force of the Weight-to-Stress Principle (WSP; Prince 1983, 1990), stated in (4a). This makes (**L** L) the best possible trochee, since the WSP rules out (**L** H) (or any end-heavier foot), and it makes (L **L**) the worst possible iamb, since the WSP rules out (H **L**) (or any top-heavier foot). This is shown by the scales in (4) (feet ruled out by the WSP are shaded, and the symbol '>' means 'is more harmonic than').

(4) The Weight-to-Stress Principle and the Grouping Harmony scales

a. WSP: Heavy syllables are heads of feet.
b. *Trochaic:* (**L** S) > (**L** H) > (**L** L) > (**H** L)
c. *Iambic:* (L **S**) > (L **H**) > (L **L**) > (H **L**)

Like the standard theory, the scale in (4) deems (L **H**) more harmonic than (L **L**). The difference is that the scale also deems (L **S**) more harmonic than (L **H**). My modification of Prince's definition of Grouping Harmony distinguishes (H) from all feet, since they are not subject to its evaluation. These distinctions, I argue, allow for a unified account of all the quantitative adjustments in Yupik. In this paper, I propose that Grouping Harmony is the basis of the following ranked and violable Optimality-Theoretic constraint.[2]

[2] See Green 1996 for another use of the Grouping Harmony function within Optimality Theory.

(5) FTHARM

For every disyllabic foot G, increase $H(G)$.

The paper is organized as follows. In §1, I briefly analyze Yupik's left-to-right footing of syllables into quantity-sensitive iambs. In §§2–3, I examine the quantitative adjustments resulting from such footing and provide a unified account of them, making crucial use of FTHARM's interaction with various other constraints already familiar from the Optimality-Theoretic literature. In §4, I propose an analysis of the different segmental realizations of the quantitative adjustments of Central Alaskan Yupik. In §5, I discuss properties of the word-final position. §6 is a brief summary of the entire Yupik analysis. In §7, I extend the utility of FTHARM to account for iambic lengthening's sister phenomenon, trochaic shortening, in Boumaa Fijian. §8 concludes the paper with a comparison of the present accounts of iambic lengthening and trochaic shortening with the standard rule-based accounts found in Hayes 1995.

1 Left-to-right, quantity-sensitive iambs

The dialects of Yupik that I will be primarily concerned with and their relationships to each other are as shown in (6). I make a distinction between St. Lawrence Island and Chaplinski, the two dialects of Central Siberian Yupik, for convenience; what I say about Chaplinski actually holds for younger speakers of St. Lawrence Island as well (see Krauss 1985c).

(6)

Yupik
- Central Siberian
  - Chaplinski
  - St. Lawrence Island
- Central Alaskan

Stress in Yupik "falls on nonfinal heavy syllables and on the nonfinal even-numbered members of a light-syllable string, counting from left to right" (Hayes 1995:240). Clearly, Yupik has a quantity-sensitive, left-to-right iambic footing system; the lack of final stress is attributed here, as in Krauss 1985a and Hayes 1995, to the intonational system.[3] To analyze this footing pattern, I assume the ranked-and-violable, Optimality-Theoretic constraints in (7) and the partial ranking of them in (8).[4]

(7) Constraints for Yupik footing

a. PARSE-σ Syllables are parsed into feet.
b. ALL-FT-R Align all feet with the right edge of PrWd.
c. FTBIN Feet are binary at some level of analysis (σ, μ).
d. IAMB Feet are right-headed.
e. TROCHEE Feet are left-headed.

(8) Partial ranking of constraints for Yupik footing

PARSE-σ » {ALL-FT-R, FTBIN}; IAMB » TROCHEE

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[3] On the independent lack of final lengthening, see §5 below and Buckley 1996. See also Hayes 1995, §6.3.8.8 for arguments that final unstressed syllables are footed in Yupik. Hayes does not assume the existence of final degenerate feet in Yupik (there appears to be a minimal word requirement arguing against them), but one of the arguments for final syllable footing requires them (again, see §5 below).

[4] Other analyses of (aspects of) Yupik footing, apart from those already mentioned and to be mentioned later, include Halle 1990, Hewitt 1992, Idsardi 1992, Bobaljik 1993, and Kager 1993.

The WSP is undominated and unviolated, so all heavy syllables must be heads of feet. PARSE-σ ranked above ALL-FT-R has the effect of directional footing, familiar from much prosodic work in OT, and PARSE-σ ranked above both ALL-FT-R and FTBIN will force a final light syllable to be footed degenerately (on which see §5.3). (Arguments for the crucial use of ALL-FT-R as opposed to ALL-FT-L for the analysis of left-to-right footing with a final degenerate foot can be found in Crowhurst & Hewitt 1994.)

Finally, IAMB ranked above TROCHEE builds iambs rather than trochees. I assume that headship of a foot is a property of syllables only, so that monosyllabic feet have a head and no nonhead and thus (vacuously) satisfy both IAMB and TROCHEE. I do not assume that monosyllabic feet are inherent trochees (following e.g. Prince 1983, Kager 1993), since this assumption conflicts with the sonority profile of falling diphthongs and the rising tone on long vowels in Central Alaskan Yupik. The internal profile of monosyllabic feet, I assume, is due to independent considerations not discussed here (on which see Hayes 1995, §3.9.1).

2 Quantitative Adjustments in Yupik

2.1 Iambic lengthening and nonlengthening

In both Central Siberian Yupik and Central Alaskan Yupik, when an LL sequence is footed together into an iamb, the stressed syllable is augmented with a mora, creating an (L **H**) iamb. This is iambic lengthening. (The segmental realization of the added mora is discussed in §4.)

(9) Iambic lengthening (Yupik)

a.	**L L**		**(L H)**	
	/qayani/	→	**[qayá:ni]**	'his own kayak'
b.	**L L**		**(L H)**	
	/saɣuya:ni/	→	**[saɣú:yá:ni]**	'in his (another's) drum'

An LH sequence is footed together into an (L **H**) iamb in Chaplinski, one of the two dialects of Central Siberian Yupik. I call this quantitative *non*adjustment NONLENGTHENING.

(10) Nonlengthening (Chaplinski)

a.	**L H**		**(L H)**	
	/qaya:ni/	→	**[qayá:ni]**	'in his (another's) kayak'
b.	**L H**		**(L H)**	'in his (another's) future
	/qayapixka:ni/	→	**[qayá:pixká:ni]**	authentic kayak'

Iambic lengthening (9) makes an (L **H**) iamb out of an underlying LL sequence, and nonlengthening (10) makes the same type of foot out of an underlying LH sequence. The standard theory recognizes this neutralizing effect of iambic lengthening and nonlengthening as support for the view that (L **H**) is the perfect iamb. However, the quantitative adjustments of LH sequences in the other dialects of Yupik conflict with the standard theory.

2.2 Overlengthening and pre-long strengthening

When an LH sequence is footed together in the other dialect of Central Siberian Yupik, St. Lawrence Island, the stressed syllable is augmented with a mora, creating an (L **S**) iamb.

Following Hayes 1995 and the authors in Krauss 1985a, I refer to this quantitative adjustment as OVERLENGTHENING.

(11) Overlengthening (St. Lawrence Island)

a.	**L H** **/qaya:ni/**	→	**(L S)** **[qayá::ni]**	'in his (another's) kayak'
b.	**L H** **/qayapixka:ni/**	→	**(L S)** **[qayá:pixká::ni]**	'in his (another's) future authentic kayak'

When an LH sequence is *expected to be* footed together in the other dialect of Yupik, Central Alaskan Yupik, the light syllable is augmented with a mora and the two syllables are instead footed separately as monosyllabic feet (**H**) (**H**). Hayes (1995) calls this quantitative adjustment PRE-LONG STRENGTHENING.

(12) Pre-long strengthening (Central Alaskan Yupik)

a.	**L H** **/qaya:ni/**	→	**(H)(H)** **[qáyyá:ni]**	'in his (another's) kayak'
b.	**L H** **/qayapixka:ni/**	→	**(H)(H)** **[qayá:píxká:ni]**	'in his (another's) future authentic kayak'

If (L **H**) is the perfect iamb, then why do overlengthening and pre-long strengthening alter it? No underlying LH sequence is ever parsed as (L **H**) in St. Lawrence Island; such a sequence is moraically augmented by overlengthening to become the even more asymmetric (L **S**). Likewise, no such sequence is ever parsed as (L **H**) in Central Alaskan Yupik; it is moraically augmented by pre-long strengthening to become two monosyllabic feet (**H**) (**H**). Only in Chaplinski does underlying LH surface as (L **H**). A unified approach to these quantitative adjustments must abandon the assumption that (L **H**) is the perfect iamb.

The following table summarizes the quantitative adjustments in Yupik presented in this section. The example numbers in the last column refer the reader to the data provided in this section and to the tableaux demonstrating the proposed analysis in the next section.

(13) Summary of quantitative adjustments

Process	Dialect(s)	Schema	Examples
Iambic lengthening	Yupik	LL → (L **H**)	(9), (17)
Nonlengthening	Chaplinski	LH → (L **H**)	(10), (19), (25)
Overlengthening	St. Lawrence Island	LH → (L **S**)	(11), (20), (26)
Pre-long strengthening	Central Alaskan Yupik	LH → (**H**) (**H**)	(12), (24)

3 Analysis

3.1 Iambic lengthening

It is clear from the existence of iambic lengthening that footing an LL sequence as (L **H**) is better, by some measure, than footing it as (L **L**). In a unified approach to the three quantitative adjustments, that same measure must deem that footing an LH sequence as (L **S**) or as (**H**) (**H**) is better than footing it as (L **H**). That measure is Grouping Harmony. The constraint based on Grouping Harmony that I am proposing is repeated here from (5).

(14) FTHARM

For every disyllabic foot *G*, increase *H*(*G*).

I return to the details of the definition of FTHARM in §3.3; for now, it is only necessary to basically understand how it evaluates candidates. To this end, allow me to distinguish a *faithful footing* from *unfaithful footings* of an input (sequence). The faithful footing *F* of an input is the one that foots the sequence as is; there are no moras in the foot that aren't in the input and there are no moras in the input that aren't in the foot. Unfaithful footings of an input are any footings that either have a mora that isn't in the input or that lack a mora that is in the input.

The faithful footing *F* is, all else being equal, preferred to all unfaithful footings because *F* lacks the violations of faithfulness constraints that unfaithful footings incur. All else is not equal, however, when FTHARM dominates one of these faithfulness constraints. Unfaithful footings that only violate a FTHARM-dominated faithfulness constraint are preferred to *F* if the Harmony of the unfaithful footings is greater than the Harmony of *F*. Once that preference is established, the preference for minimal violation of the faithfulness constraint distinguishes the minimally unfaithful footing from the rest.

The relevant faithfulness constraints in this paper are Correspondence constraints (McCarthy & Prince 1995) on moras, where Correspondence is defined as in (15). The constraints themselves are given in (16).

(15) Correspondence (McCarthy & Prince 1995)

Given two strings S_1 and S_2, **correspondence** is a relation *R* from the elements of S_1 to those of S_2. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as **correspondents** of one another when $\alpha R \beta$.

(16) Moraic Correspondence constraints[5]

a. DEP-*μ*

Output moras have input correspondents (i.e., don't insert moras).

b. MAX-*μ*

Input moras have output correspondents (i.e., don't delete moras).

Consider an input sequence LL that must be footed iambically. The faithful footing *F* of this input is (L **L**). Alternatively, the second syllable can be made heavy by the insertion of a mora, violating the faithfulness constraint against their insertion (DEP-*μ*, (16a)) and giving the minimally unfaithful footing (L **H**). This satisfies FTHARM because its Harmony (|H| / |L| = 2 / 1 = 2) is greater than the Harmony of *F* (|L| / |L| = 1 / 1 = 1).

