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# Stress in Harmonic Serialism

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# STRESS IN HARMONIC SERIALISM

A Dissertation Presented

by

KATHRYN RINGLER PRUITT

Submitted to the Graduate School of the  
University of Massachusetts Amherst in partial fulfillment  
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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Linguistics

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Time present and time past  
Are both perhaps present in time future,  
And time future contained in time past.  
...  
What might have been and what has been  
Point to one end, which is always present.  
– T. S. Eliot, *Four Quartets*

## **ABSTRACT**

### **STRESS IN HARMONIC SERIALISM**

SEPTEMBER 2012

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This dissertation proposes a model of word stress in a derivational version of Optimality Theory (OT) called Harmonic Serialism (HS; Prince and Smolensky 1993/2004, McCarthy 2000, 2006, 2010a). In this model, the metrical structure of a word is derived through a series of optimizations in which the ‘best’ metrical foot is chosen according to a ranking of violable constraints. Like OT, HS models cross-linguistic typology under the assumption that every constraint ranking should correspond to an attested language.

Chapter 2 provides an argument for modeling stress typology in HS by showing that the serial model correctly rules out stress patterns that display non-local interactions, while a parallel OT model with the same constraints and representations fails to make such a distinction.

Chapter 3 discusses two types of primary stress—autonomous and parasitic—and argues that limited parallelism in the assignment of primary stress is war-

ranted by a consideration of attested typology. Stress systems in which the primary stress appears to behave autonomously from secondary stresses require that primary stress assignment be simultaneous with a foot's construction. As a result, a provision to allow primary stress to be reassigned during a derivation is necessary to account for a class of stress systems in which primary stress is parasitic on secondary stresses.

Chapter 4 takes up two issues in the definition of constraints on primary stress, including a discussion of how primary stress alignment should be formulated and the identification of vacuous satisfaction as a cause of problematic typological predictions. It is proposed that all primary stress constraints be redefined according to non-vacuous schemata, which eliminate the problematic predictions when implemented within HS.

Finally, chapter 5 considers the role of representational assumptions in typological predictions with comparisons between HS and parallel OT. The primary conclusion of this chapter is that constituent representations (i.e., feet) are necessary in HS to account for rhythmic stress patterns in a typologically restrictive way.



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# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

This dissertation is broadly concerned with the typology of word stress and how it can be modeled in a constraint-based framework. This work is based on the assumption that identifying and formalizing the dimensions along which phonological systems may differ—and, conversely, dimensions along which they never seem to differ—can help to illuminate the forces by which all phonological systems are shaped. Ultimately, formalizing cross-linguistic typology is seen as a way to discover fundamental shared properties of linguistic systems in order to provide insight into the underlying cognitive structures that acquire, store, and utilize those systems.

For modeling phonological typology I assume the general framework of Optimality Theory (OT; Prince and Smolensky 1993/2004, McCarthy and Prince 1993b, 1995, Kager 1999, McCarthy 2002, 2008a). In OT, the grammar is conceptualized as a set of competing pressures which are arranged in a hierarchy of relative importance on a language-particular basis. The language-particular ranking determines an optimal output (surface form) for each input (underlying form), and typology is modeled with the assumption that the input-output mappings of every ranking should correspond to an attested language.

I adopt a model that differs in one crucial way from the standard conception of OT—namely, I assume that the grammar is derivational and operations apply serially rather than in parallel. This model, Harmonic Serialism (HS), was con-

sidered by Prince and Smolensky (1993/2004) in their original proposal for OT. Although they ultimately decide in favor of the parallel version of the theory, recent work has demonstrated the utility of HS for modeling phonological processes (for a review, see McCarthy 2010a, as well as the further exposition below).

Word stress provides the empirical focus of the dissertation. Stress is an area of phonology in which the explicit consideration of typology has had a long history (e.g., Halle and Vergnaud 1987, Hayes 1980, 1981, 1985, 1987, 1995, Kager 1992a,b, 1993, Prince 1983, etc.). It is also an area in which representational issues are paramount, which provides fertile ground for comparing theories that approach structure-building in different ways (in this case, serially or in parallel). This dissertation will propose a model of stress assignment in HS that builds metrical structure by optimizing feet one-at-a-time. This model will be justified on the basis of its typological predictions, with metrical locality, patterns of primary stress, and the representation of rhythm forming the central topics which are addressed.

The rest of this chapter is organized as follows. Section 1.2 describes the basic components of an OT grammar and how Harmonic Serialism departs from the standard assumptions. Section 1.3 presents the basis for a theory of stress in HS, including assumptions about representations and how gradualness, the property that distinguishes serialism from parallelism, is defined for stress. Section 1.4 discusses in broad terms how typological predictions follow from a particular hypothesis about the grammar and includes a brief discussion of the computational tools that were utilized to derive predictions and make comparisons between theories. Finally, §1.5 concludes this chapter by providing an outline of the rest of the dissertation and a summary of its main findings.

## 1.2 OT and Harmonic Serialism

A particular theory in the framework of OT involves three primary components: a set of constraints (CON), a set of candidates or a procedure for generating candidates (GEN), and a procedure for determining how the constraints are applied to the candidates to determine the optimal output for each input (EVAL). The grammar of one language is modeled with a particular constraint ranking (sometimes notated  $\mathcal{H}$  for ‘hierarchy’), and typological predictions are made by considering all possible constraint rankings. A theory of CON, GEN, and EVAL together can be thought of as a ‘meta-grammar’, which predicts the existence of certain grammars (and thus, certain combinations of input-output mappings) but not others. OT can be used to model typology when the components are defined with the goal of maximizing coverage of attested languages while minimizing over-generation. This means producing a grammar for known languages, but not producing grammars which do not correspond to some natural language.

The standard implementation of OT assumes a parallel architecture, in which candidates are generated by applying multiple operations at the same time and EVAL is defined to apply the constraint ranking to this set once to determine the optimal output (for a particular input) in one step. The architecture is parallel because any processes that apply between a phonological underlying form (the input) and a phonological surface form (the output) apply simultaneously. For stress, the input is a word or, abstractly, a word shape (some number of syllables with particular properties), and the output is the stress pattern that is applied to that word or type of word. In parallel OT, constraints determine the optimal configuration of metrical structure over the entire word at once.

An alternative is to assume that processes are restricted to applying serially, one at a time, entailing multiple optimizations and a derivation with the potential for intermediate steps between the input and the output. A version of OT that utilizes



such derivations is Harmonic Serialism (HS; Prince and Smolensky 1993/2004, McCarthy 2000, 2006, 2007a,b, 2010a,b).<sup>1</sup>

HS shares with parallel OT several trademark features, including the characterization of a grammar as a ranking of some presumed-to-be universal set of constraints, but it departs from parallel OT in its assumptions about how this ranking is accessed as an input is mapped onto an output.<sup>2</sup> An input to an HS grammar is gradually altered to reach an output, with each step in the derivation chosen by optimization over a set of alternatives derived by “do[ing] any *one* thing” to the previous iteration’s output (Prince and Smolensky 1993/2004:6). The same ranking is used at each step and the derivation *converges* when the input to an iteration is returned as the optimal candidate, as this indicates that no additional changes result in a more harmonic output relative to the constraint hierarchy. For stress, then, HS differs from OT in that metrical structure is built piece-by-piece with the constraint ranking used each time to determine the optimal substructures that combine over successive evaluations to form the metrical structure of the whole word.

In terms of the formal architecture, CON and EVAL work the same in HS and parallel OT, while GEN and the relationship between GEN and EVAL are different. The GEN of HS does not have the ‘freedom of analysis’ of parallel OT’s GEN (McCarthy and Prince 1993b). Instead, it only provides candidates differing in at most one respect from the input at each iteration. The formalization of ‘one difference’ for stress assignment will be discussed below. The GEN-EVAL relationship also differs in HS, in that GEN and EVAL are in a loop until convergence: GEN produces a set

---

<sup>1</sup>See also Elfner (2010), Jesney (to appear), Kimper (2011), McCarthy (2007c, 2008b,c, 2011a,b), McCarthy, Kimper, and Mullin (2012), McCarthy, Mullin, and Smith (2012), McCarthy, Pater, and Pruitt (to appear), McCarthy and Pruitt (to appear), Pater (to appear), Staubs (2010), Wolf (2008), and papers in McCarthy and Pater (to appear).

<sup>2</sup>The HS-specific terminology used throughout this section follows McCarthy (2007a, *et seq.*).

of single-change candidates, EVAL selects the optimal one relative to the constraint hierarchy of the language, and this intermediate output is passed back to GEN for another iteration in which all single-change candidates from this intermediate form are computed and then compared.

Because of the nature of optimization, it is true in HS as well as in parallel OT that any form that wins over a faithful candidate is less marked with respect to the constraint hierarchy (Moreton 2004). This is because a form which violates a faithfulness constraint can only win when it better satisfies a higher ranked markedness constraint. The result is that derivations are always harmonically improving. Each form is more harmonic than the previous form and less harmonic than any subsequent form (until convergence); this is guaranteed by the architecture of the system.

Finally, a winner at any iteration is a locally optimal candidate; it wins when compared to the members of a limited candidate set, which includes only the input to that iteration (the local input) and forms that are one change away from the input. At each iteration both the best *kind* of change is chosen (whether to delete a segment, or to build a metrical foot, for example), and also the best *instance* of the best change (e.g., the *best* way to delete one segment, or the *best* way to build one foot). Thus, *every* form in an HS derivation is a local optimum. Parallel OT, in contrast, always finds the *global* optimum relative to a particular input and constraint ranking. The global optimum is the best possible candidate, relative to a given constraint ranking, among the potentially infinite set of candidates produced by the unrestricted GEN of parallel OT. Sometimes an HS derivation terminates at a local optimum that also happens to be the global optimum, but sometimes it does not. In the latter case, the typological predictions of parallel OT and HS can differ even when the same constraints are used. Failure to converge on the hypothetical global optimum in an HS derivation occurs when it is not possible to reach it in

a series of gradual, locally optimal, harmonically improving steps, however one step has been defined. Several arguments for HS over parallel OT (chapter 2, and other recent work, e.g., McCarthy 2006, 2010a,b) rely on the fact that parallel OT's global optimum is not always the typologically correct output. In other words, HS's failure to reach such a candidate is often not a failure at all.

In the next section I propose and illustrate the theory of stress that will form the basis of the dissertation. Although many details will be left to be spelled out in later chapters, the basic assumption is that stress patterns are derived by optimizing feet one at a time within the framework provided by HS.

### **1.3 Iterative foot optimization**

In this section I lay out a proposal for a model in which word stress is assigned by iteratively building the 'best' foot with a series of optimizations. I will refer to this proposal as HS with iterative foot optimization (HS/IFO or IFO). In many rule-based theories of stress, "iterative" refers to the repeated application of rules that build metrical structure, and this is distinguished from non-iterative parsing, in which a stress rule applies only once, yielding non-rhythmic stress (Hayes 1995:113). Here, in contrast, *iterative* simply refers to the fact that in HS, evaluations occur repeatedly until convergence. The entire grammar is iterative in this sense, and I will refer to a particular derivational step or evaluation as an "iteration." Not coincidentally I will also be primarily concerned with stress systems which are iterative in the traditional sense, but the specifics of IFO will also extend to other stress systems, since the constraint ranking determines whether multiple feet are built. In §1.3.1, I spell out the assumptions and then in §1.3.2 illustrate how they work.

### 1.3.1 Gradualness in IFO

Because of the requirement that GEN produce only candidates with at most one difference relative to the input at any given iteration, derivations are gradual. It is necessary to assume some theory of gradualness (that is, of GEN) in order to derive predictions from HS. This dissertation explores the consequences of defining gradualness in metrical structure-building as the addition of one metrical foot (although chapter 5 will consider different representational assumptions).<sup>3</sup> At each iteration GEN produces candidates corresponding to all possible ways of adding one foot to that input (in addition to candidates with other kinds of single changes). EVAL selects among these candidates based on the constraint hierarchy, and a stress derivation proceeds by building the ‘best’ foot each time, as long as it is harmonically improving to do so.

I will assume throughout that GEN is restricted to producing candidates with feet that are maximally disyllabic and have exactly one syllable designated as a head. Given these assumptions, an exhaustive list of the candidates for the first iteration of stress assignment in a five syllable word is shown in (1).<sup>4</sup> The candidate set includes the faithful candidate and every candidate that adds a single foot; the list contains the five possible monosyllabic feet, the four possible trochaic (left-headed) feet, and the four possible iambic (right-headed) feet. The ranking of markedness constraints on metrical structure will determine which of the candidates in (1) is optimal. I will assume that underlying foot structure is not at issue

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<sup>3</sup>Unlike recent work by McCarthy (2007a, 2008c), I do not assume that GEN’s permissible operations have a necessary relationship to faithfulness constraints, at least not for prosodic structure building. See also Elfner (2009), Kimper (2011), and Pater (to appear).

<sup>4</sup>The symbol  $\sigma$  stands for a syllable, foot boundaries are marked with parentheses, and stress is marked with ' or ´ (when the stress is primary or when degrees of stress are not differentiated) or marked with , or ` (when stress is non-primary).

here.<sup>5</sup> Chapters 3 and 4 articulate a full proposal for how and when primary stress is assigned in an HS derivation; until then I will also set aside degrees of stress in my illustrations.

(1) Candidates for first foot in a five-syllable word

<b>Operation</b>	<b>Candidates</b>
None (faithful)	$\sigma\sigma\sigma\sigma$
Mono- $\sigma$ foot	$(\sigma)\sigma\sigma\sigma$ $\sigma(\sigma)\sigma\sigma$ $\sigma\sigma(\sigma)\sigma$ $\sigma\sigma\sigma(\sigma)$ $\sigma\sigma\sigma\sigma(\sigma)$
Di- $\sigma$ trochee	$(\sigma\sigma)\sigma\sigma$ $\sigma(\sigma\sigma)\sigma$ $\sigma\sigma(\sigma\sigma)$ $\sigma\sigma\sigma(\sigma\sigma)$
Di- $\sigma$ iamb	$(\sigma'\sigma)\sigma\sigma$ $\sigma(\sigma'\sigma)\sigma$ $\sigma\sigma(\sigma'\sigma)$ $\sigma\sigma\sigma(\sigma'\sigma)$

Another assumption that must be made explicit is how metrical structure that is built at one iteration is to be treated in subsequent iterations. In general I will adopt the assumption that feet can be built by GEN but not altered or removed.<sup>6</sup> One consequence of this assumption is that foot building can only parse ‘free’ syllables, i.e., those that are not yet in a foot. This requirement is familiar from Prince (1985) as the Free Element Condition, given in (2). Similar notions have been adopted and argued for in other work (e.g., Steriade 1988).

