AN OPTIMALITY-THEORETIC APPROACH TO TERNARY STRESS SYSTEMS*

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0. Introduction

The main purpose of this paper is to present an analysis of ternary stress systems within the framework of Optimality Theory proposed by Prince and Smolensky (1993) (hereafter P&S (1993)) and further developed by McCarthy and Prince (1993a; 1993b) (hereafter M&P (1993a; 1993b), respectively). It is shown that ternary alternation, which has resisted any principled account under the rule-based theory, is a natural consequence of satisfying constraints on prosody/prosody alignment and parsing. I will argue that the analysis has advantages over Kager's (1994a; 1994b) and Green and Kenstowicz's (1995) analyses in that it does not make use of the foot repulsion constraint, which is only needed for ternary alternation and thus not independently motivated. I will also argue that the analysis provides evidence in support of Generalized Alignment (GA) proposed in M&P (1993b), demonstrating that like other stress systems, ternary alternation is also subsumed under GA. Since GA is embedded under a constraint-based theory, it also lends support in favor of Optimality Theory.

The organization of this paper is as follows. Section 1 investigates the typology of ternary stress systems and presents an overview of the analysis. Section 2 deals with ternary alternation languages parsed under persistent footing. Using the Chugach dialect of Pacific Yupik as an example, I will argue that ternary alternation with persistent footing straightforwardly follows from Align-Prwd-L/R, *Lapse >> All-Ft-R/L >> Parse-σ, where Align-Prwd and All-Ft have opposite edge specifications. Section 3 is concerned with ternary alternation languages parsed under non-persistent footing. I will discuss Cayuvava as an example and argue that "weak local parsing" in this language also follows from Align-Prwd-L/R, *Lapse >> All-Ft-R/L >> Parse-σ. Unlike in languages with persistent footing, however, a double upbeat may occur at either edge of a Prwd in those with non-persistent footing like Cayuvava. It is shown that existence of a double upbeat follows from the fact that extrasyllabic segments are allowed to occur at either edge of a Prwd due to the lower-ranked status of Align-Prwd-σ and Parse-segment. Section 4 considers the difference in constraint rankings between languages with persistent footing and those with non-persistent footing. I will argue that it is the demotion of Align-Prwd-σ in constraint rankings that derives non-persistent footing. Section 5 summarizes this paper.

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1. Typology of Ternary Stress Systems

This section investigates the typology of ternary stress systems. It is shown that languages with ternary systems can be classified based on the directionality of footing and persistent/non-persistent footing. I will then present an overview of the analysis of each type of ternary stress systems.

1.1 Directionality of "Weak Local Parsing"

Languages with ternary alternation can be classified into two types, depending on the directionality of footing. L-R ternary alternation is observed in the Chugach dialect of Pacific Yupik, Estonian, Winnebago, Mantjiltjara, and Bani-Hassan Arabic while R-L ternary alternation is observed in Cayuvava, Sentani, and Auca.

Essentially following Hammond (1990) and Hayes (1995), I assume that languages with ternary alternation are parsed under what Hayes (1995) calls "weak local parsing." Under "weak local parsing," feet, being binary, are allowed to be constructed non-adjacently, but may only be separated from each other by the smallest definable prosodic unit, *i.e.* a mora. I argue that the following four constraints are crucial in deriving "weak local parsing":

(1) Align-Prwd-L/R
Align (Prwd, L/R, Ft, L/R) (cf. M&P (1993b))

(2) All-Ft-L/R
Align (Ft, L/R, Prwd, L/R) (cf. M&P (1993b))

(3) Anti-Lapse (*Lapse)
One of the two adjacent stress units must be parsed by a foot.

(4) Parse-σ
All syllables must be parsed by feet.
(cf. P&S 1993, M&P 1993a, M&P 1993b)

Align-Prwd-L/R requires that the left/right edge of each Prwd should coincide with the left/right edge of some foot. All-Ft-L/R requires, on the other hand, that the left/right edge of every foot should coincide with the left/right edge of a Prwd. Violations of these two constraints are gradient and degree of violation is measured by the number of prosodic elements intervening between the edge of a Prwd and the edge of a foot. Align-Prwd-L/R and All-Ft-R/L belong to a family of prosody/prosody alignment constraints. *Lapse, which is proposed in Kager (1994a; 1994b), prohibits adjacent stress units from being left unfooted. Given that degenerate feet are prohibited, *Lapse

I argue that Align-Prwd-σ plays a crucial role in deriving these two types of footing. While Align-Prwd-σ is highly ranked in persistent footing languages, it is low ranked in non-persistent languages.