Since Yupik has iambic lengthening and the unfaithful footing wins, it is established that FTHARM dominates DEP-*μ* in Yupik. To demonstrate the relevance of minimal violation, consider

[5] Compare Urbanczyk's (1995) TRANSFER and McCarthy's (1996) WT-IDENT, both of which mediate moraic correspondence through the corresponding segments they dominate (similar to the treatment of featural identity in McCarthy & Prince 1995, on which see also Lombardi 1995, McCarthy 1996, and Alderete *et al.* 1996). It is entirely possible that both types of moraic correspondence constraints are necessary; see §5 for some evidence for this view.

another, more unfaithful footing (L **S**), where the second syllable is made superheavy by the insertion of two moras. This also satisfies FTHARM because its Harmony (|S| / |L| = 3 / 1 = 3) is greater than the Harmony of *F* (|L| / |L| = 1 / 1 = 1). But, it violates DEP-*μ* twice, as opposed to the single time that the minimally unfaithful footing (L **H**) violates it. Thus, (L **S**) loses. All of the above is summarized in the following tableau.

(17) Iambic lengthening: FTHARM » DEP-*μ*

Input: LL

Candidates	FTHARM	DEP-*μ*
(L **L**)	*!	
☞ (L **H**)		*
(L **S**)		**!

This interaction between FTHARM and DEP-*μ* in Yupik wants to add a *single* mora to *any* iamb, because that will (minimally) increase its Harmony. Under this account, (L **H**) is not necessarily what every iamb strives to be; with FTHARM as the driving constraint, it all depends on the input and the ranking between FTHARM and constraints that conflict with it. In the following subsections I demonstrate how the interaction between FTHARM and DEP-*μ* shown above forms the core of all the quantitative adjustments in Yupik.

3.2 Nonlengthening and overlengthening

Now consider the following additional constraint, which is only directly relevant in the footing of an LH input sequence. It plays a central role in distinguishing nonlengthening from overlengthening in the two dialects of Central Siberian Yupik.

(18) BIMORA

Syllables have no more than two moras.

This familiar constraint corresponds to McCarthy & Prince's (1988) Mora Syllabification rule. See Sherer 1994 and Baković 1995 for the use of this constraint in OT; see also, among many others, Myers 1987 and Hayes 1989.

If BIMORA dominates FTHARM, then LH cannot satisfy FTHARM by being unfaithfully footed as (L **S**), because the superheavy syllable violates BIMORA. Another option is the faithful footing (L **H**), violating FTHARM and giving rise to nonlengthening.

(19) Nonlengthening, Chaplinski: BIMORA » FTHARM » DEP-*μ*

Input: LH

Candidates	BIMORA	FTHARM	DEP-*μ*
☞ (L **H**)		*	
(L **L**)	*!		*

Ranking BIMORA below FTHARM produces overlengthening, because under this ranking, FTHARM can be satisfied by the minimally unfaithful (L **S**) footing. The superheavy syllable violates BIMORA, but this ranking forces this result.

(20) Overlengthening, St. Lawrence Island: FTHARM » {BIMORA, DEP-μ}

Input: LH

Candidates	FTHARM	BIMORA	DEP-μ
(L **H**)	*!		
☞ (L **S**)		*	*

The existence of the independently-motivated constraint BIMORA and its interaction with FTHARM thus explains the difference between the two dialects of Central Siberian Yupik. In Chaplinski, trimoraic syllables are simply not tolerated, and FTHARM must be sacrificed. In St. Lawrence Island, trimoraic syllables *are* tolerated to satisfy FTHARM, at the expense of BIMORA. When it comes to simple iambic lengthening, BIMORA is not at issue — the fact that FTHARM dominates DEP-μ in both dialects is then sufficient to guarantee the optimality of the iambically lengthened candidate, as was shown in §3.1.

3.3 The definition of FTHARM

Now that we have seen how the anti-faithfulness constraint FTHARM interacts with other constraints to explain some of the quantitative adjustments of Yupik, we can return to the details of its definition. So far, the vague definition I've offered is as repeated here in (21).

(21) FTHARM

For every disyllabic foot *G*, increase *H*(*G*).

Taken at face value, FTHARM can never be satisfied in the worst case. This is the case when it comes to iambs, because their Harmony can always be increased — just increase the size of the second syllable. (In the case of trochees, this is of course prevented by the WSP.) In the best case, FTHARM neutralizes to some best possible foot. In Chaplinski, there is a two-mora upper limit on the size of syllables (due to high-ranking BIMORA), so the neutralization of LL and LH sequences to (L **H**) is accounted for. But if FTHARM dominates BIMORA, as I am arguing for St. Lawrence Island, then LL sequences shouldn't be footed as (L **H**) and LH sequences as (L **S**); both should be footed as (L **S**) since this is as good as iambs get (assuming a three-mora upper limit on syllable size).

To account for the lack of neutralization in St. Lawrence Island, FTHARM must somehow be "intelligent" enough to know that a foot's Harmony has been "increased" from what it *would have been* had the input sequence been footed as is, faithfully (hence the distinction made in §3.1 between faithful and unfaithful footings). Put more provocatively, FTHARM inherently enforces minimal violation of the conflicting faithfulness constraint(s) it dominates, even though Harmony could be increased more by nonminimal violation.

Gene Buckley (p.c.) points out that this is reminiscent of Kirchner's (1996) proposal to account for synchronic chain shifts. Kirchner's idea is that the anti-faithfulness constraint *A*, which does not inherently enforce minimal violation of a conflicting faithfulness constraint *F* but is better satisfied when *F* is violated more, dominates *F* but is in turn dominated by the *local conjunction* (Smolensky 1995) of *F* with itself (F^2). This mimics the enforcement of minimal violation of *F* because although *A* prefers more violation of *F*, it is dominated by F^2 and thus only one violation of *F* is tolerated to satisfy *A*. (See Gnanadesikan, in preparation for a different approach to chain-shift-type phenomena.)

I do not take this sort of approach to account for these quantitative adjustments because it predicts a possible language in which both LL and LH are augmented to (L **S**), if FTHARM dominates BIMORA and both DEP-μ and its local self-conjunction DEP-μ^2. The reader may think that this would be difficult to distinguish from the case of iambic lengthening LL → (L **H**) and nonlengthening LH → (L **H**) in Chaplinski, which similarly neutralizes both input sequences. However, simply comparing the heavier syllable of a disyllabic foot with a heavy monosyllabic foot (**H**) could conceivably distinguish the two. Since such a language is not attested, I believe that the intelligence of FTHARM is best understood as inherent enforcement of minimal violation.

I propose instead that this intelligence is encoded in the definition of FTHARM itself in the following manner. Following the conventions in the definition of the Grouping Harmony function in (3), let X_o be the moraic contents of the first syllable of a disyllabic foot G_o and let Y_o be the moraic contents of its second syllable (the subscript "o" stands for "output candidate"). The Harmony H of G_o is calculated by dividing the size of Y_o in moras (notated $|Y_o|$) by the size of X_o in moras (notated $|X_o|$). For FTHARM to check if it has been satisfied by G_o, it refers to *the input correspondents* of the segments and associated moras in X_o and Y_o; X_i and Y_i, respectively (the subscript "i" stands for "input") and divides $|Y_i|$ by $|X_i|$ (effectively treating $X_i + Y_i$ as a group, here notated G_i for convenience). If $H(G_o)$ is greater than $H(G_i)$, then FTHARM is satisfied.

FTHARM thus has three parts: the Harmonic evaluation H of a candidate output foot G_o, the Harmonic evaluation H of the correspondent input "grouping" G_i, and a comparator function that returns a violation mark if $H(G_o)$ is less than or equal to $H(G_i)$; i.e., if the Harmony of G_o hasn't been increased. Defined this way, FTHARM does not actually compare unfaithful footings with the faithful footing, as described in §3.1. What it does is compare all footings with the input, mediated through Correspondence. If FTHARM dominates a conflicting faithfulness constraint (e.g., DEP-μ), then the many unfaithful footings that satisfy FTHARM are evaluated by the dominated but still active faithfulness constraint, which picks the least unfaithful form.

In the following two demonstrative tableaux, I have decomposed FTHARM into its three parts to show the evalutation of candidate footings of LL and LH input sequences in St. Lawrence Island, the dialect of Central Siberian Yupik with both iambic lengthening and overlengthening.

(22) Iambic lengthening (a) and overlengthening (b)

a. Input: LL

Candidates	FTHARM			DEP-μ
	$H(G_o)$	$H(G_i)$	Comparator	
(L **L**)	$\|Y_o\| / \|X_o\| = 1$	$\|Y_i\| / \|X_i\| = 1$	$H(G_o) = H(G_i)$; *!	✓
☞ (L **H**)	$\|Y_o\| / \|X_o\| = 2$	$\|Y_i\| / \|X_i\| = 1$	$H(G_o) > H(G_i)$; ✓	*
(L **S**)	$\|Y_o\| / \|X_o\| = 3$	$\|Y_i\| / \|X_i\| = 1$	$H(G_o) > H(G_i)$; ✓	**!

b. Input: LH

Candidates	FTHARM			DEP-μ
	$H(G_o)$	$H(G_i)$	Comparator	
(L **H**)	$\lvert Y_o\rvert / \lvert X_o\rvert = 2$	$\lvert Y_i\rvert / \lvert X_i\rvert = 2$	$H(G_o) = H(G_i)$; *!	✓
☞ (L **S**)	$\lvert Y_o\rvert / \lvert X_o\rvert = 3$	$\lvert Y_i\rvert / \lvert X_i\rvert = 2$	$H(G_o) > H(G_i)$; ✓	*

Only FTHARM and DEP-μ are shown here; the (L **S**) candidate in each case also violates BIMORA, which, as was shown in (20), is ranked below FTHARM in St. Lawrence Island. In Chaplinski, where BIMORA is ranked above FTHARM, the FTHARM-violating first candidate in (22b) wins. Because BIMORA is irrelevant in (22a) (though it independently rules out the third candidate), the same FTHARM-satisfying second candidate wins. This unified account of iambic lengthening, and nonlengthening vs. overlengthening, allows for a simple account of pre-long strengthening as well, as I show in the next subsection.

3.4 Pre-long strengthening

Recall that the Grouping Harmony function, as I've defined it in (3), only evaluates disyllabic feet. Monosyllabic feet have no Harmony value to increase, so they vacuously satisfy FTHARM. There is thus one more way to violate DEP-μ and satisfy FTHARM with an LH input sequence, given that the sequence must be footed due to high-ranking PARSE-σ: footing the two syllables separately and adding a mora to the light syllable, making it heavy (to also satisfy FTBIN). This is pre-long strengthening in Central Alaskan Yupik. This option comes at a price, of course: the extra foot violates the foot alignment constraint ALL-FT-R once more than necessary.[6]

(23) ALL-FT-R

Align all feet with the right edge of PrWd.

Ranking ALL-FT-R below both FTHARM and BIMORA gives rise to pre-long strengthening. Directly attempting to satisfy FTHARM by overlengthening runs afoul of BIMORA, as we already know from nonlengthening, so FTHARM is best satisfied vacuously.[7]

(24) Pre-long strengthening: {FTHARM, BIMORA} » ALL-FT-R; FTHARM » DEP-μ

Input: LH

Candidates	FTHARM	BIMORA	ALL-FT-R	DEP-μ
(L **H**)	*!			
(L **S**)		*!		*
☞ (**H**) (**H**)			*	*

[6] I thank Gene Buckley for suggesting the use of this independently needed constraint instead of an additional one penalizing monosyllabic feet. Though such an additional constraint is not needed here, constraints penalizing monosyllabic feet have been proposed; see Hewitt 1994, Green 1995, and Green & Kenstowicz 1995.