(2) Free Element Condition (FEC; Prince 1985:479)

Rules of primary metrical analysis apply only to Free Elements – those that do not stand in the metrical relationship being established.

To see how this assumption works, consider a case in which the candidate with a left-aligned disyllabic trochee,  $(\sigma\sigma)\sigma\sigma$ , was the most harmonic among the candidates in (1) at the first iteration; the set of candidates considered at the second iteration will then be those shown in (3). This set includes a locally faithful candidate, which inherits the structure from the previous output but adds no more. It

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<sup>5</sup>See McCarthy and Pruitt (to appear) for arguments that lexical foot structure is not a viable way of encoding contrastive stress in HS and for an alternative proposal.

<sup>6</sup>In Pruitt (2010) I referred to this assumption as *strict inheritance*.

also includes all the candidates derivable from this input by building one foot on its remaining free syllables.

(3) Candidates for second foot in a five-syllable word with local input ('σσ)σσσ

<b>Operation</b>	<b>Candidates</b>
None (faithful candidate)	('σσ)σσσ
Mono-σ foot added	('σσ)(,σ)σσ ('σσ)σ(,σ)σ ('σσ)σσ(,σ)
Di-σ trochee added	('σσ)(,σσ)σ ('σσ)σ(,σσ)
Di-σ iamb added	('σσ)(σ,σ)σ ('σσ)σ(σ,σ)

Given these assumptions, (4) gives examples of derivations that are not allowed. The derivation in (a) is not allowed because it is insufficiently gradual; GEN does not produce candidates with more than one foot added in a single step. The derivations in (b) and (c) are not permitted because they violate the FEC. The derivations in (d)-(f) are not possible mainly because they would not be harmonically improving even if such operations were allowed. For instance, in (d), if input /σσσσσ/ becomes ('σσ)σσσ, then ('σσ)σσσ must have been more harmonic than its competitors, including σσσσσ, at the first step. As a result, a subsequent iteration accessing the same constraint ranking could not possibly judge σσσσσ to be more harmonic than ('σσ)σσσ, assuming all else is equal. The same goes for the derivations in (e) and (f).

(4) Illicit derivations

Hypothetical derivation	Reason disallowed
a. σσσσσ ↘ ('σσ)(,σ)σσ	Insufficiently gradual
b. ('σσ)σσσ ↘ ('σ)(,σσ)σσ	FEC
c. ('σσ)σσσ ↘ ('σ)(σ'σ)σσ	FEC
d. σσσσσ → ('σσ)σσσ ↘ σσσσσ	(Not improving)
e. σσσσσ → ('σσ)σσσ ↘ ('σ)σσσσ	(Not improving)
f. σσσσσ → ('σσ)σσσ ↘ (σ'σ)σσσ	(Not improving)

### 1.3.2 Illustration

I will illustrate this proposal with a stress derivation from Pintupi, a Pama-Nyungan language spoken in the Northern Territory of Australia (Hansen and Hansen 1969, 1978). Pintupi has a relatively straightforward stress pattern: main stress is initial and secondary stresses fall on all other odd-numbered non-final syllables, suggesting an analysis in terms of quantity-insensitive syllabic trochees (Hayes 1995). The data in (5) illustrate the pattern. Vowel length in Pintupi is only contrastive in the initial syllable, which always receives main stress, and syllable codas are assumed to be non-moraic because stress is indifferent to them.

(5) Pintupi (Hansen and Hansen 1969:163)

Word	Gloss	Proposed foot structure
'paŋa	'earth'	('σσ)
'tuŋaja	'many'	('σσ)σ
'maŋa,wana	'through (from) behind'	('σσ)(,σσ)
'puŋiŋ,kalaŋu	'we (sat) on the hill'	('σσ)(,σσ)σ
'ŋamu,limpa,ŋuŋku	'our relation'	('σσ)(,σσ)(,σσ)

I analyze Pintupi with left-aligning (that is, left-to-right) syllabic trochees, adapting the standard analysis from Hayes (1995), using constraints developed in Prince and Smolensky (1993/2004) and McCarthy and Prince (1993a).<sup>7</sup> The constraints that will be used inherit their definitions from parallel OT analyses, though they can result in different predictions in IFO (as in chapter 2, for example) because of the difference between parallel and serial evaluation.

The constraint *PARSE-σ*, defined in (6), provides the impetus for foot-building (Prince and Smolensky 1993/2004), while the alignment constraints *ALLFTL/R*,

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<sup>7</sup>A straightforward introduction to the McCarthy and Prince (1993a) and Prince and Smolensky (1993/2004) theory of stress in parallel OT can be found in Kager (1999:Ch. 4).

defined in (7), account for directionality by preferring feet to be aligned as far as possible to the edge of the word (McCarthy and Prince 1993a).

(6) **PARSE- $\sigma$**

Assign one violation mark for every syllable that is not a member of some foot

(7) **ALLFTL/R**

For each foot in a word assign one violation mark for every syllable separating it from the left/right edge of the word

In order to enforce left-headed feet (i.e., trochees) over right-headed feet (i.e., iambs), the two constraints in (8) will be necessary. These are equivalent to the **RHTYPE** ('rhythmic type') constraints of Prince and Smolensky (1993/2004:63). Monosyllabic feet are assumed (for now) to satisfy both constraints.

(8) **TROCHEE/IAMB**

Assign one violation mark for a foot whose head is not aligned with the left/right edge of the foot

Feet in Pintupi are strictly disyllabic, so a constraint preferring binary feet is needed. I adopt Prince and Smolensky's (1993/2004:56) foot binarity constraint, **FTBIN**, which they adapt from Prince (1980), defined in (9).

(9) **FTBIN**

Feet are binary at some level of analysis ( $\mu$ ,  $\sigma$ )

In principle, this constraint assigns violations to a foot with fewer than two moras, ('L), and feet with more than two syllables, ( $\sigma\sigma\sigma$ ), etc., but it does not rule out ('H) since a heavy syllable is binary at the moraic level. Thus, **FTBIN** can force disyllabic feet just when a language makes no quantity distinctions. Pintupi contrasts vowel length only in initial position, so if we make the reasonable assumption that the



grammar will account for the limited distribution of long vowels, the definition of FTBIN in (9) will be sufficient. It will prevent words in Pintupi from having monosyllabic feet, ruling out parses like ('σσ)('σσ)('σ) when it is ranked above PARSE-σ, which successfully accounts for the absence of stress on final syllables in this language.<sup>8</sup> This will be evident in the tableaux below.

For a syllabic trochee stress pattern, these constraints must be ranked so that a five-syllable input /σσσσσ/ is ultimately parsed as [(('σσ)('σσ)σ] in a series of harmonically-improving foot-building steps. The derivation will follow the trajectory shown in (10) with a five-syllable word from Pintupi. The following paragraphs provide ranking arguments for the derivation of this form in HS.

- (10) Derivation for Pintupi, input /pu[ɪŋ]kalatu/ 'we (sat) on the hill'  
 /pu[ɪŋ]kalatu/ → ('pu[ɪŋ])kalatu → ('pu[ɪŋ])(kala)tu → [(('pu[ɪŋ])(kala)tu]

In the first step, a left-aligned disyllabic trochee beats every other candidate (see (1) for an exhaustive list). The tableau in (11) shows the first step of the derivation.<sup>9</sup> For the left-aligned disyllabic trochee to be optimal in the first step of this derivation, the tableau in (11) shows that ALLFTL must dominate ALLFTR (accord-

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<sup>8</sup>This statement is true for IFO but not for parallel OT. A parallel OT analysis of Pintupi requires an additional constraint to prevent monosyllabic feet in initial position when the first syllable is heavy. Detailed discussion of the reasons for this can be found in chapter 2 (§2.2).

<sup>9</sup>This and subsequent tableaux in this dissertation are presented in a modified version of the comparative format of Prince (2002) (the “combination format” described in McCarthy 2008a). Each row displays the number of violation marks that the candidate receives on each constrain as a series of positive integers (replacing the familiar \*'s). Rows with losing candidates are also annotated with Ws and Ls to indicate how each losing candidate compares to the winner with respect to each constraint. When a losing candidate receives more violations than the winning candidate on a given constraint, a W accompanies the loser's violations, to indicate that the constraint favors the winner. When a losing candidate receives fewer violations than the winning candidate on a given constraint, an L appears instead, to show that the constraint favors the loser. If a losing candidate has the same number of marks for a constrain as the winning candidate, neither a W nor an L is present. This tableau format allows ranking arguments to be displayed clearly. A ranking is shown to be necessary when it eliminates a losing candidate; this is evident in this tableau format as a W preceding an L in any given row, when no other W precedes that L. For the intended winner to win, any loser-favoring constraint must be dominated by a winner-favoring constraint, and thus any L in the tableau must be preceded by a W in the same row. This follows from the requirement that the highest-ranked constraint which can distinguish between a winner and a loser must favor

ing to row (c)), and TROCHEE must dominate IAMB (row (d)). PARSE- $\sigma$  must also be high enough ranked to compel building this foot, even though doing so causes violations of IAMB and ALLFTR, as indicated by the location of Ws and Ls in row (a).

(11) First iteration ranking arguments

PARSE- $\sigma$  » IAMB, ALLFTR; ALLFTL » ALLFTR; TROCHEE » IAMB

<i>/pu ijkalatu/ 1st iteration</i>	<i>PARSE-<math>\sigma</math></i>	<i>TROCHEE</i>	<i>ALLFTL</i>	<i>IAMB</i>	<i>ALLFTR</i>
a. pu ijkalatu	W <sub>5</sub>			L	L
→ b. ('pu ij)kalatu	3			1	3
c. pu ijka('latu)	3		W <sub>3</sub>	1	L
d. (pu' ij)kalatu	3	W <sub>1</sub>		L	3

For a complete analysis it is necessary to continue through the derivation and confirm that the rankings that are needed at the first iteration are consistent with those required at subsequent iterations. Additional ranking arguments can also be made as the derivation proceeds. At the second iteration, ('pu|ij)(kala)tu wins over its competitors. As row (a) of the tableau in (12) shows, this requires that one additional ranking be assumed: PARSE- $\sigma$  » ALLFTL. McCarthy and Prince (1993a) show that this ranking must hold to account for rhythmic/iterative stress in parallel OT, and the same holds for HS. If this ranking were reversed it would not be optimal to build additional feet.

(12) Second iteration ranking argument, PARSE- $\sigma$  » ALLFTL

<i>('pu ij)kalatu 2nd iteration</i>	<i>PARSE-<math>\sigma</math></i>	<i>ALLFTL</i>
a. ('pu ij)kalatu	W <sub>3</sub>	L
→ b. ('pu ij)(kala)tu	1	2

---

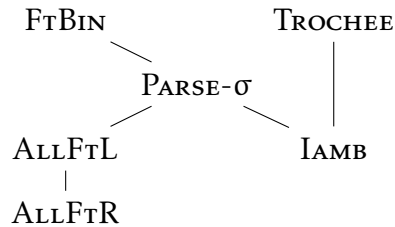
the winner (the “Cancellation/Domination Lemma” of Prince and Smolensky 1993/2004; see also McCarthy 2002:28-29).

The third iteration requires that ('pu|ij)(,kala)tu again be returned as the best output, indicating that additional foot-building is not harmonically improving and signaling convergence. Because the input to this iteration, ('pu|ij)(,kala)tu, contains only one free syllable, there is only one other candidate for adding foot structure, ('pu|ij)(,kala)(,tu). This candidate loses on the grounds that it contains a monomoraic foot, even though it satisfies PARSE- $\sigma$  perfectly. The ranking FTBIN » PARSE- $\sigma$  accounts for this, as shown in (13). The diagram in (14) summarizes the Pintupi ranking.

(13) Third iteration ranking argument, FTBIN » PARSE- $\sigma$

	('pu ij)(,kala)tu 3rd iteration	FTBIN	PARSE- $\sigma$
→ a.	('pu ij)(,kala)tu		1
b.	('pu ij)(,kala)(,tu)	W <sub>1</sub>	L

(14) Pintupi ranking (L→R syllabic trochees)



The summary tableau in (15) shows the full derivation of this form with this ranking in place. In this tableau format a winning candidate at a particular iteration is indicated by an outward-pointing arrow symbol that initiates an arc to the next iteration. The locally faithful candidate at each iteration (the original input at the first iteration or the previous iteration's winner) is the first candidate listed. Rows are indexed continuously within derivational tableaux to avoid ambiguity in referring to candidates. To recap, candidate (b) wins in the first iteration because it satisfies TROCHEE and FTBIN, and is left-aligned to the edge of the word in accordance with ALLFtL. This form is passed to the second iteration where it is listed in

(e) as the locally faithful candidate. At this step, candidate (f) is chosen as optimal because it adds a foot of the proper form (disyllabic trochee) and satisfies  $\text{PARSE-}\sigma$  better than not adding a foot. This form is then passed to the third iteration, at which point the new locally faithful candidate in (g) is compared to the only remaining stress candidate, which has added a monomoraic foot on its final syllable. The fully parsed candidate fatally violates  $\text{FTBIN}$ , which outranks  $\text{PARSE-}\sigma$ , and the derivation converges by choosing candidate (g).

(15) Pintupi derivation summary for input /pu<sub>0</sub>liŋka<sub>0</sub>la<sub>0</sub>tu/

	$\text{FTBIN}$	$\text{TROCHEE}$	$\text{PARSE-}\sigma$	$\text{ALLFTL}$	$\text{LAMB}$	$\text{ALLFTR}$
<b>/pu<sub>0</sub>liŋka<sub>0</sub>la<sub>0</sub>tu/ 1st iteration</b>						
a. pu <sub>0</sub> liŋka <sub>0</sub> la <sub>0</sub> tu			W <sub>5</sub>		L	L
b. ('pu <sub>0</sub> liŋ)ka <sub>0</sub> la <sub>0</sub> tu			3		1	3
c. pu <sub>0</sub> liŋka('la <sub>0</sub> tu)			3	W <sub>3</sub>	1	L
d. (pu <sub>0</sub> 'liŋ)ka <sub>0</sub> la <sub>0</sub> tu		W <sub>1</sub>	3		L	3
<b>2nd iteration</b>						
e. ('pu <sub>0</sub> liŋ)ka <sub>0</sub> la <sub>0</sub> tu			W <sub>3</sub>	L	L <sub>1</sub>	L <sub>3</sub>
f. ('pu <sub>0</sub> liŋ)(ka <sub>0</sub> la <sub>0</sub> )tu			1	2	2	4
<b>3rd iteration</b>						
g. ('pu <sub>0</sub> liŋ)(ka <sub>0</sub> la <sub>0</sub> )tu			1	2	2	4
h. ('pu <sub>0</sub> liŋ)(ka <sub>0</sub> la <sub>0</sub> )(tu)	W <sub>1</sub>	W <sub>1</sub>	L	W <sub>6</sub>	W <sub>3</sub>	4

→ **Output:** [('pu<sub>0</sub>liŋ)(ka<sub>0</sub>la<sub>0</sub>)tu]

This example shows how standard OT stress constraints combined with the architecture of HS and the assumptions of IFO are capable of modeling the common directional stress pattern of Pintupi.