In the following sections, I will consider in detail how the analysis works, looking at concrete examples. As space is limited, I will only look at Chugach, an L-R ternary alternation language with persistent footing, and Cayuvava, a R-L ternary alternation language with non-persistent footing. The analysis, however, can easily be extended to the other languages with ternary alternation.

2. Chugach

2.1 Stress Patterns in Chugach

Stress patterns in the Chugach dialect of Pacific Yupik are extensively described in Leer (1985a; 1985b) and have been analyzed in work by, among others, Halle (1990), Hammond (1990), Hayes (1995), Hewitt (1992), Kager (1993; 1994a; 1994b), and Rice (1988).

Due to space constraint, I will concentrate on words containing only light syllables. As observed in (6), the second syllable is always stressed, and in words of sufficient length, every third syllable thereafter is also stressed. Where the ternary count would leave a sequence of two stressless syllables at the end of a word as in (6)(b) and (e), the word-final syllable is stressed. Stressed non-final open syllables undergo vowel-lengthening, as represented in the phonetic forms of (6).[2] In (6), I present examples with their foot structures:[3]

(6) a. (σ σ́) σ — atáka [atá:ka] 'my father'
b. (σ σ́) (σ σ́) — akútamék [akú:tamék] 'food'
c. (σ σ́) σ (σ σ́) — atúqunikí [atú:qunikí] 'if he (refl.) uses them'
d. (σ σ́) σ (σ σ́) σ — pisúqutaqúni [pisú:qutaqú:ni] 'if he (refl.) is going to hunt'
e. (σ σ́) σ (σ σ́) (σ σ́) — maŋáRsuqutáquní [maŋáRsuqutá:quní] 'if he (refl.) is going to hunt porpoise'

[2]In the text, an underlying long vowel and a derived long vowel are represented as VV and V:, respectively.

[3]In this paper, the following orthography is used:
'e' = schwa
'R' = voiced uvular fricative

2.2 Foot Headedness and Foot Binarity

It is clear from (6) that Chugach is an iambic language. Following M&P (1993b), I assume that the headedness of feet can be expressed in terms of GA. Iambicity is defined as follows:

(7) FtForm (Iambic) (Undominated)
Align (Ft, R, H(Ft), R),
where H(Ft) is the head of a foot, *i.e.* the strongest syllable-daughter of a foot.

FtForm (Iambic) requires that the right edge of every foot should match the right edge of some stressed syllable. I argue that FtForm (Iambic) is undominated in this language, which ensures that feet in Chugach are always right-headed.

As pointed out by Hewitt (1994), foot construction in Yupik languages is based on underlying syllable weight, but not on surface syllable weight. This also holds in the Chugach dialect. We observe from (6) that underlying short vowels in open stressed syllables are phonetically lengthened. As far as foot construction is concerned, however, surface syllable weight is irrelevant. In foot construction, syllables with an underlying long vowel always count as heavy, and those with an underlying short vowel as light. In other words, only underlying moras, but not non-underlying moras, are visible to foot construction algorithm. Following Hewitt (1994), I assume that FtBin applies at the level of underlying moras in Chugach:

(8) FtBin-μ (Undominated)
Feet are strictly binary at the level of underlying moras.
(cf. M&P (1993b), P&S (1993))

FtBin-μ (8) requires that a foot should dominate exactly two underlying moras. I assume that FtBin-μ is also an undominated constraint in this language. This ensures that feet are always underlyingly bimoraic.

In the following tableaux, I will assume for expository purposes that Gen does not submit structures which violate either of these two undominated constraints.

2.3 "Weak Local Parsing"

As clear from the foot structures in (6), Chugach employs L-R "weak local parsing." As mentioned above, L-R "weak local parsing" follows from Align-Prwd-L, *Lapse >> All-Ft-R >> Parse-σ. Let us look at in detail how these rankings are motivated.

Align-Prwd-L and All-Ft-R are in conflict with each other with respect to the position of the leftmost foot. Since the leftmost foot is always properly prohibits anything of a foot size from being left unfooted.[1] Parse-σ prohibits syllables from being left unfooted. *Lapse and Parse-σ belong to a family of parsing constraints.