[7] The relevance of BIMORA here is foreseen by Miyaoka (1985:54): "[T]he second vowel of two successive identical vowels has its lengthening blocked due to the two-mora limitation in [Central Alaskan Yupik]."

The optimal, pre-long strengthening candidate in (24) is of course a possible candidate in Central Siberian Yupik, too. It is not optimal in Chaplinski nor in St. Lawrence Island because ALL-FT-R is ranked higher than FTHARM in the former and higher than BIMORA in the latter. These results are shown in (25) and (26), respectively.

(25) Nonlengthening: {BIMORA, ALL-FT-R} » FTHARM » DEP-μ

Input: LH

Candidates	BIMORA	ALL-FT-R	FTHARM	DEP-μ
☞ (L **H**)			*	
(L **S**)	*!			*
(**H**) (**H**)		*!		*

(26) Overlengthening: {FTHARM, ALL-FT-R} » BIMORA; FTHARM » DEP-μ

Input: LH

Candidates	FTHARM	ALL-FT-R	BIMORA	DEP-μ
(L **H**)	*!			
☞ (L **S**)			*	*
(**H**) (**H**)		*!		*

Assuming that FTHARM is vacuously satisfied by monosyllabic feet allows for this rather simple account of pre-long strengthening in Central Alaskan Yupik. By ranking ALL-FT-R high enough, overlengthening and nonlengthening are able to be accounted for as well. FTHARM and its interaction with the other constraints discussed here thus explains the range of quantitative adjustments found in the different dialects of Yupik.

3.5 Summary

In this section I have given a unified account of quantitative adjustments in Yupik, using the proposed FTHARM constraint. Overlengthening and pre-long strengthening are formally related to iambic lengthening under this account because all three involve violations of DEP-μ in order to satisfy FTHARM. Even when it dominates DEP-μ, however, FTHARM can be sacrificed when it is dominated by ALL-FT-R and BIMORA, as it is in Chaplinski. These constraints are only relevant when the Harmony of a footed LH sequence needs to be increased; they are not relevant when the Harmony of a footed LL sequence needs to be increased. This explains how Chaplinski can have iambic lengthening and nonlengthening, since FTHARM's demands can be met by LL inputs but not by LH inputs under this ranking.[8]

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[8] There is another way in which LH can be footed in vacuous accordance with FTHARM that my analysis predicts, however: as L (**H**); that is, as an unfooted light syllable followed by a monosyllabic foot. It is the high-ranking of PARSE-σ and FTBIN that actually does the footing and gemination; FTHARM just opens up the possibility. This would be more or less indistinguishable from nonlengthening, but there is independent evidence for the L (**H**) footing in Koniag Alutiiq (Pacific Yupik; Leer 1985a and Hewitt 1994). Foot-initial consonants are fortis, and the initial consonant of the heavy syllable, not that of the light one, is fortis in such a sequence. Another way to force the appearance of nonlengthening, then, is to demote PARSE-σ at least below FTHARM. A low-ranking PARSE-σ is consistent with the ternary stress pattern of Pacific Yupik, a plausible analysis of which involves syllable skipping (cf. Hayes' Weak Local Parsing; see also Kager 1994 and Hewitt 1994). See Hyde 1996 for an alternative view.

Below I provide summary rankings for each phenomenon and partial rankings for each language. The key is the ranking for iambic lengthening in (27a), which is the necessary component shared by all the phenomena.

(27) Summary rankings

a.	FTHARM » DEP-μ	Iambic lengthening	(Yupik)
b.	{ALL-FT-R, BIMORA} » FTHARM	Nonlengthening	(Chaplinski)
c.	{ALL-FT-R, FTHARM} » BIMORA	Overlengthening	(St. Lawrence Island)
d.	{BIMORA, FTHARM} » ALL-FT-R	Pre-long strengthening	(Central Alaskan Yupik)

(28) Partial rankings established

<u>Chaplinski</u>

ALL-FT-R, BIMORA » FTHARM » DEP-μ

Nonlengthening

<u>St. Lawrence Island</u>

ALL-FT-R » BIMORA; FTHARM » BIMORA; FTHARM » DEP-μ

Overlengthening

<u>Central Alaskan Yupik</u>

BIMORA » ALL-FT-R; FTHARM » ALL-FT-R; FTHARM » DEP-μ

Pre-long strengthening

4 Segmental realization

There is a significant difference between the two quantitative adjustments in Central Alaskan Yupik that I have so far been putting aside: the segmental realization of the mora that is added in iambic lengthening (henceforth IL) and pre-long strengthening (PLS). This difference is the topic of this subsection.[9]

The two quantitative adjustments agree on the segmental realization of the added mora when the syllable is closed — the mora is realized on the syllable-closing consonant.[10]

(29) Mora realization on syllable-closing consonant[11]

a.	IL	**V VC** **/uluɣnia/**	→	**(V VC)** **[ulúɣnia]**	‘he says she looked away’
b.	PLS	**VC V:** **/qayapixka:ni/**	→	**(VC)(V:)** **[qayá:píx ká:ni]**	‘in his (another’s) future authentic kayak’

When the quantitatively adjusted syllable is open, IL realizes the added mora as vowel length, while PLS realizes it as gemination of the following consonant.

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[9] I thank Akin Akinlabi and Alan Prince for discussion of the facts and analysis contained in this section. I also thank people who responded to a query on the Optimal List. Any errors of fact or interpretation are my own.

[10] Hayes (1995:247) notes that “[this] change looks vacuous in phonemic transcription, but in the detailed phonetics, the light versus heavy CVC distinction actually does have real consequences. Woodbury [1981] notes […] that the class of syllable-final consonants [analyzed] as having their own mora […] have greater phonetic length; this plausibly is the phonetic manifestation of their bearing their own mora.”

[11] In the schematic representations in this section and the next, C denotes a consonant, G denotes either half of a geminate, V denotes a short vowel, and V: denotes a long vowel; usually only absolutely relevant segments are highlighted this way (e.g., usually only rhymes, not onsets). As before, stress on these symbols is indicated by **boldface**; parentheses denote foot boundaries. Boldface type also distinguishes moraic segments from nonmoraic ones; e.g., C**VC** denotes a bimoraic stressed syllable while C**V**C denotes a monomoraic stressed syllable.

(30) Mora realization: vowel length vs. consonant gemination

a.	IL	**V V**		**(V V:)**	
		/saɣuya:ni/	→	**[saɣú:yá:ni]**	'in his (another's) drum'
b.	PLS	**V V:**		**(VG)(GV:)**	
		/qaya:ni/	→	**[qáy yá:ni]**	'in his (another's) kayak'

While PLS never realizes the added mora as vowel length, there is a condition under which IL realizes the added mora as gemination of the following consonant: when the would-be lengthened vowel is schwa, because long schwa is uniformly banned in Yupik (see §5.3 and Buckley 1996 for another case of IL gemination). Following the practice of Yupik scholars, the vowel *e* represents schwa.

(31) IL gemination: no long schwa[12]

V e		**(V éG)**	
/atepik/	→	**[atéppik]**	'real name'

The generalization here is that the mora added by both quantitative adjustments is best realized by a syllable-closing consonant, but in the absence of such a consonant, the quantitative adjustments diverge: IL prefers vowel lengthening, while PLS prefers consonant gemination. When vowel lengthening is not possible (as in the case of schwa), IL settles for consonant gemination. There seems to be no parallel condition on PLS, such that vowel lengthening would be preferred to consonant gemination when the latter is not possible.

Indeed, it seems that we have a paradox: modulo the availability of syllable-closing consonants, vowel lengthening is the default for IL while consonant gemination is the default for PLS. In Hayes 1995, this paradox is handled by the following preference order on persistent rules of stray mora association (see also Bobaljik 1991).

(32) Stray Mora Association (Hayes 1995:245, (237))

Stray moras associate with:
a. Non-moraic syllable-final consonants, if present; otherwise
b. Stressed vowels; otherwise
c. The onset of the following syllable.

It is the '*stressed* vowels' part of (32b) that distinguishes IL from PLS. In Hayes' account, IL and PLS rules are applied to *already footed and stressed* LL and LH sequences — their inputs are (L **L**) and (L **H**), respectively. IL adds a mora to the stressed syllable, and if this syllable is open, the stressed vowel is lengthened according to (32b). PLS adds a mora to the unstressed syllable, and if this syllable is open, the onset of the following syllable is geminated according to (32c). Persistent footing (see Hayes 1995; cf. the Domino Condition of Halle & Vergnaud 1987) then repairs the resulting sequence by refooting and stressing the quantitatively adjusted syllable.[13]

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[12] This example is from the Norton Sound Unaliq dialect; other dialects of Central Alaskan Yupik delete schwa rather than geminate, and schwa deletion interacts with other processes in different ways to characterize each individual dialect (see Jacobson 1985, Miyaoka 1985, Woodbury 1987, and Hayes 1995, §6.3.8.6).

[13] Persistent footing and stray mora association are both 'persistent rules' (cf. Myers 1991), but it seems that they must be ordered with respect to each other in Hayes' account; to wit, stray mora association must precede persistent footing to get the right result that the syllable quantitatively adjusted by PLS is unstressed when stray mora

Depending crucially on intermediate stages of derivation, this type of analysis seems to be not possible within the OT account being advanced here. However, the notion of a preference order is the type of analytical device that OT is designed to characterize directly. I propose that the segmental realization of the added mora is indeed the consequence of the ranking of a few interacting constraints. My core hypothesis is that moraic, syllable-closing consonants violate the constraint NOCODA-*μ*, long vowels violate the constraint NOLONG, and geminate consonants violate both NOCODA-*μ* and NOLONG. No matter what the ranking between these two constraints, the prediction is that geminates are worse than both simple moraic codas and long vowels. To get a surface geminate, then, some other constraint *C* must prevail by dominating both of these constraints. This is all summarized in (33).

(33) Constraints on moraic association

a. NOCODA-*μ* Moraic codas are disallowed.

b. NOLONG Long segments are disallowed.

c.

	C	NOCODA-*μ*	NOLONG
moraic coda	(*)	*	
long vowel	(*)		*
geminate		*	*

To characterize the preference order expressed by (32a), NOLONG must dominate NOCODA-*μ* in Central Alaskan Yupik (and, like DEP-*μ*, both must be dominated by FTHARM). Thus, when there is a coda consonant to be associated with the added mora, NOCODA-*μ* will be preferably violated. When no coda consonant is available, NOLONG will have to be violated by vowel lengthening. The following schematized examples of IL show how this works.

(34) Iambic lengthening: FTHARM » NOLONG » NOCODA-*μ*; FTHARM » DEP-*μ*

a. Input: CVCVCCV…

	Candidates	FTHARM	NOLONG	NOCODA-*μ*	DEP-*μ*
	(CV.C**V**C)(CV…	*!			
☞	(CV.C**VC**)(CV…			*	*
	(CV.C**V:**C)(CV…		*!		*

b. Input: CVCVCV…

	Candidates	FTHARM	NOLONG	NOCODA-*μ*	DEP-*μ*
	(CV.C**V**)(CV…	*!			
☞	(CV.C**V:**)(CV…		*		*
	(CV.C**VG**)(GV…		*	*!	