## 1.4 Typological modeling

### 1.4.1 Arguing from typological predictions

The argumentation contained in this thesis relies on the assumption that the goal of an OT-based theory is to accurately model phonological typology. This has two components—maximizing coverage and minimizing over-generation. It

should be possible to analyze attested systems without also predicting an abundance of unattested systems at the same time. The second of these goals is frequently the explicit focus in this dissertation. I will often belabor specific predictions of a theory in order to identify *types* or *classes* of stress patterns that are characteristic of that theory. Theories or sets of assumptions are then compared based on what types or classes of stress patterns they predict to exist and how that accords with attested typology. For example, in chapter 2 I identify a distinction between local and non-local stress patterns—the latter of which are argued not to exist—which is captured by adopting HS/IFO. Because the main focus is on types of systems, I will not generally characterize the performance of a particular model in numeric terms.

#### **1.4.2 Tools utilized in the computation of typologies**

The goal of building a theory which matches attested typology is made considerably more tractable with computational tools that automate all or part of the process of generating typological predictions. The tools that have been used in this dissertation are discussed in this section. In most of the dissertation the use of these tools is not discussed explicitly (chapter 5 is the exception), but they have nonetheless been utilized extensively in the testing and comparison of hypotheses presented throughout.

Typological predictions of HS models were computed with the aid of OT-Help 2.0 (OTH2; Staubs, *et al.* 2010). OTH2 accepts a set of inputs, a set of constraints, and a set of operations, which it uses to determine every optimal set of derivations that can be derived from these assumptions. Representations and constraints in OTH2 are stored in structured input files containing definitions written as modified regular expressions. For details about how these inputs are defined, see the OTH2 user manual (Mullin, *et al.* 2010). The end result of a typology calculation

is a set of outputs, one for each input, the derivations for which are jointly optimal under some ranking. Each set of outputs constitutes a predicted language or, in this case, a stress pattern.

Typological predictions for similar sets of assumptions were also calculated for parallel OT using OT-Help 2.0 along with two other programs: OTSoft (Hayes, Tesar, and Zuraw 2011) and OTWorkplace (Prince and Tesar 2010). In general, each of the parallel OT typology calculators accepts a file with a set of inputs, candidates, constraints, and violation marks, and will deliver the sets of outputs that can be made jointly optimal under some ranking, as these constitute the languages (or stress patterns) that are predicted by the given assumptions.<sup>10</sup> I used OTWorkplace to automate the generation of metrical candidate sets, and I used OTH2 to generate the violation profiles for every candidate using the same constraint definition file used in the HS typology calculations.<sup>11</sup>

Finally, a note about tied candidates in HS and parallel OT typology calculations. As discussed in some detail in the OTH2 user guide (Mullin, *et al.* 2010), ties may occur in intermediate steps of an HS derivation and may or may not affect the ultimate outcome of the derivation. In general, if the choice among tied candidates at an intermediate stage can yield *different* outputs, a warning is provided in OTH2 when the results are given, as such ties should generally be avoided.<sup>12</sup>

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<sup>10</sup>For further explanation of the structure of input files for these programs, as well as the algorithms that are used to generate the typologies, see the user guides for OT-Help [v. 1] (Becker and Pater 2007), OTSoft (Hayes 2011), and the instructions that accompany OTWorkplace.

<sup>11</sup>Thanks to Sam Baldwin for introducing this ‘after market’ functionality to OT-Help 2.0. OTSoft and OTWorkplace also have ways of defining constraints to automate the assignment of violation marks, but I used OTH2 in order to utilize the constraint definitions that I had already written for the HS typology calculations. A search-and-replace was conducted to change the default representations of the OTWorkplace metrical candidate sets into representations that matched the OTH2 constraint definitions.

<sup>12</sup>In addition to the OTH2 manual (Mullin, *et al.* 2010), discussion of ties in HS can be found in McCarthy (2009) and Pruitt (2009).

Tied optima can also arise in a parallel OT evaluation, although no intermediate steps are involved. This issue is mentioned here because the different software packages for parallel OT typology calculations treat tied optima differently, and thus, it matters which program one uses to generate typologies when tied optima are known or suspected. The parallel OT typology calculation in OTH2 omits any ranking that gives tied optima (or more accurately, its ranking algorithm fails when it tries to make a candidate that ties with another candidate optimal, even if their shared violation profile is in principle capable of winning under some ranking; Becker and Pater 2007), leading to relatively smaller predicted typologies compared to the other two programs. Adding a constraint that breaks such a tie will result in an increase in the number of languages predicted in OTH2.

At the other end of the spectrum, OTSoft appears to treat each combination of optima under a given ranking as a separate language, potentially yielding larger typologies relative to the other two programs. In this case, adding a tie-breaking constraint *reduces* the number of predicted languages; this is the only situation in which adding a constraint can make a typology smaller.<sup>13</sup>

In contrast to both of these approaches, OTWorkplace predicts a language for every non-harmonically-bounded violation profile and collapses any tied candidates in these cases into one cell. Adding a tie-breaking constraint leaves the number of predicted languages unchanged (assuming, again, that the constraint does nothing but break the tie among tied candidates). Since each of the typology calculators for parallel OT has a different way of dealing with rankings that produce tied optima, all three programs were used for comparison when tied optima were suspected.

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<sup>13</sup>OTSoft provides a warning when multiple candidates are found to have the same violation profile, and its warning says that it will “pick randomly” among them. However, the manual does not explain exactly what this means, and it does not appear from the results of the typology calculation that any of the tied optima are ever discarded.

## 1.5 Outline of dissertation

Beginning with chapter 2, the rest of the dissertation is devoted to identifying consequences of adopting HS to model stress typology and to comparing this framework with parallel OT when other assumptions are held constant.

Chapter 2 presents an argument for HS based on an over-generation problem with the standard theory of stress in parallel OT. Parallel OT with standard representations and constraints predicts a class of unattested stress systems which are shown to be implausible because they involve *non-locality*. Non-local stress patterns arise from whole-word stress optimization, where the metrical structure in a particular place within a word is predicted to depend on the phonological properties of syllables at unbounded distances in both directions. Such systems are unattested, and HS/IFO correctly predicts that they should not occur. The predictions of HS and parallel OT are compared with a focus on the interaction of metrical parsing with syllable weight, vowel shortening, and constraints on the edges of prosodic domains. This chapter also includes some comparisons between the HS model of stress adopted in this dissertation and rule-based derivational models.

Chapters 3 and 4 turn to a discussion of primary stress (which is set aside entirely in chapter 2). Chapter 3 addresses the issue of ‘when’ main stress should be assigned within the derivation of a stress pattern. The typology of primary stress is used to argue in favor of treating primary stress assignment as a ‘free’ operation that applies whenever and wherever it can. This correctly accounts for the diversity of primary stress patterns, in which primary stress may be autonomous or parasitic with respect to secondary stresses. Free assignment (and reassignment) of primary stress represents a kind of limited parallelism in stress that is justified by these typological considerations.



Chapter 4 is devoted to two issues in the formulation of constraints on primary stress. First, primary stress alignment is discussed and it is argued that primary stress alignment constraints must exist in both syllable-referring and foot-referring versions. It is also argued that primary stress alignment constraints must determine the location of the primary stress with respect to the syllable structure of a word rather than its metrical structure. The second issue addressed in this chapter is the problem of vacuous satisfaction of constraints on primary stress. Typical definitions of primary stress markedness constraints allow candidates without a primary stress to escape violation, but as a consequence they predict languages with non-uniform culminativity—primary stress in some words but not others on the basis of arbitrary properties of inputs. Since non-uniform culminativity is not attested, schemata are proposed for the redefinition of primary stress constraints, eliminating the potential for vacuous satisfaction. The problem posed by vacuous satisfaction of primary stress constraints is shown to occur both in HS and in parallel OT, but the proposed constraint redefinitions are argued to require the restricted GEN of HS in order to function as intended.

Chapter 5 provides a comparison between HS and parallel OT in accounting for purely rhythmic stress under different representational assumptions. With standard constituent representations (i.e., feet), parallel OT and HS are shown to differ in their treatment of monosyllabic feet. While HS uses the derivation itself to control the location of monosyllabic feet, parallel OT relies on alignment constraints. This causes the predictions of the two frameworks to diverge under certain circumstances, and in general the frameworks are left with different patterns of over-generation. When representations and constraints are instead grid-based, with no constituency assumed, considerable differences between parallelism and serialism are observed, with the parallel theory behaving in a more typologically restrictive

way. It is argued, then, that constituent representations are requisite for the serial derivation of stress patterns using violable constraints.

Finally, chapter 6 presents a brief summary of the topics addressed in this dissertation.

## CHAPTER 2

### LOCALITY IN METRICAL TYPOLOGY

Note: This chapter is a minimally revised version of Pruitt (2010).

#### 2.1 Introduction

There is emerging evidence that Harmonic Serialism provides a general solution to a class of problems in parallel OT having to do with locality. To illustrate the sense of locality intended here I borrow an example from McCarthy (2006, 2007b, 2010b). McCarthy shows that parallel OT predicts a language with a non-local truncation process if CON contains a constraint against syllable-final obstruents (CODA-COND) and a constraint requiring phonological words to end in a consonant (FINAL-C), each of which receives independent support from phonological typology. When both FINAL-C and CODA-COND outrank the constraint against deletion (MAX), parallel OT predicts a language that deletes every segment to the right of the rightmost sonorant consonant in the word. This is shown in (16) with a hypothetical input form. In this same language, no truncation occurs in words that have no sonorant consonants.

(16) Non-local truncation in parallel OT (McCarthy 2006)

/palasanataka/	FINAL-C	CODA-COND	MAX
a. palasanataka	W <sub>1</sub>		L
b. palasanatak		W <sub>1</sub>	L <sub>1</sub>
c. palasanata	W <sub>1</sub>		L <sub>2</sub>
d. palasanat		W <sub>1</sub>	L <sub>3</sub>
e. palasana	W <sub>1</sub>		L <sub>4</sub>
→ f. palasan			5

This process of deletion can accurately be described as non-local. In order to know whether a particular vowel or non-sonorant consonant in a word of this language will undergo deletion as part of this truncation process, we have to know whether a sonorant consonant precedes and whether a sonorant consonant follows that segment at *any distance*. If there is a sonorant consonant in the word anywhere to the right of the given segment, the segment does not delete. If there is no sonorant consonant to the right of the given segment, then the segment deletes if and only if there is a sonorant consonant anywhere to its left. There is no known language with an active process of this kind, and it would be a surprise to discover a language that works this way. The process of truncation is non-local because information about the entire word, at unbounded distances to the left and right, is required to successfully predict whether a given segment will delete.

Parallel OT predicts non-local processes of this kind because it compares candidates with any number of deletions (and other changes) simultaneously. HS solves this problem, as McCarthy demonstrates, by treating each deletion as a separate step.<sup>1</sup> The output in (16) could only be reached in HS if every one of the deletions showed improvement on the constraint hierarchy individually, but they do not; the ultimate advantage of deletion is not realized until five segments have undergone deletion. HS has been shown to solve similar locality problems for autosegmental spreading (Kimper 2010, McCarthy 2006, 2011a), metathesis (McCarthy 2006), tone flop (*ibid.*), and positional faithfulness (Jesney to appear). This chapter adds to this list by showing that the standard theory of stress in parallel OT (McCarthy and Prince 1993a, Prince and Smolensky 1993/2004) is similarly vulnerable to locality problems of precisely this sort, while a model of stress assignment based in HS eliminates these non-local predictions. Parallel OT makes the incorrect pre-

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<sup>1</sup>In McCarthy (2006) Harmonic Serialism is called “persistent OT”.

diction that the metrification of a particular syllable can be affected not just by its local context but also by syllables or feet at unbounded distances on both sides of it. The HS-based model of stress proposed in this dissertation prevents these non-local interactions by proceeding iteratively with foot-building, effectively limiting the properties of the word that can affect foot placement at each iteration and more accurately representing the attested typology as a result. Based on this difference, it is argued that HS with serial foot-building provides an advantage over the standard theory of stress in parallel OT in accounting for natural language stress systems.

In the next three sections I compare the predictions of IFO and parallel OT using the standard stress constraints and metrical representations that were employed in the analysis of Pintupi in chapter 1. There are two reasons for adopting this method of comparison. First, some assumptions about GEN and CON have to be made in order for HS and parallel OT to make typological predictions, and holding these assumptions constant highlights the role of serialism vs. parallelism for the resulting typologies. And secondly, the stress constraints of Prince and Smolensky (1993/2004) and McCarthy and Prince (1993a) are widely used in parallel OT, as are the representational assumptions on which they are based. It is not a stretch to say that this set of assumptions represents the standard theory of stress in parallel OT. Throughout the discussion I will continue to refer to this as “the standard theory of stress in parallel OT,” (or occasionally just “the standard theory”) in order to emphasize that the specifics of the discussion depend, as always, on one’s assumptions about GEN and CON.

The organization of this chapter is as follows: §2.2-§2.4 address cases in which parallel OT predicts non-local stress systems while HS does not (§2.2 explores this dichotomy with the interaction of syllable weight and metrical parsing, building on a previous discussion by Hyde (2007); §2.3 shows similar non-local predictions

for metrically-conditioned quantity adjustments; and §2.4 turns to a non-local interaction between final syllable extrametricality and foot headedness). Section 2.5 briefly compares the theory of stress assignment proposed in this chapter with alternatives beyond the standard theory of parallel OT, and §2.6 concludes.