I argue that "weak local parsing" follows from Align-Prwd-L/R, *Lapse >> All-Ft-R/L >> Parse-σ, where Align-Prwd and All-Ft have opposite edge specifications. L-R "weak local parsing" follows from Align-Prwd-L, *Lapse >> All-Ft-R >> Parse-σ while R-L "weak local parsing" follows from Align-Prwd-R, *Lapse >> All-Ft-L >> Parse-σ. The salient property of the analysis is that the two prosody/prosody alignment constraints, *i.e.* Align-Prwd and All-Ft, have opposite edge specifications, and thus are in the push/pull relation. In other words, it is the tension between these two prosody/prosody alignment constraints that derives ternary alternation. An overview of the analysis of "weak local parsing" is as follows. Align-Prwd requires that the edgemost foot should lie at the one edge of a Prwd. All-Ft, being dominated by Align-Prwd, pulls all the other feet to the opposite edge as much as possible, keeping them apart from the edgemost foot. Since *Lapse is undominated, every foot can only be separated from each other by one stress unit. It is also crucial that Parse-σ is low ranked. Otherwise complete parsing such as [(σ σ́)(σ σ́)(σ σ́)] would be more harmonious than "weak local parsing" such as [(σ σ́) σ (σ σ́) σ]. This correctly gives rise to "weak local parsing."

1.2 Persistent vs. Non-Persistent Footing

Languages with ternary alternation can also be classified into persistent and non-persistent footing languages. Persistent footing is observed in the Chugach dialect of Pacific Yupik, Estonian, Karelian, Hungarian, Finnish, Winnebago, Auca, and Bani-Hassan Arabic while non-persistent footing is observed in Cayuvava, Sentani, and Mantjiltjara. With derivational terms, the difference between persistent and non-persistent footing would be described as follows. In languages with persistent footing, if two stress units are left over after the initial ternary parsing, they are regrouped into a foot, as shown in (5a). In languages with non-persistent footing, on the other hand, such stray stress units are left unparsed, as shown in (5b):

(5) a. Persistent Footing
(σ σ́) σ (σ σ́) σσ ---> (σ σ́) σ (σ σ́) (σ σ́)
b. Non-Persistent Footing
(σ σ́) σ (σ σ́) σσ

[1] *Lapse could be regarded as an extension of the anti-lapse filter put forward by Selkirk (1984). Dealing with English stress system, she proposes the anti-lapse filter, which prohibits metrical grids from having a lapse within the domain of a root.

aligned with the left edge of a Prwd, Align-Prwd-L dominates All-Ft-R, as shown in tableau (9):[4]

(9) Align-Prwd-L >> All-Ft-R, from / σ σ σ /

Candidates	Align-Prwd-L	All-Ft-R
a. ☞ [(σ σ́) σ]		μ
b. [σ (σ σ́)]	σ!	

Candidate (9a) violates All-Ft-R while candidate (9b) does not. The latter, however, violates Align-Prwd-L, which the former does not. Since (9a) is the actual output form, we conclude that Align-Prwd-L dominates All-Ft-R. Hence, Align-Prwd-L >> All-Ft-R makes the effect of All-Ft-R irrelevant with respect to the leftmost foot, and thus guarantees that the left edge of the leftmost foot is always properly aligned with the left edge of a Prwd.

With respect to the feet other than the leftmost one, on the other hand, the effects of All-Ft-R are visible. All-Ft-R pulls them to the right edge of a Prwd as much as possible. Hence, in words consisting of five syllables, "weak local parsing" [(σ σ) σ (σ σ)] is optimal. Especially, it is more harmonious than "strong local parsing," as shown in (10). Here, we ignore the candidates which violate the undominated Align-Prwd-L constraint:

(10) Application of All-Ft-R, from / σ σ σ σ σ /

		All-Ft-R
a. ☞	[(σ σ́) σ (σ σ́)]	μμμ
b.	[(σ σ́) (σ σ́) σ]	μμμμ!

Next, it is crucial that Parse-σ is low ranked. Since less complete parsing like [(σ σ́) σ (σ σ́) σ] is more harmonious than complete parsing like [(σ σ́) (σ σ́) (σ σ́)] in this language, Parse-σ is dominated by All-Ft-R. The following tableau certifies this ranking. Note again that we ignore the candidates which violate the undominated Align-Prwd-L constraint in tableau (11):

(11) All-Ft-R >> Parse-σ, from / σ σ σ σ σ σ /

Candidates	All-Ft-R	Parse-σ
a. ☞ [(σ σ́) σ (σ σ́) σ]	μμμμμ	**
b. [(σ σ́) (σ σ́) (σ σ́)]	μμμμμμ!	