Consonant gemination can be enforced by a constraint dominating both NOLONG and NOCODA-*μ*. For instance, when there is no coda consonant and the would-be lengthened vowel is

association applies. This does not fall out independently from the theory; persistent footing could require that moras be associated to segments to be recognized as elements of weight, but it is not at all obvious that this is anything more than a stipulation that guarantees the right ordering of the rules in question. See §8 for discussion of other problems associated with persistent footing in Hayes' account.

schwa, the constraint NOLONG-[e] will force gemination of the following onset consonant in the Norton Sound Unaliq dialect, as discussed above.

(35) Iambic gemination: {FTHARM, NOLONG-[e]} » NOLONG » NOCODA-*μ*

Input: CVCeCV…

	Candidates	FTHARM	NOLONG-[e]	NOLONG	NOCODA-*μ*
	(CV.C**é**)(CV…	*!			
	(CV.C**é:**)(CV…		*!	*	
☞	(CV.C**éG**)(GV…			*	*

The reason that the mora added by PLS is realized as consonant gemination instead of as vowel lengthening, then, must be due to a constraint ranked above NOLONG and NOCODA-*μ* that is precisely sensitive to the PLS context, just as NOLONG-[e] is precisely sensitive to the schwa-lengthening context. More concretely, what is needed is a constraint ruling out the competing PLS candidate in (36a) and allowing the actual candidate in (36b).

(36) Competing candidates for PLS

a. * **V V:** **(V:)(V:)**
/qaya:ni/ → **[qá: yá:ni]**

b. **V V:** **(VG)(GV:)**
/qaya:ni/ → **[qáy yá:ni]** 'in his (another's) kayak'

An obvious candidate for such a constraint is one that disallows two long vowels in adjacent syllables (Alderete 1996), forcing gemination instead of vowel lengthening. Another possibility is that a constraint against adjacent stresses (Zoll 1992) could be used to distinguish (36a) from (36b), assuming the possibility that stress adjacency (stress clash) is defined over syllable heads, making syllable-adjacent long vowels (36a) stress-wise more adjacent than a geminate followed by a long vowel (36b).[14]

Neither of these possibilities will work here, however: the optimal IL candidate *can* have two long vowels in adjacent syllables, and thus adjacent stresses in the relevant sense, if the vowel in the syllable following an iambically lengthened foot is underlyingly long. This is the case with (30a), repeated here with the relevant losing competing candidate.

(37) Competing candidates for IL

a. **V V V:** **(V V:)(V:)**
/saγuya:ni/ → **[saγú: yá:ni]** 'in his (another's) drum'

b. * **V V V:** **(V VG)(GV:)**
/saγuya:ni/ → **[saγúy yá:ni]**

The responsible constraint must be sensitive to the monosyllabic footing of the long vowels in (36a) as opposed to the bisyllabic + monosyllabic footing of the long vowels in (37a). With this in mind, I pursue an account that takes advantage of independent tonal properties of long vowels in monosyllabic feet in Central Alaskan Yupik. Due to the WSP and the rankings for PLS, syllables with underlying long vowels always end up being footed individually. According to Miyaoka

[14] Thanks to John Alderete and Cheryl Zoll for directing me to their respective works in this area.

(1985), these long vowels have a rising tone, as opposed to long vowels created by IL, which have a level (high) tone. Miyaoka (1985:54, fn. 8) cites the distinction between (38a) and (38b); (38c) is also consistent with his description.[15]

(38) Long vowels and tone

a. High **V V** → **(V V*h*)**
/isχatkaLu/ → **[ísχatká:Lu]** 'also my grass basket'

b. Rising **VC V:** → **(VC)(V*r*)**
/isχatka:Lu/ → **[ísχát ká:Lu]** 'also it is his grass basket'

c. Both **V V V:** → **(V V*h*)(V*r*)**
/saɣuya:ni/ → **[saɣú: yá:ni]** 'in his (another's) drum'

It is reasonable to assume that the rising tone on underlying long vowels is a function of their being footed monosyllabically, rather than of their being underlyingly long as opposed to iambically lengthened. If this is the case, then the losing PLS candidate with vowel lengthening would have two rising tones as opposed to the one rising tone in the winning PLS candidate with consonant gemination. Rising tones (a low-high rise on a single syllable) violate this constraint:

(39) NORISE

Rising tones are prohibited.

We now have a reasonable explanation for why PLS prefers consonant gemination to vowel lengthening: the latter would create a monosyllabically-footed long vowel, and another disprefered rising tone. NORISE, if ranked above NOLONG and NOCODA-μ, will force consonant gemination instead of vowel lengthening in the PLS context, where the danger of creating another rising tone exists, and not in the IL context, where there is no such danger. Compare (38c) above with (40) below.

(40) Competing candidates for PLS with (hypothesized) tones

a. * **V V:** → **(V*r*)(V*r*)**
/qaya:ni/ → **[qá: yá:ni]**

b. **V V:** → **(VG)(GV*r*)**
/qaya:ni/ → **[qáy yá:ni]** 'in his (another's) kayak'

The cluster of ranked constraints responsible for proper tone assignment (not discussed here) must also be ranked above NOLONG and NOCODA-μ, because it is obviously less costly to geminate a consonant to avoid a NORISE violation than it is to assign a tone other than rising to a monosyllabically-footed long vowel. The optimal candidate is correctly chosen as shown with the schematic example in (41).[16]

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[15] Initial closed syllables are heavy in Central Alaskan Yupik, explaining the initial stress in (38a) and (38b). In the following schematics, V*h* denotes a long vowel with high tone and V*r* denotes a long vowel with rising tone. Whether rising tone is actually atomic or composed of low + high linked to a single vowel is not at issue here.

[16] Since they are not directly relevant to the matter at hand, I ignore FTHARM and BIMORA here; they respectively rule out the otherwise possible nonlengthening and overlengthening candidates by each dominating NORISE.

(41) PLS gemination: NORISE » NOLONG » NOCODA-*μ*

Input: CVCV:

Candidates	NORISE	NOLONG	NOCODA-*μ*
(C**V*r***)(C**V*r***)	**!	*	
☞ (C**VG**)(G**V*r***)	*	*	*

Note that the optimal candidate also has a NORISE violation. As noted in fn. 16, NORISE must be dominated by both FTHARM and BIMORA, just as ALL-FT-R is, to guarantee the optimality of the PLS candidate over the competing nonlengthening and overlengthening candidates. But NORISE ranked above NOLONG and NOCODA-*μ* only guarantees that long vowels will not be *derived* in the first of the two monosyllabic feet created by PLS; other constraints must be responsible for guaranteeing that *underlying* long vowels *will* surface, with rising tone, in the second of the two monosyllabic feet, and these constraints must dominate NORISE. Among these must be the cluster of ranked constraints responsible for proper tone assignment and the constraints demanding moraic faithfulness and maintenance of moraic association from input to output (MAX-*μ* and WT-IDENT; see fn. 5).[17] Thus, the one NORISE violation of the optimal candidate in (41) is unavoidable due to higher-ranked constraint demands.

5 Word-final position[18]

5.1 Final footing

Although the analysis of footing in §1 predicts that all word-final syllables are footed, they are not lengthened, where by 'lengthening' I mean adding a mora (a) to satisfy FTBIN ('bulking'), in the case of a final degenerate foot, or (b) to satisfy FTHARM, in the case of a final disyllabic iamb. Intonational phrase-finally, these syllables are also not stressed (Krauss 1985a, Woodbury 1987, Hayes 1995), as indicated in the examples in (42) and elsewhere by the lack of an acute accent over the vowel in a phrase-final footed syllable.

(42) Lack of final stress and lengthening[19]

a.	**V#**		**(V)**	(*FTBIN)
	/qayani/	→	**[qayá:<u>ni</u>]**	'his own kayak'
b.	**VC#**		**(VC)**	(*FTBIN)
	/qayamun/	→	**[qayá:<u>mun</u>]**	'to the kayak'
c.	**V V#**		**(V V)**	(*FTHARM)
	/qayamini/	→	**[qayá:<u>mini</u>]**	'in his own kayak'
d.	**V VC#**		**(V VC)**	(*FTHARM)
	/maliɣutuq/	→	**[malí:ɣ<u>utuq</u>]**	'my big boat'
e.	**V V:#**		**(V V:)**	(*FTHARM)
	/aŋyaχɬ̱aka:/	→	**[aŋyáχ<u>ɬ̱aka:</u>]**	'it is his big boat'

[17] MAX-*μ* may not need to dominate NORISE; it is sufficient that FTHARM and FTBIN dominate NORISE, since shortening a long vowel to avoid a NORISE violation will run afoul of either FTHARM or FTBIN, not just MAX-*μ*.

[18] I thank Gene Buckley for much discussion of the facts and issues surrounding the analysis in this section.

[19] To show the lack of final overlengthening (OL) in (42e), this example is from the St. Lawrence Island dialect of Central Siberian Yupik. The other forms in (42) are the same for all of Yupik (except Nunivak, a dialect of Central Alaskan Yupik, on which see §5.2).

This lack of final lengthening might lead one to believe that word-final syllables are simply not footed. However, there are at least two strong arguments in favor of word-final syllable footing and the independence of the lack of final lengthening (see also Hayes 1995, §6.3.8.8). First, phrase-internal but word-final syllables are stressed, but they are still not lengthened, as shown in (43) (see §5.3 for more details on these facts). Note the necessity brought out by (43b) for positing final degenerate feet (see fn. 3).

(43) Word-final, phrase-internal stress

a. **V V#** **(V V)**
/qayaliciquci#amani/ → **[qayá:licí:qucí#amá:ni]**
'you will be making a kayak over there'

b. **V#** **(V)**
/aŋyaliciquci#amani/ → **[áŋyalí:ciqú:cí#amá:ni]**
'you will be making a boat over there'

Second, phrase-final CVV syllables that are predicted to be footed are not stressed, yet PLS applies to these syllables and the preceding light ones in Central Alaskan Yupik.

(44) PLS with phrase-final CVV[20]

VCVV **(VG)(GVV)**
/čaŋatenʁitua/ → **[čaŋá:ténʁít tua]** 'there is nothing wrong with me'

Based on these facts it can be concluded that word-final syllables are footed, but something independent of footing destresses them phrase-finally (perhaps having to do with the intonational system; see Hayes 1995, §6.3.8.8). Given the fact that word-final syllables are footed, then, lengthening must also be independently blocked phrase-finally.[21]

The facts of Choctaw (Nicklas 1974, Lombardi & McCarthy 1991, Hayes 1995) support the conclusion that the lack of final lengthening in Yupik is independent of the lack of final stress. Choctaw is a pitch accent language; certain syllables in a word are assigned high tone by principles that are independent of foot structure. The evidence for iambic foot structure in Choctaw thus comes not from stress, but from 'rhythmic lengthening', which I assume is equivalent to the two lengthening phenomena in St. Lawrence Island, following Hayes (1995:211, 241). Despite the fact that final footed syllables are no less stressed than medial footed syllables, rhythmic lengthening is blocked finally in Choctaw. Lombardi & McCarthy attribute this condition on lengthening to a general ban on long vowels word-finally in the language. I assume that this constraint against final long vowels (against final length generally) is Spaelti's (1994) WEAKEDGE constraint.

(45) WEAKEDGE

The right periphery of PrWd should be empty.

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[20] This example is from the General Central Yupik dialect of Central Alaskan Yupik, where noninitial CVC (in this case, **/ten/**) is sometimes heavy (initial CVC is uniformly heavy in all of Central Alaskan Yupik, see fn. 15). In the Norton Sound dialect, where noninitial CVC is uniformly light, the footing of this example is **[(čaŋá:)(ténʁí:)(tua)]**, but this form does not exhibit the PLS being demonstrated here. For insightful discussion of the differences in the weight of noninitial CVC in the different dialects of Central Alaskan Yupik, see Hayes 1995, §6.3.8.3–6.3.8.6; see also Bobaljik 1991. No account of these differences is offered here, but see §5.2.