## 2.2 Quantity-sensitivity in metrical parsing

There are several otherwise-quantity-insensitive languages that allow monosyllabic feet just in the case of a heavy syllable at the end of an odd-parity word. These have been called generalized trochee languages (Kager 1992a,b, citing Hayes 1991). Two of the languages that are claimed to exemplify this stress pattern are Estonian (Hint 1973, Kager 1992a,b, Prince 1980) and Wergaia (Hercus 1969, 1986, Hyde 2007). This stress pattern is shown schematically in (17).<sup>2</sup>

(17) Generalized trochee pattern

- |                                                                            |                                                                          |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------|
| a. Odd-parity words                                                        | b. Even-parity words                                                     |
| $\sigma\sigma\sigma H \rightarrow (' \sigma\sigma)( ' \sigma\sigma)( ' H)$ | $\sigma\sigma\sigma\sigma \rightarrow (' \sigma\sigma)( ' \sigma\sigma)$ |
| $\sigma\sigma\sigma L \rightarrow (' \sigma\sigma)( ' \sigma\sigma)L$      |                                                                          |

This kind of limited weight sensitivity is clearly intended to preserve alternating rhythm except when it would create a degenerate foot, ('L). The languages with this pattern do not show a preference for stressing heavy syllables generally, but they take advantage of a syllable's heaviness in final position in an odd-parity word to preserve a regular rhythmic alternation. A traditional dichotomy distinguishes quantity-sensitive and quantity-insensitive stress patterns, but gen-

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<sup>2</sup>Hayes (1995) does not include the generalized trochee as a separate class of stress system, but instead subsumes such systems with "syllabic trochees", positing that ('L) is the only truly degenerate foot. This permits languages that normally require ('σσ) to parametrically employ ('H). Hayes uses Estonian to argue for this conception of syllabic trochees and also cites evidence that syllabic trochee languages often employ a bimoraic, rather than the expected disyllabic, word minimum (see also, Kager 1992a,b). For Kager (1992a,b), any syllabic trochee language that has a quantity contrast would be considered a generalized trochee language, and the stress pattern in (17) is predicted to emerge in such languages when quantity contrasts can appear in final position.

eralized trochee languages do not properly qualify as either one, since quantity is relevant only in limited positions. We can refer to this pattern as one which is ‘partially-quantity-sensitive’.

Hyde (2007) identifies a problem with the analysis of generalized trochee languages in the standard theory of stress in parallel OT. The constraints required by the standard theory to analyze the attested generalized trochee stress pattern also predict under ranking permutation additional partially-quantity-sensitive patterns that are bizarre and not attested. This reveals, as Hyde argues, that the standard theory of stress in parallel OT needs to be revised. In this section I follow Hyde in using the Australian language *Wergaia* to illustrate the attested generalized trochee pattern. Section 2.2.1 provides analyses of *Wergaia* in HS and in parallel OT with the standard stress constraints. In §2.2.2 I summarize Hyde’s discussion of the problematic predictions of the standard theory but re-characterize the problem as one of (non)locality. Finally, in §2.2.3 I show that this errant prediction does not arise from the minimally different serial analysis and discuss the properties of HS that make this true.

### **2.2.1 Local weight sensitivity in *Wergaia***

*Wergaia* (Pama-Nyungan; Southeastern Australia (extinct); Hercus 1969, 1986) has a stress pattern that is nominally similar to that of *Pintupi*, which was discussed in chapter 1. Main stress is initial, with secondary stresses on remaining odd-numbered syllables. But while stress never falls on the final syllable in *Pintupi*, in *Wergaia* a final odd-numbered syllable is stressed if (and only if) it is heavy, making it a canonical generalized trochee stress pattern. Vowel length in *Wergaia* is limited to initial position (Hercus 1986:81), and thus only closed syllables are

able to induce final stress in odd-parity words.<sup>3</sup> The data in (18) illustrate. In (a) are words with an even number of syllables, (b) shows odd-parity words with a final light syllable, and (c) shows odd-parity words with a final heavy syllable.

(18) Weṛgaia data (Hercus 1969, Hyde 2007)

	Word	Gloss	Proposed foot structure
a.	'gaba	'to chase'	('LL)
	'bajig	'stone tomahawk'	('LH)
	'winag,ɟera	'to leave one another'	('LH)(,LL)
	'wiɽim,buliɽ	'spider'	('LH)(,LH)
b.	'dagunɟa	'to punch someone'	('LH)L
	'delguna	'to cure'	('HL)L
c.	'buna,ɖug	'broad-leaved mallee'	('LL)(,H)
	'geɟau,wil	'a lot, many'	('LH)(,H)

### 2.2.1.1 HS analysis

The stress pattern of Weṛgaia can be analyzed in HS with essentially the same ranking as Pintupi, discussed in chapter 1. Stress is assigned iteratively left-to-right, so the ranking  $\text{PARSE-}\sigma \gg \text{ALLFTL} \gg \text{ALLFTR}$  is needed; the ranking  $\text{TROCHEE} \gg \text{IAMB}$  accounts for the preference for left-headed feet; and the ranking  $\text{FTBIN} \gg \text{PARSE-}\sigma$  ensures that there will be no monomoraic feet.<sup>4</sup>  $\text{PARSE-}\sigma$  also again dominates  $\text{IAMB}$  to initiate footing. The summary of the required ranking is in (19), and the following paragraphs illustrate the analysis with examples.

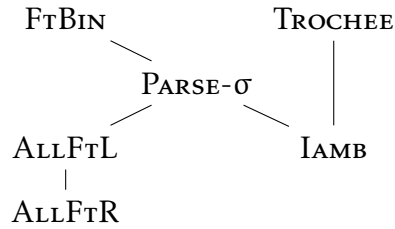
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<sup>3</sup>Diphthongs may also appear word-finally, but whether they necessarily receive stress in this position is not completely consistent in the source.

<sup>4</sup>The grammar must restrict vowel length to initial (main stress) position in both Pintupi and Weṛgaia, so the simplest way to account for the difference in the stressability of the final syllable between the two languages is to assume that codas are moraic in Weṛgaia but not in Pintupi. In other words, the stress grammar of the two languages is identical and the difference comes from the distribution of syllable weight (which is itself conditioned by the other parts of the grammar). The difference between the languages could be captured in other ways and it would not significantly affect the discussion in this section.



(19) Weṛgaia ranking



The tableau in (20) shows the derivation of an even-parity word, in which an input with the light-heavy sequence /LHLH/ is parsed as ('LH)(LH). In the first iteration, the candidate with a disyllabic left-aligned trochee, ('wiṛim)bulip, is chosen as optimal because it meets the bimoraic minimum required by undominated FTBIN while parsing as much as possible and being left-aligned in accordance with ALLFtL. This form is passed to the second iteration, where the addition of another disyllabic foot is found to be harmonically improving, so ('wiṛim)(bulip) is optimal. The third iteration shows convergence, which is trivial in this case because all syllables have been parsed into feet by this point. This derivation shows that, in general, parsing is insensitive to syllable weight in generalized trochee languages, since parsing this word yields two feet with heavy syllables in weak position.

(20) Weṛgaia /LHLH/ → [(LH)(LH)]

	/wiṛimbulip/ 1st iteration	FTBIN	PARSE-σ	ALLFtL	ALLFtR
	a. wiṛimbulip		W <sub>5</sub>		L
←	b. ('wiṛim)bulip		3		2
→	<b>2nd iteration</b>				
	c. ('wiṛim)bulip		W <sub>3</sub>	L	2
←	d. ('wiṛim)(bulip)			2	2
	(Convergence step not shown)				
→	<b>Output: [('wiṛim)(bulip)]</b>				

The tableau in (21) below shows a derivation for /delguna/, an odd-parity word ending in a light syllable. The first iteration chooses a left-aligned disyllabic trochee as the best foot, just as in (20). In the second iteration the locally faithful candidate is compared with a candidate in which the final syllable is parsed

into a foot, but footing the last syllable fails to improve harmony because FTBIN outranks PARSE- $\sigma$ . The output is [(‘delgu)na].

(21) Weṛgaia /HLL/ → [(‘HL)L]

	/delguna/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	ALLFTR
a.	delguna		W <sub>3</sub>		L
b.	(‘del)guna		W <sub>2</sub>		W <sub>2</sub>
c.	(‘delgu)na		1		1
	<b>2nd iteration</b>				
d.	(‘delgu)na		1		1
e.	(‘delgu)(na)	W <sub>1</sub>	L	W <sub>2</sub>	2

→ **Output:** [(‘delgu)na]

However, in the tableau in (22) an input with the shape /LLH/ (/bunaḍug/) becomes output (‘LL)(,H), with parsing sensitive to the weight of the last syllable. At the first iteration, the candidate with a left-aligned disyllabic trochee wins. At the second iteration this candidate is compared with a candidate that has the last syllable footed, (‘buna)(ḍug). The latter wins because it better satisfies PARSE- $\sigma$  while also satisfying the bimoraic minimum on feet, since the final syllable is heavy. Convergence will occur at the third iteration because no more metrification is possible, and thus the output is [(‘buna)(,ḍug)].

(22) Weṛgaia /LLH/ → [(‘LL)(,H)]

	/bunaḍug/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	ALLFTR
a.	bunaḍug		W <sub>3</sub>		L
b.	(‘buna)ḍug		1		1
	<b>2nd iteration</b>				
c.	(‘buna)ḍug		W <sub>1</sub>	L	1
d.	(‘buna)(,ḍug)			2	1

(Convergence step not shown)  
→ **Output:** [(‘buna)(,ḍug)]

Clearly the grammar of Weṛgaia must allow both (,σσ) and (‘H) while banning (‘L). This is the canonical definition of the generalized trochee, as proposed by Prince (1980) for Estonian, and later extended by Kager (1992a,b) and Hayes

(1995). Our definition of *FTBIN* encodes this preference by allowing  $(,σσ)$  and  $(^H)$  but not  $(^L)$ , and as long as other constraints sensitive to quantity are low-ranked, all disyllabic feet are treated equally for the purposes of assigning stress. However, we must also capture the generalization that disyllabic feet are preferred, other things being equal, since monosyllabic heavy feet are limited to final position. Previous derivational work in stress often states this generalization as a maximality condition on foot building, preferring feet to be as large as possible (Halle and Vergnaud 1987:15; Hayes 1995:102-103; Prince 1980). The HS analysis presented above is able to capture this generalization as a result of relatively high-ranked *PARSE-σ*, which prefers a larger foot in HS; when one foot is added at a time, a larger foot means fewer remaining unparsed syllables. Thus, *PARSE-σ* mimics to some extent the maximality condition of rule-based metrical parsing, with the crucial difference being that it is violable. We will see in the next section that an analysis of *Wergaia* in parallel OT requires an additional constraint to favor disyllabic feet; this is because *PARSE-σ* does not function as a maximality condition when metrical parses are compared in parallel.

### 2.2.1.2 Parallel OT Analysis

Hyde (2007) shows that it is not possible to account for the *Wergaia* stress pattern using only the standard parsing constraints (*ALLFTL/R*, *PARSE-σ*, *FTBIN*) in parallel OT, but that a high-ranked rhythm constraint like *\*CLASH*, defined in (23) (Kager 1994, Prince 1983, Selkirk 1984), makes an analysis possible.

(23) *\*CLASH*

Assign one violation mark for every adjacent pair of stressed syllables

To see why *\*CLASH* is necessary, consider the input */delguna/*, a sequence of a heavy syllable followed by two light syllables. The tableau in (24) shows that this input is incorrectly parsed as  $*[(^del)(,guna)]$ , rather than the correct  $[(^delgu)na]$ . The

grammar of Weɽgaia must permit ('H) feet in order to account for mappings like /bunaɖug/ → [( 'buna)(ɖug)], but in (24) the incorrectly optimal candidate capitalizes on this by placing a monosyllabic foot in *initial* position in order to achieve better overall satisfaction of PARSE-σ.

(24) Weɽgaia /HLL/ ↘ [( 'HL)L] — Wrong result

/delguna/ 1st iteration	FTBIN	PARSE-σ	ALLFTL	ALLFTR
☹ a. ('delgu)na		1		1
→ b. ('del)(guna)			1	2

Since the wrong winner in (24), ('del)(guna), has a stress clash, which no words of Weɽgaia show on the surface, we may posit that \*CLASH is undominated in this language to achieve the desired stress pattern. This rules out the mapping /HLL/ → [( 'H)(LL)] in (24), and instead predicts the right result for this input, as shown in (25). This ranking is consistent with the other attested mappings in Weɽgaia since no surface forms in the language violate \*CLASH.

(25) Weɽgaia /HLL/ → [( 'HL)L] in parallel OT with high-ranked \*CLASH

/delguna/ 1st iteration	*CLASH	FTBIN	PARSE-σ	ALLFTL
→ a. ('delgu)na			1	
b. ('del)(guna)	W <sub>1</sub>		L	W <sub>1</sub>

It would not be possible to change the definition of FTBIN to avoid the need for \*CLASH in this analysis. If FTBIN were defined to prefer strictly disyllabic feet, this would produce the right result for /delguna/ → [( 'delgu)na], but then /bunaɖug/ would be incorrectly parsed as ('buna)ɖug, rather than the correct ('buna)(ɖug). Similarly, a definition of FTBIN that preferred feet to be strictly bimoraic would correctly account for /bunaɖug/ → [( 'buna)(ɖug)], but would not correctly analyze /delguna/, which surfaces with a trimoraic foot, ('delgu)na. Thus, a constraint defined as a bimoraic *minimum*, as FTBIN has been defined here, is necessary for an analysis of Weɽgaia and other generalized trochee languages, in both HS and in

parallel OT. In the HS analysis incremental foot building accounts for the limited distribution of ('H), while in the parallel OT analysis this is achieved with \*CLASH.

### 2.2.2 Non-local weight sensitivity (unattested)

It is clear that a relatively straightforward analysis of *Wetgaia* is possible in both HS and in the standard theory of stress in parallel OT with the addition of a commonly used rhythm constraint. But the constraints needed for the standard analysis in section 2.2.1.2 predict other partially-quantity-sensitive stress patterns which are non-local and are not attested, revealing an over-generation problem for the standard theory of stress in parallel OT. The discussion in this section follows Hyde (2007), though very similar problems for the standard theory are discussed by Frampton (2007) and Karttunen (2006).

When rhythm constraints like \*CLASH are ranked low enough to allow the standard parsing constraints to dictate stress patterns, Hyde demonstrates that a class of languages that have “a very peculiar type of weight sensitivity” (2007:312) is predicted to exist. With the ranking FTBIN » PARSE-σ » ALLFTL » \*CLASH for example, parallel OT generates a language with the stress system illustrated in the following tableaux.