In words with more than five syllables, however, Align-Prwd-L >> All-Ft-R >> Parse-σ is not sufficient to derive "weak local parsing." Align-Prwd-L

[4]Note that degree of violation of the All-Ft constraint is indicated by the number of moras separating the edge of each foot from the edge of a Prwd. In section 4, we will see why violation of the All-Ft constraint needs to be indicated by the number of moras.

>> All-Ft-R >> Parse-σ would require that the leftmost foot should lie at the left edge of a Prwd and that all the other feet should lie as close as possible near the right edge of the Prwd. Hence, this ranking would wrongly predict that parsing such as [(σ σ́) σ σ σ σ (σ σ́)] is more harmonious than "weak local parsing" such as [(σ σ́) σ (σ σ́) σ (σ σ́)]. I argue that *Lapse plays a role here. Given the undominated status of FtBin-μ, *Lapse prohibits anything of a foot size from being left unfooted. I argue that *Lapse is undominated and ranked higher than All-Ft-R. Hence, All-Ft-R can only pull all the feet other than the leftmost one toward the right edge of a Prwd as much as possible unless the resultant foot structure would violate *Lapse. In other words, all the feet other than the leftmost one should lie as close as possible near the right edge of a Prwd, but all feet can only be separated from each other by one light syllable. This argument is certified in tableau (12). In the tableau (12), we again ignore the candidates which violate the undominated Align-Prwd-L constraint:

(12) *Lapse >> All-Ft-R, from / σ σ σ σ σ σ σ σ/

Candidates	*Lapse	All-Ft-R
a. ☞ [(σ σ́) σ (σ σ́) σ (σ σ́)]		μμμμμμμμμμ
b. [(σ σ́) σ σ σ σ (σ σ́)]	*!**	μμμμμμμ

To sum up, "weak local parsing" in Chugach straightforwardly follows from the following constraint rankings:

(13) Align-Prwd-L, *Lapse >> All-Ft-R >> Parse-σ

2.4 Persistent Footing

We observe in Chugach that in words with 3n+1 underlying moras (where n is any natural number) like (6)(b) and (e), two underlying light syllables are left over after initial ternary parsing. Since Chugach employs persistent footing, these stray syllables are regrouped into a foot.

Following Kager (1994a; 1994b), I argue that persistent footing follows from the undominated status of *Lapse. This is because if the two underlying light syllables did not form a foot, it would result in prosodic structures where two adjacent stress units are left unfooted. This would violate *Lapse, as shown below:

(14) Application of *Lapse, from / σ σ σ σ σ σ σ /

	*Lapse
a. ☞ [(σ σ́) σ (σ σ́) (σ σ́)]	✓
b. [(σ σ́) σ (σ σ́) σ σ]	*

2.5 Summary of Chugach Stress Patterns

The motivated rankings put forward in the discussion of Chugach stress system provide the following rankings on the constraint set:

(15) Align-Prwd-L, FtForm (Iambic), FtBin-μ, *Lapse >> All-Ft-R >> Parse-σ

I have argued that among these constraint rankings, Align-Prwd-L, *Lapse >> All-Ft-R >> Parse-σ is crucial in deriving the ternary alternation in Chugach.[5]

3. Cayuvava

This section investigates Cayuvava, a ternary alternation language parsed under non-persistent footing. Unlike in languages with persistent footing like Chugach, there exists a double upbeat at either edge of a Prwd in those with non-persistent footing. Based on this fact, Kager (1994a; 1994b) claims that while *Lapse is undominated in languages with persistent footing, *Lapse is low ranked in those with non-persistent footing. I will argue, however, that *Lapse is also undominated in languages with non-persistent footing. It is shown that the existence of a double upbeat at either edge of a Prwd in non-persistent footing languages follows from the fact that extrasyllabic segments are allowed to occur at either edge of a Prwd due to the low-ranked status of Align-Prwd-σ and Parse-segment. The difference between languages with persistent footing and those with non-persistent footing resides in the fact that while Align-Prwd-σ is undominated in the former, it is low ranked in the latter. Although I will only deal with Cayuvava in this section, the analysis to be presented, I argue, can easily be extended to the other ternary alternation languages with non-persistent-footing.