[21] See also Jacobson 1985, Woodbury 1987, and Buckley 1996 for similar conclusions.

What WEAKEDGE says is that the elements of prosody (foot, syllable, mora) along the right edge of a Prosodic Word (i.e., projecting up from the final segment) should be as few as possible.[22] Final long vowels place two moras at the right edge of the Prosodic Word, while final short vowels only place one mora there. Thus, according to WEAKEDGE, shorter vowels are preferred to longer vowels finally. Ranking WEAKEDGE below PARSE-σ but above FTBIN and FTHARM successfully forces final footing but blocks word-final lengthening, as shown in (46).

(46) Lack of final bulking (a) and IL (b)
PARSE-σ » WEAKEDGE » {FTBIN, FTHARM} » DEP-*μ*

a. Input: CV#

	Candidates	PARSE-σ	WEAKEDGE	FTBIN	DEP-*μ*
	(C**V:**)#		F, σ, *μ*, *μ*!		*
☞	(C**V**)#		F, σ, *μ*	*	
	CV#	*!	σ, *μ*		

b. Input: CVCV#

	Candidates	PARSE-σ	WEAKEDGE	FTHARM	DEP-*μ*
	(CV.C**V:**)#		F, σ, *μ*, *μ*!		*
☞	(CV.C**V**)#		F, σ, *μ*	*	
	CV.CV#	*!*	σ, *μ*		

(Having made the argument that PARSE-σ dominates WEAKEDGE, I leave PARSE-σ out of subsequent tableaux.) Ranking MAX-*μ* (the constraint against mora deletion) above WEAKEDGE avoids the danger of word-final shortening, as shown in (47).[23]

(47) Lack of final OL and shortening: MAX-*μ* » WEAKEDGE » FTHARM » DEP-*μ*
Input: CVCV:#

	Candidates	MAX-*μ*	WEAKEDGE	FTHARM	DEP-*μ*
	(CV.C**V::**)#		F, σ, *μ*, *μ*, *μ*!		*
☞	(CV.C**V:**)#		F, σ, *μ*, *μ*	*	
	(CV.C**V**)#	*!	F, σ, *μ*		

WEAKEDGE is not a constraint against final long vowels alone; the account just presented predicts that final consonants will also not bear weight due to lengthening (see fn. 10). This is demonstrated with a bulking case in (48) and an IL case in (49) below.

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[22] Spaelti also counts the final segment itself, but this has no consequences unless WEAKEDGE distinguishes among segment types (see fn. 27 for evidence that it does not). I thus omit segments from the set of WEAKEDGE violators.

[23] MAX-*μ* ranked above WEAKEDGE also prevents word-final deletion of a short vowel's only mora, another plausible candidate not considered in (46) (in Spaelti's (1994) analysis of Micronesian languages, this is the representation of a voiceless vowel). A highly-ranked constraint demanding vocalic moraicity must independently rule this candidate out in languages with final long vowel shortening or final vowel length contrast neutralization; i.e., in languages where WEAKEDGE dominates MAX-*μ* (for instance Choctaw, Chugach, and Nunivak; see below).

(48) Lack of final bulking with consonants: WEAKEDGE » FTBIN » DEP-μ

Input: CVC#

Candidates	WEAKEDGE	FTBIN	DEP-μ
(C**VC**)#	F, σ, μ!		*
☞ (C**V**C)#	F, σ	*	

(49) Lack of final IL with consonants: WEAKEDGE » FTHARM » DEP-μ

Input: CVCVC#

Candidates	WEAKEDGE	FTHARM	DEP-μ
(CV.C**VC**)#	F, σ, μ!		*
☞ (CV.C**V**C)#	F, σ	*	

The fact that OL is blocked finally, as shown in (47), calls for another crucial ranking in St. Lawrence Island, since the other way to satisfy FTHARM with an LH sequence is to pre-long strengthen. Therefore, ALL-FT-R must dominate FTHARM in St. Lawrence Island and FTHARM is simply violated finally, as shown in (50).

(50) No final PLS (St. Lawrence Island): {WEAKEDGE, ALL-FT-R} » FTHARM » DEP-μ

Input: CVCV:#

Candidates	WEAKEDGE	ALL-FT-R	FTHARM	DEP-μ
(CV.C**V::**)#	F, σ, μ, μ, μ!			*
☞ (CV.C**V:**)#	F, σ, μ, μ		*	
(CVG)(G**V:**)#	F, σ, μ, μ	*!		*

The implicit prediction here is that FTHARM could dominate ALL-FT-R in a language which is otherwise like St. Lawrence Island, with OL generally but PLS finally. I am unaware of any such cases at present, but an interesting twist on this prediction may be found in Nunivak, discussed in the following subsection.

5.2 Final shortening and penultimate stressing in Nunivak

In Nunivak, there is no final lengthening and final long vowels are shortened (Jacobson 1985:38).[24] WEAKEDGE ranked above MAX-μ accounts for these facts. Jacobson cites the following forms.

(51) Word-final shortening in Nunivak

a. **V:** → **(V)**
/qayaqa:/ → **[qayá: qa]** 'it is his kayak'

b. **VCV:** → **(VG)(GV)**
/aŋyaqa:/ → **[áŋ yáq qa]** 'it is his boat'

---

[24] This same shortening rule applies in Chugach (Pacific Yupik; Leer 1985a, Hayes 1995). Choctaw also lacks final long vowels (Nicklas 1974, Lombardi & McCarthy 1991, Hayes 1995).

Final vowel shortening applies as expected in (51a). In (51b), the final long vowel is in a PLS context. Even though it is shortened, PLS still seems to apply, geminating the preceding onset consonant. Jacobson attributes this gemination to an opaque application of PLS before the rule of final shortening. Given the definition of FTHARM, I argue, this opaque application of PLS is completely expected. Since the final vowel is underlyingly long in (51b), the part of FTHARM that evaluates the input correspondents of an output foot recognizes that vowel's underlying weight. The vowel must be shortened due to WEAKEDGE's rank above MAX-μ, but footing the last two syllables together as (L L) fatally violates FTHARM, since the input is the more harmonic LH. Since FTHARM dominates DEP-μ and ALL-FT-R, it can force their violation by adding a mora to the penultimate light syllable, making it heavy, and footing both syllables separately. This is all shown in the tableau in (52).[25]

(52) Final opaque PLS due to shortening (Nunivak)

Input: CVCV:#

Candidates	FTHARM			DEP-μ ALL-FT-R
	$H(G_o)$	$H(G_i)$	Comparator	
(CV.C**V**)#	$\lvert Y_o \rvert / \lvert X_o \rvert = 1$	$\lvert Y_i \rvert / \lvert X_i \rvert = 2$	$H(G_o) < H(G_i)$; *!	✓DEP-μ ✓ALL-FT-R
☞ (C**VG**)(G**V**)#	*vacuously satisfied*			*DEP-μ *ALL-FT-R

A candidate with "transparent" PLS is correctly expected to win in the rest of Central Alaskan Yupik, because there is no final long vowel shortening; i.e., MAX-μ dominates WEAKEDGE. This rules out the optimal candidate in (52) and the decision then falls to FTHARM, as shown in (53).

(53) Final transparent PLS due to nonshortening (Rest of Central Alaskan Yupik)
MAX-μ » WEAKEDGE » FTHARM » ALL-FT-R

Input: CVCV:#

Candidates	MAX-μ	WEAKEDGE	FTHARM	ALL-FT-R
(CV.C**V:**)#		F, σ, μ, μ	*!	
☞ (C**VG**)(G**V:**)#		F, σ, μ, μ		*
(C**VG**)(G**V**)#	*!	F, σ, μ		*

The prediction made here is that FTHARM could also be satisfied by a final LL sequence in Nunivak by footing it as (**H**) (L): the (**H**) foot would satisfy FTHARM vacuously, as in the case of PLS, and the final degenerate foot would simply violate FTBIN under pressure from WEAKEDGE and FTHARM as it does in (52) above (see fn. 25). This is the twist on the prediction made at the end of §5.1, and it seems to be borne out, though there are some complications in the available descriptions of Nunivak (Jacobson 1985 and Miyaoka 1985).

In his discussion of the lack of word-final stress in Central Alaskan Yupik, Miyaoka (1985:65-66) notes that in Nunivak, "a penultimate open syllable [is stressed] … if [iambic stress]

[25] Note that FTBIN is also violated by the optimal form here; as I show further below, this is because FTHARM also dominates FTBIN in Nunivak but not in the rest of Central Alaskan Yupik.

is due to fall on the word-final syllable." I call this PENULTIMATE STRESSING, which looks like PLS gone awry: a final degenerate foot is treated as if it is heavy. The examples Miyaoka gives are ones with final closed syllables in (54a-b); the description just quoted implies that examples with final light open syllables, such as the one in (54c), also have penultimate stressing.[26]

(54) Penultimate stressing (Nunivak)

a.	**VCVC#**		**(VG)(GVC)**	
	/ivʁuciq/	→	**[ívʁúc ciq]**	'waterproof boot'
b.	**VCVC#**		**(VG)(GVC)**	
	/maliɣutuq/	→	**[malí:ɣút tuq]**	'he goes along with'
c.	**VCV#**		**(VG)(GV)**	
	/aŋyaqa/	→	**[áŋyáq qa]**	'my boat'

Oddly, Miyaoka's description also implies that a penultimate *closed* syllable is *not* stressed if iambic stress is due to fall finally. Miyaoka cites no forms to (dis)confirm this. For reasons to be explained shortly, I assume that Miyaoka's description is partially incorrect, and that penultimate stressing applies to closed syllables, giving (55).

(55) Penultimate CVC stressing (Nunivak)

VCCVC#		**(VC)(CVC)**	
/maqikatgun/	→	**[maqí:kát gun]**	'with the future steambath material'

Since WEAKEDGE dominates MAX-μ and FTHARM in Nunivak, final lengthening is blocked and final long vowels are shortened. But FTHARM can also be satisfied by a final LL sequence by adding a mora to the penultimate light syllable and footing the syllables separately, giving (**H**) (L). The only additional ranking that must be made clear is that FTHARM dominates FTBIN (see fn. 25), because the final syllable is degenerately footed.

(56) Penultimate stressing (Nunivak):
WEAKEDGE » FTHARM » {FTBIN, ALL-FT-R}

Input: CVCVC#

Candidates	WEAKEDGE	FTHARM	FTBIN	ALL-FT-R
(CV.C**VC**)#	F, σ, μ!			
☞ (C**VC**)(C**V**C)#	F, σ		*	*
(CVC**V**C)#	F, σ	*!		

This is of course the wrong form for the rest of Central Alaskan Yupik; the third candidate should win. Therefore, the opposite ranking between FTBIN and FTHARM must hold in the rest of Central Alaskan Yupik to account for their lack of penultimate stressing. This is shown in (57).

[26] Jacobson (1985:38) seems to disagree with Miyaoka's description, since the Nunivak Jacobson describes has no penultimate stressing, only opaque PLS as in (52). A plausible analysis of Jacobson's Nunivak is a compensatory lengthening one (Hayes 1989): both WEAKEDGE and MAX-μ dominate WT-IDENT (see fn. 5), forcing the final underlying mora to be "flopped" over to the previous syllable; this analysis does not predict penultimate stressing as the analysis in the text does. (I thank Greg Lamontagne for discussion of this alternative analysis of opaque PLS.) Discussion of the details of this analysis would take us too far afield here.