When no heavy syllables are present in a word with an odd number of syllables, the parsing appears to be unambiguously left-to-right, as shown in (26)

(26) Left-to-right parsing<sup>5</sup>

/LLLL/ 1st iteration	FTBIN	PARSE-σ	ALLFTL	*CLASH
→ a. ('LL)(‘LL)L		1	2	
b. ('LL)(‘LL)(‘L)	W <sub>1</sub>	L	W <sub>6</sub>	
c. L(‘LL)(‘LL)		1	W <sub>4</sub>	

<sup>5</sup>In using the terminology “left-to-right”, I intend to describe the surface alignment of feet that emerges from a parallel OT analysis. Since feet are assigned all-at-once in a parallel theory there is no true directionality, but words can show what looks like directionality as a result of foot alignment.

However, as shown in (27), an initial heavy syllable is also parsed into a monosyllabic foot, as permitted by FTBIN, in order to better satisfy PARSE- $\sigma$  when an even number of syllables follows. Similarly, a medial heavy syllable with an even number of light syllables to its left and to its right is parsed as a monosyllabic foot in (28). \*CLASH will not be respected because it is low ranked, unlike what we find in generalized trochee languages.

(27) Maximal parsing with initial heavy syllable

/HLLL/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('H)('LL)('LL)			4	1
b. ('HL)('LL)L		W <sub>1</sub>	L <sub>2</sub>	L
c. ('HL)('LL)('L)	W <sub>1</sub>		W <sub>6</sub>	L

(28) Maximal parsing with medial heavy syllable

/LLHLL/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('LL)('H)('LL)			5	1
b. ('LL)('HL)L		W <sub>1</sub>	L <sub>2</sub>	L
c. ('LL)('HL)('L)	W <sub>1</sub>		W <sub>6</sub>	L

The tableau in (29) shows that this language is indeed only partially-quantity-sensitive. The input /HLHLH/ has three heavy syllables, and only one (the leftmost) is stressed and footed as a monosyllable, while the other two heavy syllables are parsed into the weak branch of a foot. Thus, heavy syllables are not preferred to be stressed generally under this ranking, and in fact are only parsed as monosyllabic feet when doing so improves the word's overall performance on PARSE- $\sigma$ . When several heavy syllables can serve this purpose, the choice between them is made by ALLFTL, as comparing candidate (a) with (b) and (c) in tableau (29) reveals.<sup>6</sup>

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<sup>6</sup>As Hyde notes, picking the *leftmost* H to foot as a monosyllable is a result of the preference of the left-alignment constraint (as shown in (29)) and is related to the known preference for alignment constraints to attract monosyllabic feet towards the dominant edge of alignment in parallel OT (Crowhurst and Hewitt 1995a). Alignment constraints in HS do not show this behavior, as shown in chapter 5 (§5.2.2).

(29) Maximal parsing with initial, medial, and final heavy syllables

/HLHLH/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('H)('LH)('LH)			4	1
b. ('HL)('H)('LH)			W <sub>5</sub>	1
c. ('HL)('HL)('H)			W <sub>6</sub>	L
d. ('HL)('HL)H		W <sub>1</sub>	L <sub>2</sub>	L

This point is reinforced by tableau (30), which shows that heavy syllables appearing in even-numbered syllables of odd-parity words are not stressed, and they never form monosyllabic feet because doing so does not improve performance on PARSE- $\sigma$  (and in this case, it actually degrades performance). The tableaux in (31) and (32) show furthermore that heavy syllables in even-parity words are not parsed into monosyllabic feet, even when PARSE- $\sigma$  can be equally satisfied by doing so (e.g., candidate (b) in (32)).

(30) Odd-numbered syllables heavy, no weight sensitivity

/LHLHL/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('LH)('LH)L		1	2	
b. L('HL)('HL)		1	W <sub>4</sub>	
c. L('H)L('H)L		W <sub>3</sub>	W <sub>4</sub>	

(31) Even-parity, no weight sensitivity

/HLLL/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('HL)('LL)			2	
b. ('H)('LL)L		W <sub>1</sub>	L <sub>1</sub>	W <sub>1</sub>

(32) Even parity, no weight sensitivity

/HLLH/ 1st iteration	FTBIN	PARSE- $\sigma$	ALLFTL	*CLASH
→ a. ('HL)('LH)			2	
b. ('H)('LL)('H)			W <sub>4</sub>	W <sub>1</sub>

The result of this ranking is a stress system described in terms of weight-sensitivity in the following way, paraphrasing Hyde (2007:312): parsing is *insensitive* to the weight of a heavy syllable when it occurs in an even-numbered

syllable of an odd-parity word, or any syllable of a word with even parity; parsing *is* sensitive to the weight of a heavy syllable when it occurs in an odd-numbered syllable of an odd-parity word, and is the closest heavy syllable to the left edge of the word among those heavy syllables with these properties. The description of this stress pattern is necessarily somewhat convoluted. A schematic illustration is given in (33).

(33) Schematic summary of predicted language

a. Even parity words

$\sigma\sigma\sigma\sigma \rightarrow (' \sigma\sigma)( ' \sigma\sigma)$

were  $\sigma$  = any weight (H or L)

b. Odd parity words

$L\sigma L\sigma L \rightarrow (' L\sigma)( ' L\sigma)L$

$H\sigma\sigma\sigma\sigma \rightarrow (' H)( ' \sigma\sigma)( ' \sigma\sigma)$

$L\sigma H\sigma\sigma \rightarrow (' L\sigma)( ' H)( ' \sigma\sigma)$

$L\sigma L\sigma H \rightarrow (' L\sigma)( ' L\sigma)( ' H)$

etc.

For Hyde, this prediction is one of several stress patterns produced by the standard theory that show an odd pattern of weight-sensitivity. In the rest of this subsection I offer a different way of viewing this problematic prediction, in terms of (non)locality (see also, Frampton 2007). Although an input with an odd number of light syllables suggests that the language uses left-to-right parsing, as was shown in (26), the other forms in the language fail to show a consistent direction of metrification. For an input like /HLLLL/, the outcome is ('H)('LL)('LL) with the heavy syllable parsed as a monosyllabic foot, as was shown in (27), while for /HLLL/, it is ('HL)('LL) with the heavy syllable parsed into a disyllabic foot with the immediately following syllable, as in (31). The strangeness of this stress system derives from the fact that the parity count of the syllables in the word must be known in order to know how to parse an initial heavy syllable despite the fact that it otherwise appears to be a left-to-right stress system. If the total number of syllables in the word is odd, as in /HLLLL/, then an initial heavy is parsed as a monosyllabic foot, but if the total number is even, as in /HLLL/, an initial heavy is parsed into a disyllabic foot with the syllable that follows, whether heavy or light.



Providing a generalization for how a given word-*medial* heavy syllable will be parsed in this language reveals the pattern to be very much like the non-local truncation process discussed in the introduction. For a given word-medial heavy syllable, it is parsed into a monosyllabic foot if and only if there are no heavy syllables in odd-numbered syllables to its left *and* there are an even number of syllables to its right; otherwise, it will be parsed into a disyllabic foot<sup>7</sup> (this can be confirmed by consulting (33)). In stress systems it is common for the metrification of a particular syllable to depend on information at an unbounded distance preceding *or* following a syllable, though not both—a word-medial syllable in a language with rightward alternating trochaic stress like Pintupi (see chapter 1 (§1.3.2)) will be stressed if an even number of syllables precede (unbounded) and if it is not adjacent to the right edge of the word (bounded), otherwise the syllable does not receive stress. This kind of dependency is naturally explained by the directional iteration of foot-building. But the unattested language predicted by the standard theory in parallel OT effectively relies on information at unbounded distances in *both* directions in order to know how to treat an individual syllable. In this sense, the prediction is nearly identical in character to the non-local truncation example.<sup>8</sup>

This prediction is problematic because a language with non-local weight sensitivity of this kind has not been attested. Attested stress systems with weight distinctions overwhelmingly demonstrate them to be local. In Wergaia it is only at the end of the metrical parse that parsing is sensitive to the weight of a final stray syllable; in other quantity-sensitive trochaic languages heavy syllables are treated uniformly throughout the word or are only affected only by their local context.

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<sup>7</sup>It will be the stressed member of the disyllabic foot if an even number of syllables precedes and an odd number follow, and it will be unstressed member of the disyllabic foot if the reverse is true.

<sup>8</sup>Recall the non-local truncation description in the introduction: a given vowel or non-sonorant consonant will delete if and only if there is no sonorant consonant to its right but there is one to its left.

Given the strange character of the non-local pattern just described, it is not plausibly an accidental gap in the typology of stress but instead appears to be an example of undesirable over-generation for the standard theory of stress in parallel OT.

What can be done to eliminate this prediction from the standard theory? Positing new constraints is not a successful strategy, because expanding CON can only ever add languages to the predicted typology of a given set of constraints. Although there are rankings in which this prediction does not surface, there will always be a ranking in which constraints that prevent it (\*CLASH for example) are ranked too low to matter. Removing or modifying the responsible constraints would be a more promising step towards preventing this prediction, but it is difficult to do this and still preserve the ability to analyze Wergaia and similar languages without venturing well beyond the standard theory. The burden of responsibility for this prediction lies with PARSE- $\sigma$  and FTBIN when implemented with parallelism.<sup>9</sup> But a constraint like PARSE- $\sigma$  is required to motivate footing under standard representational assumptions, and the definition of FTBIN used here reflects the need for a constraint that bans ('L) while allowing other foot types, which was argued for in §2.2.1.1.<sup>10</sup> Some of the characteristics of this strange language appear to be due to gradient alignment constraints (ALLFTL/R). Nonetheless, theories that abandon gradient alignment in favor of other constraints to model directionality (e.g., Kager 2001, McCarthy 2003) will still predict non-local partially-quantity-sensitive stress patterns if PARSE- $\sigma$  and FTBIN are retained; when high-ranked, these constraints conspire to place monosyllabic feet wherever necessary to maximize the parsing of the whole word, despite the preferences of lower-ranking constraints.

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<sup>9</sup>Hyde (2007) also provides arguments that PARSE- $\sigma$  and FTBIN are the locus of this problem.

<sup>10</sup>Further support for this definition of FTBIN, given the representational assumptions of the standard theory, can be found in languages that use strictly disyllabic feet and yet employ a bimoraic word minimum (Hayes 1995, Kager 1992a,b). Pintupi is an example of such a language.

It seems the standard theory of stress in parallel OT requires a more radical revision. Hyde’s 2007 analysis solves the problem for parallel OT by altering the standard representational assumptions to force exhaustive parsing and by changing CON to eliminate many of the standard constraints, including PARSE- $\sigma$  and FTBIN, in favor of constraints from the NONFINALITY family. In the next section I show that HS allows a different solution, even when no changes to CON or the standard representational assumptions are made. IFO uses a serial derivation that lacks foresight, and as a result, its concomitant local decision-making cannot produce the unattested non-local stress system under any ranking of the standard constraints. A comparison between the solution advocated here and the one presented by Hyde is delayed until §2.5.1.

### 2.2.3 Why HS is local

The previous section showed that parallel OT predicts an unattested language with the ranking FTBIN » PARSE- $\sigma$  » ALLFTL » \*CLASH. In IFO, on the other hand, the attested generalized trochee pattern is produced under this ranking, as was evidenced in §2.2.1.1.<sup>11</sup> Showing a different outcome in parallel vs. serial OT for a given ranking is not, by itself, particularly informative. Instead, we are interested in a typological claim—that the non-local stress system predicted by the standard theory of stress in parallel OT is not predicted by IFO at all, given reasonable assumptions about CON. Showing that a language cannot be produced in HS requires demonstrating that there is no combination of harmonically-improving derivations that produces the relevant set of optima under a single ranking (McCarthy 2010a,b). This section shows that HS/IFO indeed does not produce the unattested

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<sup>11</sup>Although \*CLASH was not present in the analysis in that section, it can be verified that the resulting language would be unchanged were it to be included.

language discussed in the previous section under any ranking of standardly assumed stress constraints.

The hypothetical language discussed in the previous section had the strange property of appearing to base parsing decisions on word parity. To show that the same language cannot be produced with IFO, we must demonstrate that the theory will not allow an input like /HLLL/ to become ('HL)('LL) and input like /HLL/ to become ('H)('LL), while also generating a pattern that looks left-to-right in a word comprising an odd number of light syllables, /LLLLL/ → ('LL)('LL)L. These input-output pairs would require derivations like those in (34).

- (34) Derivations required for hypothetical language
- a. /HLLL/ → ('HL)LL → ('HL)('LL)
  - b. /HLL/ → ('H)LL → ('H)('LL)
  - c. /LLLLL/ → ('LL)LLL → ('LL)('LL)L

There is no ranking of the standard constraints that will produce the derivations in (34) with IFO. At the first iterations, a ranking that would prefer /HLLL/ → ('HL)LL as required for (34a) would also prefer /HLL/ → ('HL)L, contrary to what is found in (34b). The tableaux in (35) show this result. These inputs are treated the same at the first iteration. The grammar does not have the foresight to know that ('H)('LL) is the global optimum for input /HLL/ so it will not take this into account at the first iteration and choose ('H)LL instead. Furthermore, the Free Element Condition (Prince 1985; see chapter 1) prevents the actual first iteration's optimum, ('HL)L, from becoming ('H)('LL) at a subsequent step.<sup>12</sup>

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<sup>12</sup>If the FEC were not assumed then it is possible that the correct prediction would be lost in this case. Specifically, this would happen if ('H)('LL) were in the candidate set for an iteration with input ('HL)L. Whether this could occur depends crucially on what foot-altering (as opposed to foot-building) operations are assumed in GEN if the FEC is abandoned, which I have not attempted to address here. For IFO to fully reproduce the non-local language from §2.2.2 it would also have to be the case that an iteration with input ('HL)('LL)L admits ('H)('LL)('LL) into its candidate set (and so on for larger words), which would significantly weaken the definition of gradualness.