3.1 Stress Patterns in Cayuvava

This subsection illustrates stress patterns in Cayuvava, which are described by Key (1961; 1967) and have been analyzed in work by, among others, Dresher and Lahiri (1991), Halle and Vergnaud (1987), Hammond (1990), Hayes (1981; 1995), Kager (1994a; 1994b), and Levin (1988).

Cayuvava does not have any contrast of syllable weight. In other words, Cayuvava only has light syllables. The antepenultimate syllable receives main stress. In words of sufficient length, every third syllable

[5]The analysis of ternary alternation with persistent footing is much the same as Green and Kenstowicz's (1995) analysis although these two works were developed independently at the same time. As we will see in the following discussion, however, these two analyses differ regarding the analysis of non-persistent footing languages. While Green and Kenstowicz (1995) still makes use of the foot repulsion constraint, the present analysis does not.

preceding it receives secondary stress, following ternary alternation, as in (16). In (16), I present examples with their foot structures:

(16)	a.	(σ́ σ) σ	šákahe`	'stomach'
	b.	σ (σ́ σ) σ	kihíbere	'I ran'
	c.	V σ (σ́ σ) σ	ariúuča	'he came already'
	d.	(σ̀ σ) σ (σ́ σ) σ	ǰìhiraríama	'I must do'
	e.	σ (σ̀ σ) σ (σ́ σ) σ	maràhahaéiki	'their blankets'
	f.	V σ (σ̀ σ) σ (σ́ σ) σ	ikitàparerépeha	'the water is clean'
	g.	(σ̀ σ) σ (σ̀ σ) σ (σ́ σ) σ	čàadiròboβúruče	'ninety-nine'
	h.	σ (σ̀ σ) σ (σ̀ σ) σ (σ́ σ) σ	medàručečèirohíiɲe	'fifteen each'
	i.	CV σ (σ̀ σ) σ (σ̀ σ) σ (σ́ σ) σ	čaadàirobòirohíiɲe	'ninety-nine'

Notice that there are free stranding extrasyllabic segments at the left edge of the Prwd in (16c, f, i), which are indicated by either CV or V. I argue that extrasyllabic vowels are parsed by moras, but the moras are directly parsed by Prwds without being parsed by syllables or feet. Extrasyllabic consonants, on the other hand, are directly parsed by Prwds without being parsed by syllables or feet.

3.2 Foot Headedness, Foot Binarity, and Primary Stress

We observe from (16) that Cayuvava is a trochaic language. This follows from the undominated status of FtForm (Trochaic):

(17) FtForm (Trochaic) (Undominated)
Align (Ft, L, H(Ft), L),
where H(Ft) is the head of a foot, *i.e.* the strongest syllable-daughter of a foot. (cf. M&P (1993b))

Since feet are always bisyllabic, FtBin-σ is also undominated in this language:

(18) FtBin-σ (Undominated)
Feet are strictly binary at the level of syllables.
(cf. M&P (1993a), P&S (1993))

In the following tableaux, I will assume for expository purposes that Gen does not submit structures which violate either of these two undominated constraints.

We also observe that the main stress is always placed on the head of the rightmost foot in a Prwd. Following Cohn and McCarthy (1994), I argue that this follows from Rightmost ($\acute{\sigma}$):

(19) Rightmost ($\acute{\sigma}$)
Align ($\acute{\sigma}$, R, Prwd, R) (Cohn and McCarthy 1994: 15)

This constraint requires that the right edge of every syllable with main stress should coincide with the right edge of some Prwd.

3.3 Extrametricality

We observe from (16) that Prwd-final syllables are extrametrical in words with more than three syllables. In those words, the Prwd-final syllables are left unfooted and thus directly parsed by Prwd. How to account for this phenomenon through constraint interactions is a question which I want to keep beyond the scope of this paper due to space constraint.

3.4 "Weak Local Parsing"

"Weak local parsing" in Cayuvava can be explained along exactly the same line as "weak local parsing" in Chugach. Remember that "weak local parsing" follows from Align-Prwd-L/R, *Lapse >> All-Ft-R/L >> Parse-σ, where Align-Prwd and All-Ft have opposite edge specifications. Since feet are parsed from right to left in Cayuvava, "weak local parsing" in this language follows from Align-Prwd-R, *Lapse >> All-Ft-L >> Parse-σ.