(57) No penultimate stressing (Rest of Central Alaskan Yupik):
WEAKEDGE » FTBIN » FTHARM » ALL-FT-R

Input: CVCVC#

Candidates	WEAKEDGE	FTBIN	FTHARM	ALL-FT-R
(CV.C**VC**)#	F, σ, *μ*!			
(C**V**C)(C**V**C)#	F, σ	*!		*
☞ (CVC**V**C)#	F, σ		*	

Of course, this account of Nunivak may be on the wrong track if Miyaoka's description is completely correct; that is, if penultimate closed syllables (as opposed to open ones) are not stressed by the penultimate stressing phenomenon. Given that the account in §4 must somehow make geminates more marked than weight-bearing codas in Central Alaskan Yupik, there is no obvious way to explain the distinction made by Miyaoka's description. Recall that gemination to close an open syllable violates NOLONG and NOCODA-*μ*, and adding weight to a syllable-closing consonant violates only NOCODA-*μ*. Penultimate stressing of penultimate closed syllables, as in (55), is thus predicted to occur by a kind of harmonic bounding proof (Prince & Smolensky 1993): *all else being equal*, if an output of some input violating two constraints C_1 and C_2 is optimal, then an output of another input violating just constraint C_1 must also be optimal.

Whether the description is right or wrong or whether the account above is on the right track or not, there is a perhaps related fact of Central Alaskan Yupik that is not treated in this paper. In all of Central Alaskan Yupik, initial closed syllables count as heavy, and depending on the dialect, noninitial closed syllables sometimes become heavy for reasons that aren't entirely clear (see fn. 20 and Hayes 1995, §6.3.8.3–6.3.8.6). The correct account of these facts may shed light on the issues raised here. I leave this as a matter for future research.

5.3 Word-final, phrase-internal footing and stress

As explained at the outset of this section, the lack of final stress due to the intonational system is restricted to intonational phrase-final position. Word-finally but phrase-internally, stress surfaces. In (58) are some examples of word-final but phrase-internal iambic stresses.

(58) Word-final, phrase-internal stress

a. **V V#V** → **(V V)(V**
/qayaliciquci#amani/ → [qayá:licí:qucí# amá:ni]
'you will be making a kayak over there'

b. **V VC#C** → **(V VC)(C**
/qayat#takpiaχtut/ → [qayát# tákpiáχtut]
'the kayaks are very long'

The form in (58a) has a vowel hiatus around the phrase-internal word boundary. This example was used earlier (in (43a)) to show that stress surfaces in word-final, phrase-internal position, but that IL still does not apply there. The form in (58b), where two consonants straddle the word boundary, receives the same analysis, though it is not obvious in this case that the final consonant of the first word does not receive a mora (see fn. 10). Now consider the forms in (59).

(59) Final IL gemination

a. **V V#C** **(V VG)(G**
/kina#tanem/ → **[kinát# tanem]** 'who ever?'

b. **V VC#V** **(V VG)(G**
/nunat#ukut/ → **[nunát# tukut]** 'this village'

In these forms, where there is a vowel and a consonant straddling the word boundary (in either order), the consonant of whichever word it belongs to is geminated, making the final syllable of the first word heavy. The fact that this final syllable is the second syllable of an iamb indicates that this gemination is in response to FTHARM, and thus an instance of IL gemination.

These facts are due to the already-established interaction between WEAKEDGE and FTHARM. Because the final syllables of the first words in these examples are all footed as the strong syllables of disyllabic iambs, as I have been assuming throughout this paper, then they are subject to FTHARM, which has a unique chance to strut its stuff in this position because there is a following word in the intonational phrase. However, WEAKEDGE curbs FTHARM's desires because WEAKEDGE dominates FTHARM.

For instance, in the case of (58a,b), there is no other option but to leave the final syllable of the first word light. WEAKEDGE will not tolerate final vowel lengthening nor final consonant weight, and the resulting FTHARM violation must be tolerated, as shown in (60a,b).

(60) Finality effects, no IL: WEAKEDGE » FTHARM » DEP-*μ*

a. Input: CVCV#V…

Candidates	WEAKEDGE	FTHARM	DEP-*μ*
☞ (CV.C**V**)#(V…	F, σ, *μ*	*	
(CV.C**V:**)#(V…	F, σ, *μ*, *μ*!		*

b. Input: CVCVC#C…

Candidates	WEAKEDGE	FTHARM	DEP-*μ*
☞ (CV.C**V**C)#(C…	F, σ	*	
(CV.C**VC**)#(C…	F, σ, *μ*!		*

However, a final geminate is the optimal candidate under the same ranking with (59a,b), as shown in (61a,b). WEAKEDGE is violated equally by both of the relevant candidates; the choice is between a form ending in a footed moraic vowel and one ending in a footed moraic consonant, so the decision falls to FTHARM.[27]

[27] Here we find evidence for my assumption that WEAKEDGE must not be able to distinguish vowels and consonants, and thus that final segments simply don't necessarily count in the calculation of WEAKEDGE violations.

(61) Finality effects, IL gemination: WEAKEDGE » FTHARM » DEP-*μ*

a. Input: CVCV#C…

Candidates	WEAKEDGE	FTHARM	DEP-*μ*
(CV.C**V**)#(C…	F, σ, *μ*	*!	
☞ (CV.C**VG**)#(G…	F, σ, *μ*		*

b. Input: CVCVC#V…

Candidates	WEAKEDGE	FTHARM	DEP-*μ*
(CV.C**V**)#(C…	F, σ, *μ*	*!	
☞ (CV.C**VG**)#(G…	F, σ, *μ*		*

The forms in (62) and (63) below are parallel to those in (58) and (59) except in one respect: the final syllable of the first word is footed alone, so its lengthening by gemination in (63) must be due not to FTHARM, as in (59), but to FTBIN, which must also dominate DEP-*μ*.

(62) Word-final, phrase-internal noniambic stress

a. **V#V** **(V)(V**
/aŋyaliciquci#amani/ → **[áŋyalí:ciqú:cí# amá:ni]**
'you will be making a boat over there'

b. **VC#C** **(VC)(C**
/qayamun#tekituq/ → **[qayá:mún# tekí:tuq]**
'he came to the kayak'

(63) Final noniambic gemination

a. **V#C** **(VG)(G** 'that (extended)
/nunaka#tamana/ → **[nuná:kát# tamá:na]** land of mine'

b. **VC#V** **(VG)(G**
/nunanun#ukunun/ → **[nuná:nún# nukú:nun]** 'this village'

The fact that there is *no* lengthening of any kind in (62), just as in (58), must constitute violation of FTBIN, due to WEAKEDGE. WEAKEDGE must thus dominate FTBIN, which is sacrificed by final degenerate feet. The same finality effects observed in (60) and (61) follow, as shown in (64) and (65).

(64) Finality effects, no bulking: WEAKEDGE » FTBIN » DEP-*μ*

a. Input: CV#V…

Candidates	WEAKEDGE	FTBIN	DEP-*μ*
☞ (C**V**)#(V…	F, σ, *μ*	*	
(C**V:**)#(V…	F, σ, *μ*, *μ*!		*

b. Input: CVC#C…

	Candidates	WEAKEDGE	FTBIN	DEP-*μ*
☞	(C**V**C)#(C…	F, σ	*	
	(C**VC**)#(C…	F, σ, *μ*!		*

(65) Finality effects, bulking by gemination: WEAKEDGE » FTBIN » DEP-*μ*

a. Input: CV#C…

	Candidates	WEAKEDGE	FTBIN	DEP-*μ*
	(CV)#(C…	F, σ, *μ*	*!	
☞	(CVG)#(G…	F, σ, *μ*		*

b. Input: CVC#V…

	Candidates	WEAKEDGE	FTBIN	DEP-*μ*
	(C**V**)#(CV…	F, σ, *μ*	*!	
☞	(C**VG**)#(GV…	F, σ, *μ*		*

What we have here is a specific instance of the general pattern dubbed The Emergence of The Unmarked (TETU) by McCarthy & Prince (1994). Throughout this section we saw how WEAKEDGE severely limits the force of FTBIN and FTHARM at the right edge of the Prosodic Word. However, WEAKEDGE doesn't have the final word in all situations. As we saw in this subsection, there is one context where WEAKEDGE cannot distinguish between a FTBIN- or FTHARM-satisfying candidate and a FTBIN- or FTHARM-violating one; to wit, when there is a single consonant at a phrase-internal Prosodic Word boundary. WEAKEDGE thus defaults the decision to FTBIN or FTHARM, and the candidates that these constraints prefer emerge as optimal.

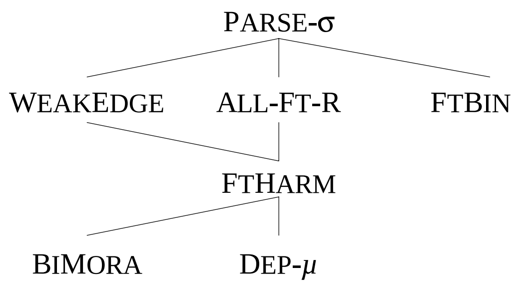
The analysis of word-final effects in this section has relied heavily on the analysis of footing provided in §1, whereby final syllables are always footed, even if they must be footed degenerately. Even though FTBIN dominates DEP-*μ*, lengthening is not tolerated Prosodic Word-finally, due to the dominance of WEAKEDGE. This result is unfortunately not easily reconciled with the apparent minimal word requirement of Yupik (see fn. 3): it seems that the only way to link it to the independently-motivated constraint FTBIN (McCarthy & Prince 1986, 1993ab, 1994 *inter alia*) is to deny the existence of degenerate feet in Yupik (as Hayes 1995 does), for which we have seen there is ample evidence. A review of the evidence for the minimal word requirement in Yupik seems to be in order, which I leave to future research.

6 Summary

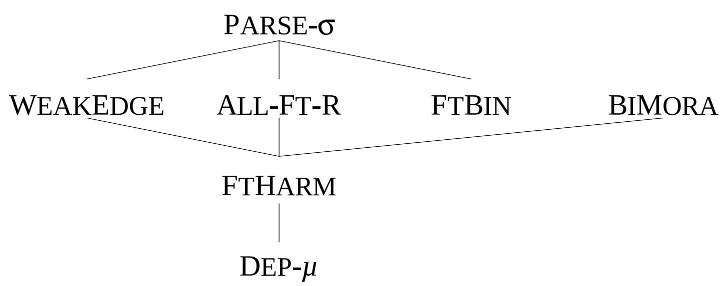
Ignoring the WSP and the IAMB and TROCHEE constraints, the partial rankings in (66) (for Central Siberian Yupik) and (67) (for Central Alaskan Yupik) represent the ranking arguments made in this paper for the different Yupik dialects discussed. I refer the reader to the various tableaux throughout the paper for confirmation; the important differences are summarized here.