(35) Disyllabic trochee preferred in both derivations (1st iteration)

	/HLL/ 1st iteration	FtBIN	PARSE- $\sigma$	ALLFtL	*CLASH
a.	a. ('H)LL		W <sub>2</sub>		
	→ b. ('HL)L		1		
	/HLL/ 1st iteration	FtBIN	PARSE- $\sigma$	ALLFtL	*CLASH
b.	a. ('H)LLL		W <sub>3</sub>		
	→ b. ('HL)LL		2		

In a similar way, a ranking that would produce /HLL/ → ('H)LL as is needed for (34b), would also prefer /HLLL/ → ('H)LLL, contrary to (34a). This is shown in (36). These tableaux show that when a constraint favoring ('H) over ('HL), which I abbreviate \*('HL), outranks PARSE- $\sigma$ , it favors ('H) in *both* derivations, not just the top one.<sup>13</sup>

(36) Monosyllabic heavy preferred in both derivations (1st iteration)

	/HLL/ 1st iteration	FtBIN	*('HL)	PARSE- $\sigma$	ALLFtL	*CLASH
a.	→ a. ('H)LL			2		
	b. ('HL)L		W <sub>1</sub>	L <sub>1</sub>		
	/HLL/ 1st iteration	FtBIN	*('HL)	PARSE- $\sigma$	ALLFtL	*CLASH
b.	→ a. ('H)LLL			3		
	b. ('HL)LL		W <sub>1</sub>	L <sub>2</sub>		

Finally, it is not the case that ('H)(LL) and ('HL)(LL) are predicted to *never* co-occur as outputs in the same language, but rather, they could not both occur in a language whose dominant parsing direction is left-to-right. If the dominant parsing mode is instead right-to-left, which assumes the ranking ALLFtR » ALL-FtL, they could both be optimal with the derivations in (37). Crucially however, this ranking would make the entire stress system right-to-left, and the initial heavy

<sup>13</sup>Actually, the ranking in (36) will favor building ('LL) feet before monosyllabic feet, though the eventual output will be the same as that intended here.

syllables would be at the end of the metrical parse rather than the beginning. Thus, the presence of optima ('H)('LL) and ('HL)('LL) in a language entails right-to-left parsing in IFO, which is consistent with the fact that IFO predicts only local stress systems.<sup>14</sup>

- (37) a. /HLLL/ → HL('LL) → ('HL)('LL)  
 b. /HLL/ → H('LL) → ('H)('LL)  
 c. /LLLLL/ → LLL('LL) → L('LL)('LL)

Thus, the combination of outputs in the unattested language from §2.2.2, though all optimal under the same ranking in parallel OT, cannot be modeled as outputs in the same language in HS/IFO with these constraints. The fact that languages of this sort do not exist lends some support to traditional views of metrical parsing. The standard theory of stress in parallel OT predicts a stress pattern that determines how to parse an HL sequence, as ('HL) or as ('H)L, based on properties of the word that would not yet be evident if parsing proceeds from left to right. When feet are built incrementally, as in IFO, each foot is affected by its local context, which may include previously built feet, but a given syllable cannot be treated differently depending on whether footing it a particular way leaves an even or odd number of syllables unparsed in the rest of the word.<sup>15</sup>

Like all typological claims in OT, this claim relies on an assumption about CON. Specifically, CON must not include constraints with definitions like “A foot should be followed by an even number of syllables” or “There should be an even number of unparsed syllables at all times”. If such constraints were admitted into the the-

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<sup>14</sup>A right-to-left stress system of this kind would be the mirror-image of the Wergaia-type generalized trochee pattern. This stress pattern would be local in the sense described in this chapter, though Hyde (2007) reports that right-to-left generalized trochee languages have not been attested.

<sup>15</sup>Frampton (2007) makes a similar observation regarding the relationship between locality and serialism.

ory this prediction would not hold, as it would then be possible to assess the consequences of a each foot choice for the potential metrical parses of the remaining syllables. A constraint of this kind could only set up the derivation for subsequent exhaustive footing indirectly, by referencing parity, but the constraint itself has no metrical characteristics. Instead, it would enforce an output preference that happens to be important for leading the way to the global optimum in this example. The exclusion of such constraints from CON does not seem unreasonable. In fact, the assumption of metrical theory is that parity counting is carried out exclusively via metrical representations, namely feet, and we would not generally expect a constraint to be afforded this power. However, allowing violations of PARSE- $\sigma$  and FTBIN to be assessed over a set of candidates with diverse, fully-specified metrical parses, as in parallel OT, effectively transfers the parity-counting power of feet beyond their normal purview to create the strange prediction outlined in the previous section. In the serial theory proposed here, the same constraints are prevented from doing this.

The theory of IFO proposed here lacks any source of derivational foresight by design. Although it can ‘see’ the whole word in each of its local evaluations, it does not envision the possible paths that each local optimum might lead to and does not know that some local optima may lead to a global optimum while others do not. Instead, it chooses based only on the relative harmony of the candidates at each iteration. As I have shown in this section, this is a desirable property of HS/IFO when compared with the standard theory of stress parallel OT, since it more accurately reflects the typology of stress systems and how and when properties of particular syllables can affect metrification. Global parsing maximization is par for the course in the standard theory, but since no language seems to stress words in this way, the standard theory is too permissive. In the next two sections I show that this is not an isolated case, and that the standard theory in parallel OT

predicts other non-local interactions that are not attested. In each case HS with IFO correctly predicts they should not occur.

## 2.3 Repairs to foot form

The relationship between quantity and stress is bidirectional—just as languages like Wergaia show that stress can be sensitive to syllable weight, so too can the distribution of syllable weight be sensitive to stress. In the previous section it was shown that when all metrical parses are compared in parallel, constraints on stress can conspire to predict non-directional stress systems with feet that take advantage of quantity just when doing so allows better satisfaction of the constraints on parsing. This section shows that these predictions extend to quantity adjustment *in response* to stress as well. The standard theory of stress in parallel OT predicts languages with non-local quantity adjustment processes (namely, shortening and lengthening) that selectively apply just when the parsing of the whole word improves as a result, but languages of this sort of have not been attested.

### 2.3.1 Local trochaic shortening in Fijian

Trochaic shortening is a quantity adjustment process wherein a stressed heavy syllable becomes light, usually by a process of vowel shortening, before an unstressed light syllable. This process is attested, according to Hayes (1995:148), in Fijian, Hawaiian, Tongan, (Middle) English, and some Italian dialects, and it is usually argued to be motivated by a preference for trochaic feet to group elements of equal weight (Hayes 1985, 1987, 1995, McCarthy and Prince 1986/1996, Mester 1994, Prince 1990; cf. Kager 1993). Shortening of the heavy syllable in an HL sequence allows it to be parsed into a balanced ('LL) trochaic foot, avoiding the unbalanced ('HL) trochee and under-parsed ('H)L. Fijian (Dixon 1988, Schütz 1985) will be used to exemplify trochaic shortening.



The stress system of Fijian is quantity-sensitive and is analyzed by Hayes (1995:142ff) with right-to-left moraic trochees, that is, with foot shapes ('H) and ('LL). Main stress falls on the final syllable if heavy, otherwise it surfaces on the penult; syllables with long vowels or diphthongs are counted as heavy. In general, secondary stresses fall on non-final heavy syllables, and sequences of light syllables are grouped into disyllabic trochees.<sup>16</sup> The data in (38) illustrate the basic patterns; the forms in (a) show stress in words ending with light syllables, and those in (b) show words with final heavy syllables.

(38) Fijian stress (Hayes 1995:142-143, from Schütz 1978, 1985, Dixon 1988)

	Word	Gloss	Proposed foot structure
a.	'lako	'go'	('LL)
	βi'naka	'good'	L('LL)
	ˌndiko'nesi	'deaconess'	(,LL)(('LL)
	ˌmbe:'leti	'belt'	(,H)(('LL)
	pa,ro:ka'ramu	'program'	L(,HL)(('LL)
b.	kil'a:	'know'	L('H)
	ˌndoke'ta:	'doctor'	(,LL)(('H)
	ˌndai,ˌreki'ta:	'director'	(,H)(,LL)(('H)
	pa,raima'ri:	'primary'	L(,HL)(('H)
	ˌnre:'nre:	'difficult'	(,H)(('H)

In Fijian no words end in a sequence of a heavy syllable followed by a light syllable (Schütz 1985:528-529, Dixon 1988:15, 26, Hayes 1995:145). Alternations confirm that this is an active prohibition, as the examples in (39) demonstrate. The roots in (a) consist of a single heavy syllable whose vowel is shortened when a

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<sup>16</sup>Secondary stresses are most easily seen in loan words, which tend to be longer than native monomorphemic words, but the direction of alignment of secondary stress feet may be subject to variation (see Hayes 1995:144 for some discussion). This does not affect the discussion of trochaic shortening in the language, and I do not discuss it further here.

monosyllabic light syllable affix is added. Dixon (1988) provides arguments from reduplication that the long vowel of these roots should be taken as underlying. The form in (b) shows an underlyingly HL root that undergoes shortening of the heavy syllable when unaffixed, but which surfaces faithfully when an affix displaces the heavy syllable out of penultimate position. Fijian trochaic shortening is obligatory when the HL sequence is word final, but it may optionally occur when a heavy syllable precedes an unparsed light syllable elsewhere in the word. I concentrate here on deriving the variant in which trochaic shortening applies word-finally but not word-medially.

(39) Fijian shortening (Dixon 1988:26-27, Schütz 1985:528)

- a. 'mbu: 'grandmother'  
       'mbu-ŋgu 'my grandmother'  
       'ða: 'bad'  
       'ða-ta 'hate/consider bad-TRANSITIVE'
- b. 'siβi 'exceed'  
       'si:βi-ta 'exceed-TRANSITIVE'

### 2.3.1.1 HS analysis

In an HS analysis, an input like /si:βi/ 'exceed' cannot become output [(si.βi)] in one step because shortening and foot building cannot happen simultaneously. This follows from the gradualness requirement in HS and the hypothesis that building a foot constitutes its own step. This leaves two possible derivations for an analysis of trochaic shortening: either shortening first, as in (40a) or foot-building first, as in (40b). Among the two logically possible orders, only (40b) can be correct. Each step must be harmonically improving relative to the constraint hierarchy, but shortening a heavy syllable before any metrification occurs, as in (40a), would not

improve harmony (McCarthy 2008c).<sup>17</sup> On the other hand, motivating shortening in (40b) is straightforward, since a constraint against ('HL) trochees is assumed to be in CON to reflect the preference for balanced trochees found in many languages.

(40) Possible orderings of shortening and foot-building

- a. /si:βi/ → siβi → ('si.βi) ✗
- b. /si:βi/ → ('si.βi) → ('si.βi) ✓

The IFO analysis will again use the standard stress constraints *PARSE-σ*, *ALL-FtL/R*, and *FtBIN*, to analyze Fijian stress, along with additional constraints to account for the trochaic shortening process, including: (i.) a markedness constraint against ('HL) trochees, (ii.) a markedness constraint compelling the initial formation of ('HL) (to be ranked above the \*HL constraint), and (iii.) a faithfulness constraint against shortening (to be ranked below the \*HL constraint).

There are several extant proposals in OT for a constraint preferring balanced trochees (i.e., ('LL) and ('H) over ('HL)). Prince and Smolensky's (1993/2004) *RHHRM* (for 'rhythmic harmony') is violated by an ('HL) foot in their analysis of Latin stress; Alber (1997) and McCarthy (2008c) adopt a constraint that summarizes the Iambic/Trochaic Law of Hayes (1995) by preferring balanced trochees and unbalanced iambs, abbreviated *ITL* or *I/TL*; and Kager (1999) adopts a constraint sensitive to rhythm on the moraic level, called *RHCONTOUR*, to penalize both an ('HL) trochee and an (L'L) iamb.<sup>18</sup> Any of these would suffice for an analysis of

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<sup>17</sup>A high-ranking general constraint against long vowels or heavy syllables could of course produce the derivation in (40a), but it would also shorten every long vowel in the word/language.

<sup>18</sup>A point of difference among these sources is whether the constraint that penalizes ('HL) also penalizes ('LH). The definitions used by Alber (1997) McCarthy (2008c) penalize both, while those of Prince and Smolensky (1993/2004) and Kager (1999) do not. But there is general agreement that a constraint against heavy syllables in the weak branch of a foot is independently required (e.g., the Weight-to-Stress Principle of Prince 1990), so ('LH) can also be ruled out on these grounds. A constraint like Weight-to-Stress can also be used to rule out ('HH) feet in moraic trochee languages like Fijian.

trochaic shortening here. I adopt the constraint in (41), which penalizes both ('HL) and ('LH), for ease of exposition in the rest of this section.

(41) **BALANCED-TROCHEE (BAL-TROCH)**

Assign one violation mark for a trochee that groups elements of unequal quantity

There must be a markedness constraint ranked over BAL-TROCH to motivate the construction of ('HL). To account for Fijian's obligatory penult shortening, this constraint must compel only a word-final HL sequence to be parsed as ('HL), while permitting non-final HL sequences to be parsed ('H)L. This can be achieved with a constraint that prefers a foot aligned to the right edge of the word, defined in (42) (McCarthy and Prince 1993a).<sup>19</sup>

(42) **ALIGNWDR**

Assign a violation mark for a word that does not have a foot at its right edge

The tableaux in (43) and (44) demonstrate the ranking required for these parses. ALIGNWDR dominates BAL-TROCH to motivate ('HL) word-finally, as shown in (43).

(43) Final HL sequence parsed as ('HL)

/si:βi/ 1st iteration	ALIGNWDR	BAL-TROCH	PARSE-σ
→ a. ('si:βi)		1	
b. ('si:)βi	W <sub>1</sub>	L	W <sub>1</sub>

---

<sup>19</sup>Elsewhere in this dissertation (namely, chapter 3 (§3.5.2)) I argue that ALIGNWD constraints are not well-motivated, particularly ALIGNWDR. In *most* cases that appear to require ALIGNWD, it is really the primary-stress-specific head-alignment constraint that is responsible for compelling a foot toward an edge in opposition to other constraints. Consistent with this assumption, I argue in chapter 4 (§4.2.1) that Fijian should be analyzed with ALIGNHDFTR instead. With the substitution of ALIGNHDFTR in all of the tableaux in this section the analysis is otherwise unchanged.

And to ensure that the language prefers ('HL) word-medially, BAL-TROCH must dominate PARSE- $\sigma$ , which would otherwise exert its preference for the larger ('HL) foot in word-medial positions as well, as shown in (44).

(44) Non-final HL sequence parsed as ('H)L

	paro:ka('ramu) 2nd iteration	ALIGNWDR	BAL-TROCH	PARSE- $\sigma$
a.	pa(,ro:ka)('ramu)		W <sub>1</sub>	L <sub>1</sub>
→ b.	pa(,ro:)ka('ramu)			2

Finally, the relevant faithfulness constraint against shortening is MAX- $\mu$ , defined as in (45), under the assumption that vowel shortening involves the loss of a mora.