3.5 Non-Persistent Footing

In order to derive non-persistent footing in Cayuvava, we have to ensure that extrasyllabic segments are only allowed at the left edge of words with "3n-1 syllables" (where n̲ is any natural number) like (16c, f, i). Before considering how to derive non-persistent footing, let us look at two general constraints on extrasyllabic segments.

First, it has been claimed (see, among others, Harris (1983), Hayes (1995), and Inkelas (1989)) that free-stranding extrasyllabic segments can only occur at the edge of a prosodic domain. M&P (1993b) proposes Align-σ, and claims that the import of the peripherality condition on extrasyllabicity can be subsumed under this alignment constraint:[6]

[6]As M&P (1993b) points out, the choice of aligning edges as L, R vs. R, L is of no importance.

(20) Align-σ (Undominated)

Align (σ, L, σ, R) (M&P 1993b: 19)

Align-σ claims that the left edge of every syllable must coincide with the right edge of a syllable. This guarantees that syllables must come one after the other uninterrupted by free stranding extrasyllabic segments.

Second, we have to ensure that only segments of a light syllable size may be left extrasyllabic at the left edge of a Prwd. *Lapse-μ, which prohibits two adjacent moras from being unsyllabified, ensures this fact:[7]

(21) Anti-Lapse-μ (*Lapse-μ) (Undominated)

One of two adjacent moras must be parsed by syllables.

In the following discussion, we will not consider the candidates which violate either of these two undominated constraints.

Returning to non-persistent footing in Cayuvava, I argue that the low-ranked status of Align-Prwd-σ-L and Parse-segment is crucial in deriving non-persistent footing, *i.e.* footing with extrasyllabic segments at the left edge of a Prwd:

(22) Align-Prwd-σ-L

Align (Prwd, L, σ, L) (M&P 1993b: 18)

(23) Parse-segment (Parse-seg)

All segments must be parsed by syllables.

(cf. P&S 1993)

The outline of the analysis is as follows. Since Cayuvava allows extrasyllabic segments at the left edge, Align-Prwd-σ-L and Parse-seg are low ranked in this language. Align-Prwd-σ-L claims that the left edge of each Prwd must coincide with the left edge of some syllable. Parse-seg requires that segments should be parsed by syllables. Since Align-Prwd-σ-L and Parse-seg are low ranked, they may be violated. In other words, free stranding segments are allowed at the left edge of a Prwd in order to satisfy some higher constraints. I argue that *Lapse, Non-Align-Prwd-L and All-Ft-L are ranked higher than Align-Prwd-σ-L and Parse-seg, and thus force violations of Align-Prwd-σ-L and Parse-seg in words with a double upbeat. Non-Align-Prwd-L requires that the left edge of every Prwd should not coincide with the left edge of some foot, as stated below:

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[7]This paper makes use of the two *Lapse constraints which apply at different elements. *Lapse applies at stress units, prohibiting two adjacent stress units from being unfooted. *Lapse-μ, on the other hand, applies at moraic level, prohibiting two adjacent moras from being unsyllabified.

(24) Non-Align-Prwd-L
Non-Align (Prwd, L, Ft, L)

Let us first consider the conflict between *Lapse, on the one hand, and Align-Prwd-σ-L and Parse-seg, on the other. Since Align-Prwd-σ-L and Parse-seg are ranked lower than *Lapse, the footing with extrasyllabic segments (25a), that is the actual output form, is more harmonious than the footing with two adjacent unfooted syllables (25b):

(25) Footing with Extrasyllabic Segments vs. Footing with Two Adjacent Unfooted Syllables
*Lapse >> Align-Prwd-σ-L, Parse-seg, from /CVCVCVCVCVCVCVCV/

Candidates	*Lapse	Align-Prwd-σ-L	Parse-seg
a. ☞ [CV σ (σ̀ σ) σ (σ́ σ) σ]		CV	**
b. [σ σ (σ̀ σ) σ (σ́ σ) σ]	*!		

Note that violation of Align-Prwd-σ-L is gradient, and degree of violation is measured by the number of intervening segments between the left edge of a Prwd and the left edge of a syllable. Although the candidate with extrasyllabic segments (25a) violates Align-Prwd-σ-L and Parse-seg, it satisfies *Lapse. On the other hand, candidate (25b), where there are two adjacent unfooted syllables, does not satisfy *Lapse. Since *Lapse dominates Align-Prwd-σ-L and Parse-seg, (25a) is optimal. Hence, a double upbeat in words with "3n-1 syllables" emerges not from the existence of two adjacent unfooted syllables at the left edge of those words, but from the existence of extrasyllabic segments of a syllable size at the left edge of those words.