(66) Partial rankings: Central Siberian Yupik

a. St. Lawrence Island



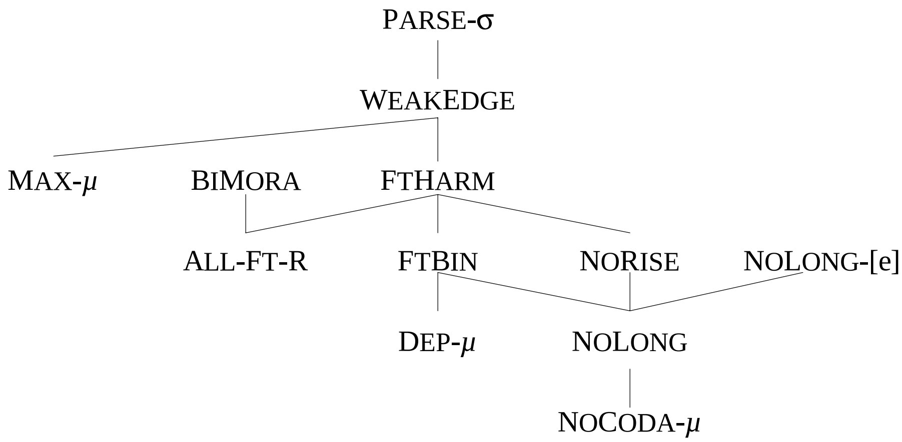
b. Chaplinski



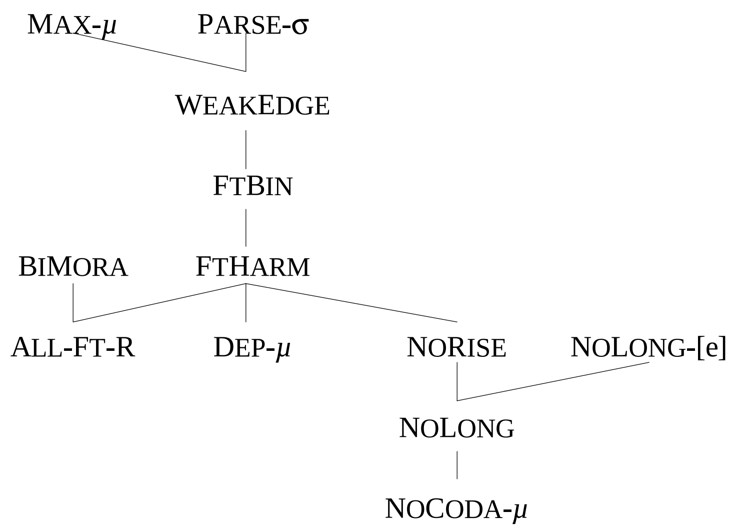
The only difference between St. Lawrence Island, which has overlengthening, and Chaplinski, which has nonlengthening, is in the ranking between BIMORA and FTHARM. FTHARM dominates BIMORA in St. Lawrence Island, so the two-mora limit on syllable size demanded by the latter constraint is sacrificed to satisfy the former. Otherwise, FTHARM is sacrificed in Prosodic Word-final position in both dialects because of dominant WEAKEDGE; final PLS is not tolerated to circumvent this result because ALL-FT-R also dominates FTHARM in both dialects.

(67) Partial rankings: Central Alaskan Yupik

a. Nunivak



d. Rest of Central Alaskan Yupik



Central Alaskan Yupik generally differs from Central Siberian Yupik in that it has PLS, which means that FTHARM and BIMORA dominate ALL-FT-R. The difference between IL and PLS in the segmental realization of the added mora is due to the rank of NORISE above NOLONG and NOCODA-μ: the PLS context potentially introduces another rising tone, forcing more marked consonant gemination, while the IL context does not, allowing less marked vowel lengthening. Within Central Alaskan Yupik, Nunivak differs from the rest of the dialects in that it has final shortening and penultimate stressing. These differences are due to the different rankings between MAX-μ and WEAKEDGE on the one hand and FTBIN and FTHARM on the other.

In §8 I discuss the advantages of the present constraint-based approach to the quantitative adjustments of Yupik over a particular rule-based approach; namely, that found in Hayes 1995, §6.3.8. Before turning to that, §7 investigates another quantitative adjustment, trochaic shortening, in Boumaa Fijian. The constraint directly responsible for this process is FTHARM, just as it is for iambic lengthening, but this time due to its rank above MAX-μ. The advantages of this approach over that in Hayes 1995, §6.1.5, is also discussed in §8.

7 Trochaic shortening in Boumaa Fijian

Grouping Harmony in (3) is formulated to define a Harmonic scale of disyllabic foot types, regardless of prominence. In conjunction with the WSP, the scale distinguishes between trochaic and iambic prominence, as shown in (68) (partially repeated from (4)).

(68) Grouping Harmony + WSP scales

a. *Trochaic:* (**L** S) > (**L** H) > (**L** L) > (**H** L)

b. *Iambic:* (L **S**) > (L **H**) > (L **L**) > (H **L**)

Just as WSP-bound FTHARM encourages iambic feet up the scale from (L **L**) to (L **H**) and from (L **H**) to (L **S**), so it encourages trochaic feet up the scale from (**H** L) to (**L** L). This phenomenon, called TROCHAIC SHORTENING, is attested in a number of languages, including English (Trisyllabic Shortening; see Stampe 1979, Borowsky 1986, Myers 1987, Prince 1990) and Boumaa Fijian (Dixon 1988, Hayes 1995). I focus here on the latter case, adapting Hayes' account which in turn follows Prince's analysis of the English case.

7.1 Boumaa Fijian stress

Boumaa Fijian syllables are CV (light) or CVV (heavy); there are no closed syllables (nasal-nonnasal representational sequences are actually prenasalized onset consonants). Main stress falls on the penult if the final syllable is light and on the final syllable if it is heavy. The following examples illustrate the pattern (from Hayes 1995:142, (43)).

(69) Boumaa Fijian stress

a.	L L		(L L)	
	/lako/	→	[láko]	'go'
b.	L L L		L(L L)	
	/βinaka/	→	[βináka]	'good'
c.	L H		L(H)	
	/kila:/	→	[kilá:]	'know'

As analyzed in these examples, the main stress foot is a quantity-sensitive trochee at the right edge of the word. (I ignore secondary stress here due to its complications in this language; see Hayes 1995:144.) This is due to high-ranking TROCHEE and ALIGN-R(PrWd,Ft´), a constraint demanding right-alignment of the Prosodic Word with the head foot.

The initial syllables in (69b,c) are analyzed as unparsed. Degenerate feet are not allowed because FTBIN dominates PARSE-σ, and light syllables are not footed and bulked because DEP-*μ* also dominates PARSE-σ. This is shown in (70) for (69b); I return to the slightly more involved analysis of (69c) in §§7.3–7.4.

(70) Unparsing: {FTBIN, DEP-μ} » PARSE-σ

Input: LLL

Candidates	FTBIN	DEP-μ	PARSE-σ
(**L**)(**L**L)	*!		
(**H**)(**L**L)		*!	
☞ L(**L**L)			*

7.2 Trochaic shortening

The above are all cases where an LL or H input sequence ends a word. When an HL input sequence ends a word, as in the following examples (from Hayes 1995:145, (50)), the heavy syllable is shortened and the two syllables are footed together as an (**L** L) foot.

(71) Trochaic shortening (TS)

a. **H L** → **(L L)** — cf. **(H)**
/mbu:-ŋgu/ → **[mbúŋgu]** 'my grandmother' *cf.* **[mbú:]**

b. **H L** → **(L L)** — cf. **(H)**
/ta:-y-a/ → **[taya]** 'chop-TRANS-3 SG. OBJ.' *cf.* **[tá:]**

c. **H L** → **(L L)** — cf. **(H)**
/nre:-ta/ → **[nréta]** 'pull-TRANS' *cf.* **[nré:]**

d. **H L** → **(L L)** — cf. **(H)(L L)**
/si:bi/ → **[síbi]** 'exceed' *cf.* **[sì:bíta]**

From the examples in (71a,b,c), one might conclude that the input sequence is actually LL, and that *lengthening* occurs in the nonsuffixed forms on the right to satisfy a minimal word requirement (which is quite obviously active in the language; see Dixon 1988:25 and Hayes 1995:144).[28] Example (71d) drives home the point that there is shortening. In this case, it is the unsuffixed form that is shortened due to its disyllabicity, and the suffixed form on the right exposes the stem's underlying weight. A lengthening analysis of this form is of course not tenable, given the argument made in tableau (70).

Before considering the role of FTHARM in the analysis of TS, it is worth asking what it is that forces the final syllables in the forms in (71) to be footed in the first place. After all, as we know well from Yupik, footing a final HL sequence as (**H**) L would satisfy FTHARM vacuously. Following Prince 1990 and Hayes 1995, I assume that the driving force is PARSE-σ, compelling final HL sequences to be footed together. FTHARM is ranked above MAX-μ in Boumaa Fijian, and thus it forces trochaically footed HL sequences to be shortened to (**L** L). Since the whole problem arises because PARSE-σ demands footing of the final syllable, PARSE-σ must also outrank MAX-μ. This is shown in (72).

[28] The analysis of such a minimal word requirement would involve a high-ranking LX=PR (Prince & Smolensky 1993, McCarthy & Prince 1993ab *inter alia*) and domination of DEP-μ by FTBIN.

(72) Trochaic shortening (TS): {PARSE-σ, FTHARM} » MAX-*μ*

Input: HL

Candidates	PARSE-σ	FTHARM	MAX-*μ*
(**H**)L	*!		
(**H**L)		*!	
☞ (**L**L)			*

Of course, all three constraints could be satisfied if the two syllables were footed separately. Again, given the argument made in tableau (70), such a candidate would either violate FTBIN (if the final syllable isn't bulked) or DEP-*μ* (if it is). Since both of these constraints outrank PARSE-σ, such a candidate is completely out of the running.

7.3 Preventing iambic shortening

If it is indeed PARSE-σ that is partially responsible for TS by dominating MAX-*μ*, then there is another candidate output for LH input sequences, like (69c), that needs to be contended with: an IAMBIC SHORTENING candidate, (**L** L), as opposed to the optimal candidate, L (**H**). Iambic shortening is Allen's (1973) term for the process in Pre-Classical Latin by which LH is footed as (**L** L) (as opposed to the Classical Latin L (**H**) footing), parallel to the case we have here. Iambic shortening is also known as *Brevis Brevians*; see Allen 1973, Prince 1990, Prince & Smolensky 1993, Mester 1994, and Hayes 1995. I use this term to refer to the Latin case as opposed to the general process of iambic shortening (IS, which also occurs in English under the guise of the "Arab" rule; see Ross 1972, Prince 1990, Hayes 1995).

In Prince & Smolensky's (1993, §4; henceforth P&S) analysis of *Brevis Brevians*, PARSE-σ dominates MAX-*μ*. Since PARSE-σ also dominates MAX-*μ* in Boumaa Fijian, some other constraint must independently rule out the IS candidate in this language. I propose that this constraint is FTHARM, which is violated by such a candidate, because (**L** L) is a step down in the Harmony scale from the input LH. FTHARM must dominate PARSE-σ so that the correct candidate wins.[29]

(73) No iambic shortening (IS): FTHARM » PARSE-σ » MAX-*μ*

Input: LH

Candidates	FTHARM	PARSE-σ	MAX-*μ*
(**L**L)	*!		*
☞ L(**H**)		*	

This analysis raises an important issue in P&S's unified analysis of *Brevis Brevians* and another Pre-Classical Latin process, cretic shortening, by which HLH input sequences are footed (**H**) (L L) — there is no stress/accent on the final disyllabic sequence, but its shortening implies its footing. As P&S note (p. 61), a serious competitor to the cretic shortening candidate is a TS

29 The analysis of *Brevis Brevians* would not involve just a simple demotion of FTHARM. P&S's account correctly holds the WSP and Latin's characteristic nonfinality of stress primarily responsible for the process. P&S do use a constraint specifically penalizing (H L) feet, however, dubbed RHHRM. They note that RHHRM is a simplification of some constraint "which favors length at the end of constituents." I do not pursue the question whether FTHARM can be somehow substituted for RHHRM, since it is unclear at this point whether it sheds any light on this case.

candidate, (**L** L) (H). Neither PARSE-σ nor MAX-*μ* can distinguish between these two candidates, so some other constraint must be responsible for the choice. It cannot be FTHARM, because FTHARM prefers the trochaic shortening candidate — (**L** L) from HL is good, (**L** L) from LH is bad. P&S attribute the choice to Peak-Prominence (PK-PROM), a constraint favoring stress on a heavy syllable to stress on a light syllable. Another possible analysis (due to Alan Prince, p.c.) involves a constraint disallowing shortening of stressed syllables as opposed to unstressed ones, which basically distinguishes between iambic vs. trochaic shortening.[30]

7.4 Preventing rhythmic reversal

The above ranking (FTHARM over PARSE-σ) has an additional advantage. It also rules out another possible analysis of the LH input, the truly iambic, (L **H**) candidate, which is prominence-wise identical to the one deemed optimal in (73). This would be a case of *rhythmic reversal* in a trochaic language (see Prince & Smolensky 1993:54-55 and Hung 1993, 1994 for such cases in iambic languages). FTHARM also rules such a candidate out because its Harmony is not increased from the input LH. If BIMORA also dominates PARSE-σ to prevent overlengthening, the correct candidate is predicted to win.