(45) MAX- $\mu$

Assign one violation mark for a mora in the input that does not have a correspondent in the output

The tableau in (46) shows the final ranking with the full derivation for /si: $\beta$ i/, which undergoes trochaic shortening and surfaces as [( $\beta$ si $\beta$ i)]. The rankings ALIGNWDR » BAL-TROCH » PARSE- $\sigma$  and BAL-TROCH » MAX- $\mu$  were just established. In addition, FTBIN dominates BAL-TROCH because a final light syllable is not a possible way to satisfy ALIGNWDR, as shown in (46d). We also assume that TROCHEE is undominated and that the ranking PARSE- $\sigma$  » ALLFTR » ALLFTL accounts for iterative right-to-left footing.

## (46) Trochaic shortening in HS/IFO

	/si:βi/ 1st iteration	FTBIN	ALIGNWDR	BAL-TROCH	MAX-μ	PARSE-σ
↙	a. si:βi		W <sub>1</sub>	L		W <sub>2</sub>
↘	b. ('si:βi)					
	<b>2nd iteration</b>					
	c. ('si:βi)		W <sub>1</sub>	L		W <sub>1</sub>
	d. si:(βi)	W <sub>1</sub>		L		W <sub>1</sub>
	e. siβi		W <sub>1</sub>	L	W <sub>1</sub>	W <sub>2</sub>
	f. ('si:βi)			W <sub>1</sub>	L	
↙	g. ('siβi)				1	

(Convergence step not shown)

→ **Output:** [(siβi)]

The tableau in (47) shows the full derivation for input /paro:karamu/ 'program', in which the medial HL sequence is parsed as ('H)L and does not undergo shortening, surfacing as [pa(,ro:)ka('ramu)]. The final ranking is summarized in (48).<sup>20</sup>

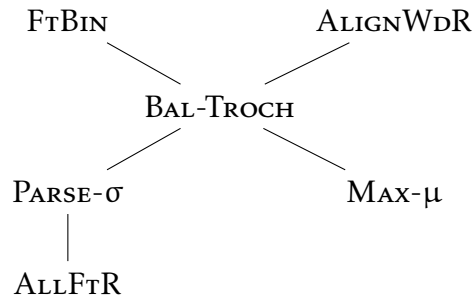
## (47) Moraic trochee stress in HS

	/paro:karamu/ 1st iteration	FTBIN	ALIGNWDR	BAL-TROCH	PARSE-σ
	a. paro:karamu		W <sub>1</sub>		W <sub>5</sub>
↙	b. paro:ka('ramu)				3
↘	<b>2nd iteration</b>				
	c. paro:ka('ramu)				W <sub>3</sub>
↙	d. pa(,ro:)ka('ramu)				2
↘	e. pa(,ro:ka)('ramu)			W <sub>1</sub>	L <sub>1</sub>
	<b>3rd iteration</b>				
↙	f. pa(,ro:)ka('ramu)				2
↘	g. (,pa)(,ro:)ka('ramu)	W <sub>1</sub>			L <sub>1</sub>
	h. pa(,ro:)(,ka)('ramu)	W <sub>1</sub>			L <sub>1</sub>

→ **Output:** [pa(,ro:)ka('ramu)]

<sup>20</sup>To account for the fact that word-medial HL sequences may optionally shorten to ('LL) in Fijian, we can assume that BAL-TROCH and PARSE-σ are in a variable or stochastic ranking (Anttila 1997, 2002, Boersma 1997; see Kimper 2011 on variable ranking in HS). The obligatory penult shortening process occurs under both rankings, but only when PARSE-σ dominates BAL-TROCH do word-medial HL sequences become parsed as ('HL) and undergo shortening at a subsequent step.

(48) Fijian trochaic shortening ranking in HS



The analysis of trochaic shortening in IFO requires a derivation that goes through an intermediate step containing a foot shape, ('HL), that arguably does not occur on the surface in Fijian. Potential differences between intermediate and surface forms are a consequence of a derivational theory with violable constraints and constraint prioritization. The ('HL) foot is the best way to satisfy *ALIGNWDR* in Fijian, as the tableau in (46) showed, and because of the ranking *BAL-TROCH* » *MAX-μ*, *any* ('HL) foot built at an intermediate step in the derivation will be shortened to ('LL) in a subsequent step. It will always be harmonically improving to shorten ('HL) in this language because of this ranking, and therefore the absence of ('HL) feet on the surface is not evidence that they cannot form part of a licit derivation (see also, McCarthy 2008c).<sup>21</sup>

In fact, the intermediate stages in the Fijian derivation echo typologically well-attested output preferences. The building of an intermediate ('HL) foot reflects the need to satisfy *ALIGNWDR* at the expense of foot form (though see footnote 19). Although Fijian corrects the dispreferred foot in a subsequent step, other languages

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<sup>21</sup>An objection has been raised (e.g., Pruitt 2010:507, fn. 20) about whether children could ever learn to posit the intermediate structure of the ('HL) step with no surface evidence for it. The response to this objection is that learning an HS derivation is like learning any other 'hidden structure', including underlying forms and foot boundaries, neither of which is directly observable in the surface forms of a language (Tesar and Smolensky 2000, Tesar 2004). Although general solutions to learning hidden structure are still being developed, the problem facing a learner of an HS grammar is not significantly different from that which is posed by any phonological grammar with abstract underlying forms, metrical feet, syllables or other unpronounced phonological representations. See Staubs and Pater (to appear) for a proposal for learning derivations in HS.

tolerate a less-than-perfect foot on the surface in order to satisfy an ALIGNWD constraint. Two examples are German (Alber 1997, 2005) and Finnish (Hanson and Kiparsky 1996, Alber 1997, 2005). In Finnish, a disyllabic foot appears at the left edge of the word, satisfying ALIGNWDL, no matter the weight of the initial two syllables. Elsewhere in the word foot building is sensitive to weight by sacrificing violations of general ALLFTL in order to avoid ('LH) feet, with occasional ternary rhythm as the result. The HS analysis, in which a surface-ill-formed foot is (temporarily) tolerated to satisfy ALIGNWDR, receives some support from the fact that other languages display the same trade-off overtly, because they demonstrate that sacrificing preferred foot-form is indeed an attested way of satisfying an ALIGNWD constraint.

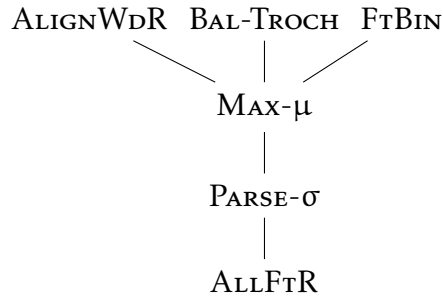
#### 2.3.1.2 Parallel OT analysis

The standard theory of stress in parallel OT handles trochaic shortening in much the same way as the IFO analysis above (i.e., using the same constraints), though of course it must do so non-derivationally. The analysis presented in this section is essentially the same as the analysis of Fijian in Kager (1999) and is somewhat similar to Prince and Smolensky's (1993/2004) analysis of "iambo-cretic" shortening in Latin.

The same constraints from the previous section are needed, though their ranking is slightly different in the parallel OT analysis. I will first assert the ranking and then point to the ranking arguments in the tableaux that follow. The ranking that is necessary is shown in (49), assuming additionally that TROCHEE is undominated and that ALLFTL is ranked below ALLFTR. The reasons for a difference in the ranking required for parallel OT and HS will be discussed in the next section.



(49) Fijian trochaic shortening ranking in parallel OT



The tableaux in (50) and (51) show input /si:βi/ undergoing shortening and footing to ['si:βi] and input /pa:ro:karamu/ being parsed into moraic trochees, [pa(ro):ka(ramu)]. The justification for the ranking in (49) should be evident in these tableaux. According to (50), FtBIN, ALIGNWDR, and BAL-TROCH must all dominate MAX-μ, since the winning candidate violates MAX-μ but still beats candidates who avoid mora deletion by incomplete parsing. Tableau (51) shows in addition that MAX-μ dominates PARSE-σ so that trochaic shortening does not happen in other environments, even though it would allow better satisfaction of PARSE-σ.

(50) Trochaic shortening in parallel OT

	<i>FtBIN</i>	<i>ALIGNWDR</i>	<i>BAL-TROCH</i>	<i>MAX-μ</i>	<i>PARSE-σ</i>
a. si:βi		W <sub>1</sub>		L	W <sub>2</sub>
b. siβi		W <sub>1</sub>		1	W <sub>2</sub>
c. si:(βi)	W <sub>1</sub>			L	W <sub>1</sub>
d. ('si:βi)			W <sub>1</sub>	L	
→ e. ('siβi)				1	
f. ('si:)βi		W <sub>1</sub>		L	W <sub>1</sub>

## (51) Moraic trochees in parallel OT

/paro:karamu/	<i>F<sub>T</sub>BIN</i>	<i>ALIGN<sub>WDR</sub></i>	<i>BAL-TROCH</i>	<i>MAX-μ</i>	<i>PARSE-σ</i>
a. paro:karamu		W <sub>1</sub>			W <sub>5</sub>
b. paro:ka('ramu)					W <sub>3</sub>
→ c. pa(ro:)ka('ramu)					2
d. pa(ro:)(,ka)('ramu)	W <sub>1</sub>				L <sub>1</sub>
e. pa(ro:ka)('ramu)			W <sub>1</sub>		L <sub>1</sub>
f. pa(roka)('ramu)				W <sub>1</sub>	L <sub>1</sub>

## 2.3.2 Non-local trochaic shortening (unattested)

IFO and parallel OT are equally able to account for Fijian penult trochaic shortening, but we can evaluate the analyses based on their predictions about other languages. The crucial ingredients in the parallel OT analysis of Fijian are essentially the same as those in the IFO analysis—the ranking of *MAX-μ* below *ALIGN<sub>WDR</sub>*, *BAL-TROCH*, and *F<sub>T</sub>BIN* prevents ('HL), ('HL), and H('L) from being optimal, favoring instead ('LL). But the ranking and behavior of *PARSE-σ* and *MAX-μ* is a crucial difference between the theories.<sup>22</sup> Unlike IFO, the parallel OT analysis requires that *MAX-μ* dominate *PARSE-σ* in order to limit shortening to only word-final HL sequences (with the assumption that we are deriving the variant of Fijian in which word-medial shortening does not occur). In IFO the constraints were unrankable because they did not conflict. If this ranking is reversed to *PARSE-σ* » *MAX-μ*, an unattested language with non-local shortening is predicted to exist by the paral-

<sup>22</sup>The other difference is less crucial: in IFO, *ALIGN<sub>WDR</sub>* must dominate *BAL-TROCH* in order for ('HL)# to win over a misaligned competitor with a balanced trochee (namely, ('H)L#), but in parallel OT, *ALIGN<sub>WDR</sub>* and *BAL-TROCH* cannot be ranked because all surface forms satisfy both constraints. See McCarthy (2006, 2010a) for discussion of these kinds of ranking differences between parallel OT and HS.

lel theory, but not the serial one. The following paragraphs demonstrate why this prediction is undesirable.

Under a ranking such as BAL-TROCH, PARSE- $\sigma$  » MAX- $\mu$ , the high ranking of PARSE- $\sigma$  and BAL-TROCH will conspire to produce non-local shortening patterns. We can otherwise keep the ranking the same as in the Fijian analysis: PARSE- $\sigma$  » ALLFTR » ALLFTL for iterative right-to-left parsing, and undominated TROCHEE and FTBIN for minimally bimoraic trochees. (The ranking of ALIGNWDR will not be crucial in this language so it is omitted from the discussion.) With this grammar, inputs with heavy syllables in final position will undergo shortening if (and only if) the global harmony of the metrical parse is improved by doing so.

A word with a final heavy syllable that is preceded by an *even* number of light syllables will *not* exhibit shortening of the heavy syllable, as shown in (52), because an ('H) is a licit balanced trochee, and maximal parsing into feet while satisfying foot form is possible by parsing the even-parity string of light syllables into disyllabic trochees of the form ('LL).

(52) Maximal parsing possible without shortening

	/LLLLH/	BAL-TROCH	PARSE- $\sigma$	MAX- $\mu$	ALLFTR
→ a.	('LL)('LL)('H)				4
b.	L('LL)('LH)	W <sub>1</sub>	W <sub>1</sub>		L <sub>2</sub>
c.	L('LL)('LL)		W <sub>1</sub>	W <sub>1</sub>	L <sub>2</sub>

However, a word with a final heavy syllable preceded by an *odd* number of light syllables, *will* show shortening of the heavy syllable, as shown in (53). In this case, best satisfaction of PARSE- $\sigma$  and constraints on foot form (BAL-TROCH and FTBIN) is achieved only in a candidate that shortens the heavy to achieve an even number of light syllables, which can be fully parsed into disyllabic units.

(53) Shortening for maximal parsing<sup>23</sup>

/LLLH/	BAL-TROCH	PARSE- $\sigma$	MAX- $\mu$	ALLFTR
→ a. ('LL)('LL)			1	2
b. ('LL)('LH)	W <sub>1</sub>		L	2
c. L('LL)('H)		W <sub>1</sub>	L	L <sub>1</sub>

What makes this combination of optima problematic from a typological standpoint is that the language shows right-to-left parsing in odd-parity sequence of light syllables, as shown in (54). A simple directional description of this stress system is not easily formulated, because the parsing of syllables at the right edge of the word depends not only on the local environment, but also on the total parity count of the preceding syllables.

## (54) Right-to-right parsing

/LLLLL/	BAL-TROCH	PARSE- $\sigma$	MAX- $\mu$	ALLFTR
→ a. L('LL)('LL)		1		2
b. ('LL)('LL)L		1		W <sub>4</sub>

These inputs show a language with right-to-left parsing that must consider the parity count of the syllables preceding a final heavy syllable in order to know whether to parse it as a monosyllabic foot or to shorten it and parse it with the preceding syllable as a disyllabic foot. The prediction is even slightly more complicated than the tableaux in (52) through (54) suggest, since inputs with heavy syllables in other positions in the word must be considered. The result is a stress system that parses a heavy syllable as a monosyllabic foot if it occurs in an odd-numbered syllable of an odd-parity word and is the closest to the right edge of all

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<sup>23</sup>This example involves shortening what would have been an ('LH) foot rather than ('HL). I defined BAL-TROCH so that both are prohibited by the same constraint, but this is not essential to this prediction. As long as the standard theory assumes a constraint against ('LH) trochees (e.g., WEIGHT-TO-STRESS), this prediction emerges from parallel OT when it is ranked where BAL-TROCH currently is.

heavy syllables satisfying this requirement,<sup>24</sup> and shortens all other heavy syllables in the word (actually, in the language) to create ('LL) feet. Such a stress system has not been attested.