Second, since Align-Prwd-σ-L and Parse-seg are ranked lower than Non-Align-Prwd-L, the footing with extrasyllabic segments (26a) is more harmonious than persistent-footing (26b). Remember that in ternary alternation languages like Cayuvava, Parse-σ is low ranked:

(26) Footing with Extrasyllabic Segments vs. Persistent Footing
Non-Align-Prwd-L >> Align-Prwd-σ, Parse-seg, from /CVCVCVCVCVCVCVCV/

Candidates	Non-Align-Prwd-L	Align-Prwd-σ-L	Parse-seg
a. ☞ [CV σ (σ̀ σ) σ (σ́ σ) σ]		CV	**
b. [(σ̀ σ)(σ̀ σ) σ (σ́ σ) σ]	*!		

Finally, since Align-Prwd-σ-L and Parse-seg are ranked lower than All-Ft-L, the footing with extrasyllabic segments (27a) is more harmonious than "strong local parsing" (27b). Remember again that Parse-σ is low ranked in Cayuvava:

(27) Footing with Extrasyllabic Segments vs. Strong Local Parsing All-Ft-L >> Align-Prwd-σ-L, Parse-seg from /CVCVCVCVCVCVCVCV/

Candidates	All-Ft-L	Align-Prwd-σ-L	Parse-seg
a. ☞ [CV σ (σ̀ σ) σ (σ́ σ) σ]	μμμμμμμ	CV	**
b. [σ (σ̀ σ)(σ̀ σ)(σ́ σ) σ]	μμμμμμμμ!μμ μμμμ		

To sum up the above discussion, in words with a double upbeat, there are free-stranding extrasyllabic segments at the left edge of a Prwd. I have shown that this follows from the low ranked status of Align-Prwd-σ-L and Parse-seg. Especially, it is crucial that Align-Prwd-σ-L and Parse-seg are dominated by *Lapse, Non-Align-Prwd-L, and All-Ft-L.

3.6 Words with Prwd-initial Stressed Syllable

In words with 3n syllables (where n is any natural number), however, the Prwd-initial syllable gets stress, as shown in (16a, d, g). This suggests that, unlike in words with "3n-1 syllables," some higher-ranked constraints are in conflict with Non-Align-Prwd-L and make performance of Non-Align-Prwd-L irrelevant in words with 3n syllables. I argue that *Lapse and All-Ft-L play that role.

Let us first consider the conflict between *Lapse and Non-Align-Prwd-L. I argue that *Lapse dominates Non-Align-Prwd-L, as the following tableau certifies:

(28) *Lapse >> Non-Align-Prwd-L, from /CVCVCVCVCVCV/

Candidates	*Lapse	Non-Align-Prwd-L
a. ☞ [(σ̀ σ) σ (σ́ σ) σ]		*
b. [σ σ σ (σ́ σ) σ]	*!*	

The candidate with Prwd-initial stress (28a) violates Non-Align-Prwd-L while non-iterative parsing (28b) does not. (28b), however, violates *Lapse, which (28a) does not. Since *Lapse >> Non-Align-Prwd-L, we can correctly predict that (28a) is the actual output form.

Let us next consider the conflict between All-Ft-L and Non-Align-Prwd-L. I argue that All-Ft-L dominates Non-Align-Prwd-L, as shown below:

(29) All-Ft-L >> Non-Align-Prwd-L, from /CVCVCVCVCVCV/

Candidates	All-Ft-L	Non-Align-Prwd-L
a. ☞ [(σ̀ σ) σ (σ́ σ) σ]	μμμ	*
b. [σ (σ̀ σ)(σ́ σ) σ]	μμμμ!	
c. [CV(σ̀ σ)(σ́ σ) σ]	μμμμ!	

The candidate with Prwd-initial stress (29a) violates Non-Align-Prwd-L while "strong local parsing" (29b) and the footing with extrasyllabic segments (29c) do not. (29)(b-c), however, induce more violations of All-Ft-L than (29a). Since All-Ft-L >> Non-Align-Prwd-L, we can correctly predict that (29a) is the actual output form. Note that investigation of these three candidates suggests that the All-Ft constraint should count the number of moras rather than the number of syllables. This is because if All-Ft-L counted the number of syllables, (29c) would be more harmonious than (29a) on the ground of All-Ft-L. We would then wrongly predict that (29c) is optimal.