(74) No rhythmic reversal: {FTHARM, BIMORA} » PARSE-σ

Input: LH

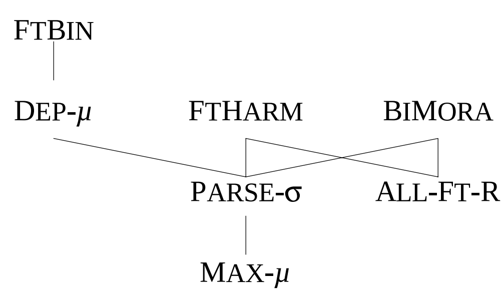
Candidates	FTHARM	BIMORA	PARSE-σ
(L**H**)	*!		
(L**S**)		*!	
☞ L(**H**)			*

Of course, the two rhythmic reversal candidates also violate TROCHEE, but since this is a violable constraint whose exact position in the constraint hierarchy of Boumaa Fijian has not yet been established, these candidates are serious contenders.

7.5 Summary

The following partial ranking for Boumaa Fijian has been established in this section. What has been primarily shown is that FTHARM is responsible for TS by dominating MAX-*μ* in a trochaic language, just as it is responsible for IL by dominating DEP-*μ* in an iambic language.

(75) Partial ranking established for Boumaa Fijian



[30] This distinction between stressed ("perceptually prominent") and unstressed syllables makes perfect sense in the positional faithfulness theory of Beckman (in preparation).

8 Conclusion

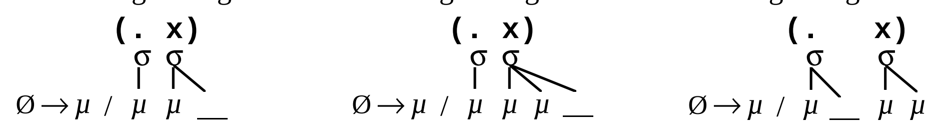
I conclude here with a comparison of the accounts of Yupik and Boumaa Fijian above with those found in Hayes 1995, §6.3.8 and §6.1.5, respectively. The latter, rule-based approach is based on the view that "phonological rules may take on relatively ad hoc forms but are valued within the grammar according to whether they create well-formed structures" (Hayes 1995:147). This statement is made in defense of the proposed rule of TS in Boumaa Fijian, but applies to all rules like IL, OL, PLS and TS whose "goal" is to satisfy some principle but whose formulation does not necessarily encode that goal.

8.1 Yupik

The proposed rule of IL in Yupik (Hayes 1995:242, (228d)) is formalized to add a mora to an iamb (i.e., to adjust quantity), but its "goal" is to observe the Iambic/Trochaic Law by creating a canonical (L **H**) iamb. However, as noted in the introduction, the Iambic/Trochaic Law fails to make sense of OL (Hayes 1995:242, (228c)) and PLS (Hayes 1995:245, (235)), so their "goal" must be some other principle. That principle, which is not stated explicitly but is alluded to often, is one of vowel-length contrast maintenance: OL and PLS, each in their own ad hoc way, serve to distinguish underlying long vowels from vowels made long by IL.

(76) Yupik quantitative adjustments (modified slightly from Hayes 1995)

Rule:	Iambic lengthening	Overlengthening	Pre-long strengthening



Principle:	Iambic/Trochaic Law	Contrast Maintenance	Contrast Maintenance

Since the principle behind OL and PLS is distinct from the principle behind IL, we expect to find, for instance, a rule that overlengthens underlying long vowels in some context to keep them distinct from lengthened short vowels in the same context. For instance, if a minimal word requirement causes /**ba**/ to be realized as [**ba:**], then /**ba:**/ should be realized as [**ba::**]. Such cases are unattested, as far as I am aware.

In the present account, the constraint FTHARM demands an increase in the Harmony of all disyllabic feet, and interacts with other constraints to drive IL (by dominating DEP-*μ*), OL (by dominating BIMORA together with ALL-FT-R), and PLS (by dominating ALL-FT-R together with BIMORA). The fact that OL and PLS apply only in languages with IL follows: to get a language without IL, DEP-*μ* must dominate FTHARM. But if this ranking holds, the candidates representing OL and PLS could never be optimal: each violates DEP-*μ*, directly or indirectly motivated by the need to satisfy FTHARM. This is exactly the right result: rather than being functionally desirable in languages with IL, the rankings necessary for OL and PLS are parasitic on the ranking responsible for IL. Since FTHARM is not relevant to monosyllabic feet, the hypothetical overlengthening rule to avoid vowel-length neutralization in minimal word contexts is not predicted to exist. Word minimality effects are driven by FTBIN, which demands binarity and not 'increase' as FTHARM does. The nonexistence of this hypothetical situation thus follows.

The crucial use of persistent footing in Hayes' analysis of Central Alaskan Yupik is also problematic (see fn. 13 for an additional complication). Without persistent footing, PLS would have to be a rule that simultaneously stresses and adds a mora to the weak branch of an (L **H**) iamb. Hayes views the power of such a rule as problematic. With persistent footing, PLS just adds the mora, creating the intermediate representation (H **H**). Persistent footing, which is quantity sensitive, repairs the representation, with the desired result of two monosyllabic (**H**) (**H**) feet. This makes the relationship between PLS and persistent footing very intimate: if footing were not persistent, we'd expect (H **H**) feet to surface by PLS. Note that we cannot safely invoke the vowel-length contrast maintenance principle here; the mora added by PLS can geminate the following onset, lengthen the preceding vowel, add weight to a previously weightless coda consonant — all of these segmental phenomena should be enough to serve the principle, without the need for additional stressing of the new heavy syllable by persistent footing.

This problem does not arise in the present account. The problematic (H **H**) representation that must be repaired by persistent footing could not be a possible way to satisfy FTHARM (aside from the fact that it violates the undominated WSP). The Harmony of such a foot is the same as it is for (L **L**), a step *downwards* in the Grouping Harmony scale from the input LH. Furthermore, since PLS is not a rule but rather the result of garden-variety constraint interaction, there is no sense in which it is too powerful. Persistent footing (stressing) follows from dominant PARSE-σ and from FTHARM and BIMORA dominating ALL-FT-R; the addition of the mora follows from FTHARM and FTBIN dominating DEP-μ (see fn. 8).

Finally, in Hayes' account, not only are the rules intended to serve their particular goals, but so is their order in the grammar: OL and PLS must precede IL, or else OL and PLS would serve to *neutralize* all iambically stressed vowels, making them all overlong or pre-strengthened. The bottom line is that the rules in (76) and their necessary ordering have only the vaguest sort of functional connection to the principles that supposedly motivate them. The principles themselves are also vague, and allow for many different types of rules to satisfy them. Take the vowel-length contrast maintenance principle that supposedly motives OL and PLS. Any rule (e.g., long vowel tensing) would do to maintain a vowel-length contrast, but the rules used in Yupik (OL and PLS) are quantitative adjustments, just like the rule that motivates their existence in the first place, IL.

One might argue that the fact that the rules are quantitative adjustments and that the order of the rules is what it is serves to satisfy another principle: extrinsic order avoidance. At least in the case of OL and IL, the rules can be formulated in such a way that the Elsewhere Condition (Kiparsky 1973, 1982) guarantees the correct intrinsic ordering, and thus all three principles (the Iambic/Trochaic Law, Contrast Maintenance, and Extrinsic Order Avoidance) can be maximally satisfied. This just underscores the point, however: there is no formalization of the connection between a grammar (the rules and their ordering) and the principles that place "value" on the organization of that grammar, and any serious attempt at such a formalization must fall back on some homunculus-type device, like Extrinsic Order Avoidance, just to adequately describe the actual situations that hold in language and to separate them from those that don't.

The limits of constraint interaction in the present account, on the other hand, impose a limit on the ways in which the distinction between underlying long vowels and iambically lengthened vowels can be maintained, since IL, OL, and PLS are all quantitative adjustments driven in some way by the same constraint (FTHARM). I conclude that the observation that OL and PLS seem to serve to maintain vowel-length contrast is an epiphenomenon under the present account, just as it actually is in Hayes' account: one might want to invoke such extragrammatical principles to describe how certain components of grammatical systems arise, but they fail to explain the scope and limits of the grammatical systems themselves.

8.2 Boumaa Fijian

The proposed rule of TS in Boumaa Fijian (Hayes 1995:146, (53)) suffers from different but related problems. As Hayes notes, "[TS, (77)] permits the sequence [(**H**) L] (foot plus stray) to be converted into [(**L** L)], a canonical moraic trochee."

(77) Boumaa Fijian TS (modified from Hayes 1995)

$$\underset{\mu\ \mu}{\sigma} \rightarrow \underset{\mu}{\sigma} \ / \ \_\_\ \sigma_i \quad \text{where } \sigma_i \text{ is metrically stray}$$

The motivation behind the rule is a combination of the Iambic/Trochaic Law (p. 148) and "a general pressure for syllables to be parsed into feet", or a principle of syllable footing (pp. 146, 147). Like the PLS rule in Central Alaskan Yupik, however, it is crucially dependent on persistent footing, since "the rule itself just alters quantity". This is apparently above and beyond the principle of syllable footing, a serious problem of duplication. As the constraint interaction account in §8 makes clear, the constraints behind the rule (the rule being mora deletion, or a violation of MAX-μ) are simply FTHARM and PARSE-σ, the latter of which resolves the duplication problem inherent in Hayes' account.

In light of these comments, the avoidance of the iambic shortening (IS) candidate for LH inputs, as was demonstrated in (73) under the present account, is a serious problem for the principles underlying TS in Hayes' account. The rule in (77) specifies a stray syllable to the right of the heavy syllable to be shortened, but the principle of syllable footing certainly does not demand such arbitrariness of specificity, and IS is expected to be just as valued a rule as TS within the same grammar. The constraint ranking solution in (73) makes perfect sense of the presence vs. absense of IS in a language with TS: FTHARM and PARSE-σ interact differently with MAX-μ when they dominate it, depending on their ranking with respect to each other. FTHARM is satisfied by TS and violated by IS, but PARSE-σ demands both. FTHARM ranked above PARSE-σ will forbid IS and allow TS, and PARSE-σ ranked above FTHARM allows both. As has been argued by Prince & Smolensky (1993, §4), ruling out TS in a language with IS (e.g., Pre-Classical Latin) involves interaction with other constraints sensitive to prominence; specifically, the prominence of the would-be shortened syllable in TS.

8.3 Concluding remarks

A unified account of the quantitative adjustments examined in this paper is possible within Optimality Theory and not within a rule-based theory (though see Bobaljik 1991, which is beset with its own problems). The rule-based account in Hayes 1995 is quite clearly the best that can be done within such a limited theory, and I hope to have shown in this section that the present OT account is superior. However, it should be clear that the two accounts share enough in common to be comparable, because the true differences lie in the choice of theoretical frameworks.

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