3.7 Summary of Cayuvava Stress Patterns

To summarize this section, "weak local parsing" and non-persistent footing in Cayuvava follows from (30)(a) and (b), respectively:

(30) a. "Weak Local Parsing":
Align-Prwd-R, *Lapse >> All-Ft-L >> Parse-σ
b. Non-Persistent Footing:
Align-σ, *Lapse-μ, *Lapse >> All-Ft-L >>
Non-Align-Prwd-L >> Align-Prwd-σ-L, Parse-seg

One way of collapsing (30)(a-b) is shown in (31):

(31) Align-σ, *Lapse-μ, *Lapse, Align-Prwd-R >> All-Ft-L >> Non-Align-Prwd-L, Parse-σ >> Align-Prwd-σ-L, Parse-seg

4. Persistent Footing vs. Non-Persistent Footing

In the present analysis, persistent footing and non-persistent footing follow from constraint rankings (32)(a) and (b), respectively:

(32) a. Persistent Footing
Align-σ, *Lapse-μ, *Lapse, **Align-Prwd-σ** >> All-Ft >>
Non-Align-Prwd >> Parse-σ
b. Non-Persistent Footing
Align-σ, *Lapse-μ, *Lapse >> All-Ft >> Non-Align-Prwd
>> **Align-Prwd-σ**, Parse-σ, Parse-seg

Under the present analysis, the difference between persistent and non-persistent footing only resides in the fact that while Align-Prwd-σ is undominated in the former, it is low ranked in the latter. Hence, it is the demotion of Align-Prwd-σ that derives non-persistent footing.[8]

In languages with persistent footing like Chugach, Align-Prwd-σ is undominated. This ensures that no free stranding extrasyllabic segments are allowed at the edge of a Prwd in these languages. Hence, if anything of a foot size is left over after initial ternary parsing, it always forms an independent foot. This is because regrouping stray elements into a foot is the only way to avoid a violation of the undominated *Lapse constraint. Notice that Non-Align-Prwd, which prohibits the edge of every Prwd from matching the edge of a foot, is ranked lower than *Lapse, and thus its performance is made irrelevant in such cases.

In languages with non-persistent footing like Cayuvava, on the other hand, Align-Prwd-σ is low ranked. The low-ranked status of Align-Prwd-σ allows us to have extrasyllabic segments at the edge of Prwd. The extrasyllabicity enables us to avoid a violation of the undominated *Lapse constraint in cases where elements of a foot size are left over after initial ternary parsing. Notice that, unlike in languages with persistent footing, we cannot avoid a violation of *Lapse by forming a independent foot consisting of elements left over after initial ternary parsing. This is because Non-Align-Prwd is ranked higher than Align-Prwd-σ, ensuring that the edge of every Prwd may not match the edge of a foot in such cases.

The present analysis receives further support from the fact that it can account for the marked status of non-persistent footing. It has been pointed out (see, among others, Hayes (1995)) that non-persistent footing is a marked option. Under the analysis, this can be accounted for by the fact that in languages with non-persistent footing, Align-Prwd-σ is low ranked. This is because it is plausible to assume that Align-Prwd-σ, which prohibits extrasyllabic segments, is highly ranked in the unmarked case.[9]

5. Conclusion

This paper has shown that ternary alternation, which has resisted any principled account under rule-based theory, straightforwardly follows from

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[8]Notice that the effects of Parse-seg in persistent footing languages are invisible, since the undominated status of Align-Prwd-σ and Align-σ ensures that all segments must be parsed by syllables irrespectively of the position of Parse-seg in the constraint rankings.

[9]One might argue that although the analysis accounts for the marked status of non-persistent footing, it does not account for the marked status of ternary alternation. As suggested by Moira Yip (personal communication), however, ternary alternation languages may not be theoretically marked, though they are rare. This is because we can only tell that languages employ ternary alternation by looking at words with more than four stress units which constitute a single stress domain. There are, however, not many languages which have words of that length with a single stress domain.

Align-Prwd, *Lapse >> All-Ft >> Parse-σ, where the Align-Prwd and All-Ft constraints have opposite edge specifications. I have also argued that the difference between languages with persistent footing and those with non-persistent footing is that while Align-Prwd-σ is undominated in the former, it is low ranked in the latter. Although space limitation only allows us to look at Chugach and Cayuvava, the analyses purported here can be extended to the other languages with ternary alternation.

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