Variations on this non-local prediction, all unattested, are predicted with other permutations of these constraints in parallel OT. This class of languages clearly demonstrates non-local interactions between stress and quantity adjustments, because the number and position of light and heavy syllables throughout the word have to be taken into account in order to know whether to shorten a given heavy syllable, yet parallel OT predicts these languages using the same constraints required for an analysis of Fijian in the standard theory. It is difficult to imagine how a minimal change to the constraint set could rule out this prediction while continuing to admit local trochaic shortening. As argued in §2.2, a more radical change to the standard theory is required.

Non-local interactions of this sort are not something we would expect to see in a natural language stress system, and IFO predicts they should not occur. In the parallel OT analysis of Fijian's local shortening process, the ranking of  $\text{PARSE-}\sigma$  and  $\text{MAX-}\mu$  is crucial—under one ranking the attested shortening pattern of Fijian emerges but under the other we get the unattested language just described. In the IFO analysis on the other hand,  $\text{PARSE-}\sigma$  and  $\text{MAX-}\mu$  are unrankable because they do not conflict. It follows that both rankings of these constraints are consistent with local shortening in IFO, in contrast to parallel OT.

Furthermore, no other ranking of the standard constraints produces this pattern in IFO either. Reproducing the non-local shortening language would require inputs /LLLLH/ and /LLLH/ to be treated differently at the first step, as shown in

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<sup>24</sup>This is because only one heavy needs to be parsed alone to ensure an even number left over. It is the H closest to the right edge because alignment constraints prefer monosyllabic feet at the dominant alignment edge in parallel OT. See the related discussion in §2.2.2.

(55), with the final heavy syllable in (55a) parsed as a monosyllabic foot and the final heavy syllable in (55b) parsed as the dependent in a disyllabic foot. These steps cannot be made simultaneously optimal in IFO, by extension of the reasoning in §2.2.3, without spurious constraints that refer directly to word-parity. Thus, IFO predicts that metrically-conditioned quantity-adjustments should be local.

- (55) a. /LLLLH/ → LLLL('H) → LL('LL)('H) → [(('LL)('LL)('H)]  
 b. /LLLH/ → LL('LH) → LL('LL) → [(('LL)('LL)]<sup>25</sup>

The same constraints that were necessary for an analysis of Fijian in the standard theory of parallel OT predict unattested languages with non-local variants of the process as well. The similarity between the unattested language from §2.2 and the one discussed in this section should be obvious. Parallel evaluation permits non-local interactions because it considers all possible metrical parses and quantity adjustments at one time. IFO on the other hand accounts for Fijian trochaic shortening using the same constraints and representations, but gradualness prevents the prediction of the non-local variants. The next section turns to a final non-local prediction of the standard theory, the interaction of stress with restrictions at the edges of prosodic domains.

## 2.4 Edge restrictions

It is common for word-final syllables to be treated exceptionally in the assignment of stress, and avoidance of word-final stressed syllables can be found in many languages (Hung 1993, 1994, Prince and Smolensky 1993/2004). Languages that employ iambic (right-headed) feet risk stressing the final syllable when a foot is aligned to the right edge of the word, but in some of these languages a stress that

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<sup>25</sup>Or possibly /LLLH/ → LL('LH) → ('LL)('LH) → [(('LL)('LL)].

would be assigned to the final syllable through the default stress algorithm is instead realized on the penultimate syllable. Prince and Smolensky call this process “rhythmic reversal” (1993/2004:64).<sup>26</sup> In this section I show that rhythmic reversal is attested as a local process, in which the word-final foot is the only one that reverses, which will be exemplified with Axininca (Arawakan; Peru). IFO and parallel OT can equally capture local rhythmic reversal, but the constraints required for the analysis of local reversal in the standard theory of parallel OT also predict unattested languages with non-local reversal in which the effect of a constraint against word-final stress can permeate the word in the opposite direction of footing. This section concludes with a discussion of the stress system of Yidij, a language that has been presented as a counterexample to this typological claim.

#### 2.4.1 Local rhythmic reversal in Axininca

Stress in the Apurucayali dialect of Axininca (Payne, Payne, and Santos 1982, McCarthy and Prince 1993b) is generally quantity-sensitive, and in sequences of light syllables the stress pattern is straightforwardly left-to-right iambic—every other syllable beginning with the second is stressed, as shown in (56a). However, stress nearly always avoids the final syllable.<sup>27</sup> As a result, disyllabic words have initial stress, as in (56b), while polysyllables ending in an even number of light syllables vary between shifting the last stress to the penult and omitting the stress altogether, (56c).<sup>28</sup> In the analyses below I focus on deriving the variant with

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<sup>26</sup>Prince and Smolensky cite Choctaw, Munsee, Southern Paiute, Ulwa, and Axininca as languages that show this process at least in disyllabic words. Southern Paiute (which they analyze; 1993/2004:65) and Axininca (which I analyze here) also show this process in a word-final foot in longer words as well. Aguaruna has a similar process before syncope of unstressed vowels, according to McCarthy (2008c).

<sup>27</sup>Words with diphthongs in the final syllable are the exception.

<sup>28</sup>Determining which syllable receives primary stress requires a comparison between the last two feet based partly on a prominence scale (Payne, Payne, and Santos 1982). I ignore those distinctions here.

rhythmic reversal (i.e., penult stress), following an analysis in the standard theory by McCarthy and Prince (1993b).

(56) Axininca stress (McCarthy and Prince 1993b:159f, Payne, Payne, and Santos 1982:188-9, 193)

	Word	Gloss
a.	tʃ <sup>h</sup> orína	‘species of palm’
	itʃ <sup>h</sup> íkakína	‘he has cut me’
b.	sári	‘macaw’
	kító	‘shrimp’
c.	kimítáka ~ kimítaka	‘perhaps’
	hotítána ~ hotítana	‘he let me in’

#### 2.4.1.1 HS analysis

McCarthy and Prince (1993b) analyze rhythmic reversal in Axininca with a trochaic foot in final position that emerges as optimal in an otherwise iambic language in order to satisfy a constraint against stress on the final syllable. Their analysis can be straightforwardly adapted into HS using the same constraints and ranking. The HS analysis involves a derivation that builds left-aligned iambs until doing so would stress the final syllable, in which case iambic foot form is sacrificed in order to avoid the final stress. The proposed foot structures are [(i'tʃ<sup>h</sup>i)(ka'ki)na] ‘he has cut me’, [(‘sari)] ‘macaw’, and [(ki'mi)(‘taka)] ‘perhaps’. The constraint militating against final stress is NONFINALITY, defined in (57), which must outrank IAMB because it can compel a trochee to be built.

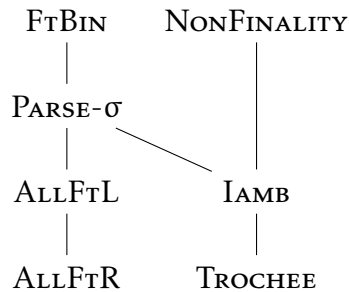
(57) **NONFINALITY**

Assign one violation mark for a word whose final syllable is stressed (McCarthy and Prince 1993b:160)



We must also assume the ranking  $\text{PARSE-}\sigma \gg \text{ALLFTL} \gg \text{ALLFTR}$  in order to enforce iterative left-to-right parsing,  $\text{IAMB} \gg \text{TROCHEE}$  in order to have a default preference for right-headed feet, and  $\text{FTBIN} \gg \text{PARSE-}\sigma$  because feet surfacing in Axininca never contain fewer than two moras. The final ranking that must be assumed is  $\text{PARSE-}\sigma \gg \text{IAMB}$ , which accounts for the fact that a trochaic foot surfaces word-finally even though leaving the syllables unfooted would allow vacuous satisfaction of  $\text{IAMB}$ . The ranking is summarized in the diagram in (58), and is exemplified in the tableaux that follow.

(58) Axininca stress ranking



The derivation of the regular iambic stress pattern in an odd-parity word will proceed as shown in (59).  $\text{NONFINALITY}$  is omitted from this tableau because it does not crucially decide any winners when regular parsing avoids the final syllable. At each of the first two steps an iambic foot is chosen as optimal. The third step shows convergence because the only remaining stress candidate fatally violates  $\text{FTBIN}$ , and (e) emerges as the winner.<sup>29</sup>

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<sup>29</sup>From these data, however, it is also feasible that it is  $\text{NONFINALITY}$  rather than  $\text{FTBIN}$  which is responsible for this decision; in that case,  $\text{NONFINALITY}$  would dominate  $\text{PARSE-}\sigma$ .

(59) Odd-parity words parsed into iambs in HS

	/iʔ <sup>h</sup> ikakina/ 1st iteration	FTBIN	PARSE-σ	ALLFTL	IAMB	TROCHEE
←	a. (iʔ <sup>h</sup> )kakina		3			1
	b. (iʔ <sup>h</sup> )kakina		3		W <sub>1</sub>	L
→	<b>2nd iteration</b>					
	c. (iʔ <sup>h</sup> )kakina		W <sub>3</sub>	L		L <sub>1</sub>
←	d. (iʔ <sup>h</sup> )(ka'ki)na		1	2		2
→	<b>3rd iteration</b>					
←	e. (iʔ <sup>h</sup> )(ka'ki)na		1	2		2
	f. (iʔ <sup>h</sup> )(ka'ki)('na)	W <sub>1</sub>	L	W <sub>6</sub>		2
→	<b>Output:</b> [(iʔ <sup>h</sup> )(ka'ki)na]					

A derivation of a word with an even number of light syllables in Axininca is shown in (60). The derivation builds iambs from the left until there are two syllables remaining, at which point it will choose to build a trochee on the two remaining syllables. Candidate (b) wins in the first iteration because regular iambic parsing is preferred. Then candidate (f), which is the eventual winner, wins in the second iteration because high-ranked NONFINALITY prevents regular iambic parsing at the right word edge, and the ranking of PARSE-σ over IAMB means that it is more important to parse words into feet than it is for the feet to be iambic, so candidate (d) also loses. The third iteration shows convergence because no more parsing is possible.

(60) Rhythmic reversal in HS

	/hotitana/ 1st iteration	NONFIN	PARSE-σ	ALLFTL	IAMB	TROCHEE
	a. hotitana		W <sub>4</sub>			L
←	b. (ho'ti)tana		2			1
	c. ('hoti)tana		2		W <sub>1</sub>	L
→	<b>2nd iteration</b>					
	d. (ho'ti)tana		W <sub>2</sub>	L	L	1
	e. (ho'ti)(ta'na)	W <sub>1</sub>		2	L	W <sub>2</sub>
←	f. (ho'ti)('tana)			2	1	1
	(Convergence step not shown)					
→	<b>Output:</b> [(ho'ti)('tana)]					

As this analysis shows, it is straightforward to account for Axininca’s rhythmic reversal in HS/IFO using the stress constraints of the standard theory. The constraint against final stressed syllables becomes relevant when parsing the final syllables of a word, and it enforces its preference then.<sup>30</sup>

#### 2.4.1.2 Parallel OT analysis

McCarthy and Prince’s (1993b) analysis of this process in parallel OT is equally straightforward on the surface. The same constraints in the same ranking deliver the desired optima. The tableau in (61) derives the regular iambic stress pattern in a word with an odd-number of light syllables. Candidate (a) wins because it has left-aligned iambs and no monomoraic feet.

(61) Odd-parity words parsed into iambs in parallel OT

	/itʰikakina/	FTBIN	PARSE-σ	ALLFTL	IAMB	TROCHEE
→ a.	(iʰi)(ka'ki)na		1	2		2
b.	(iʰi)('kaki)na		1	2	W <sub>1</sub>	L <sub>1</sub>
c.	('iʰi)('kaki)na		1	2	W <sub>2</sub>	L
d.	(iʰi)(ka'ki)(na)	W <sub>1</sub>	L	W <sub>6</sub>		2

The tableau in (62) shows how the same ranking derives rhythmic reversal in the final two syllables of a word with an even number of light syllables. Candidate (c) emerges as the winner in (62) because it satisfies NONFINALITY by violating IAMB. And finally, minimal violation of IAMB causes the parsing of the first two syllables to be iambic even though the word-final foot is trochaic.

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<sup>30</sup>To account for the variation in penult stress (e.g., [hotítána] ~ [hotítana] ‘he let me in’), we could allow the ranking of PARSE-σ and IAMB to vary, which will produce the second variant when PARSE-σ outranks IAMB, favoring candidate (d) at the second iteration in (60) instead. Note that this would derive stressless penults by not having a foot; McCarthy and Prince (1993b) assume instead that the foot is present in both cases and that the observed variation is phonetic.

## (62) Rhythmic reversal in parallel OT

/hotitana/	NONFIN	PARSE- $\sigma$	ALLFTL	IAMB	TROCHEE
a. hotitana		W <sub>4</sub>	L	L	L
b. (ho'ti)(ta'na)	W <sub>1</sub>		2	L	W <sub>2</sub>
→ c. (ho'ti)(tana)			2	1	1
d. (ho'ti)tana		W <sub>2</sub>	L	L	1
e. ('hoti)(tana)			2	W <sub>2</sub>	L

## 2.4.2 Non-local rhythmic reversal (unattested)

The two analyses appear to be equivalent ways of accounting for local reversal in Axininca. However, the standard constraints in parallel OT also predict a language with *global* rhythmic reversal, in which the effect of NONFINALITY is to change foot structure throughout the entire word. The winning candidate for input /hotitana/—[(ho'ti)(tana)], as show in (62)—has a stress clash, an adjacent pair of stressed syllables. If we assume that CON contains the constraint \*CLASH, which was in fact shown to be necessary for a standard theory analysis of Wergaia in §2.2, it must be low-ranked for the analysis of Axininca.<sup>31</sup> But factorial typology includes a ranking that is just like Axininca's but with \*CLASH high-ranked, and in such a language, [(ho'ti)(tana)] loses to candidate (e) in (62), [(hoti)(tana)]. This is shown explicitly in (63). The winning candidate in (63) is parsed into trochees despite the ranking IAMB » TROCHEE because it is the only candidate with iterative footing which neither stresses the final syllable nor shows a violation of \*CLASH. This same ranking will still produce iambs in a word ending with an odd number of light syllables, because in such words iambic rhythm can be preserved without the potential for stressing the final syllable, thereby avoiding the potential clash configuration altogether.

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<sup>31</sup>Specifically, it must be ranked below IAMB.

## (63) Global rhythmic reversal in parallel OT (Pseudo-Axininca)

/hotitana/	*CLASH	NONFIN	PARSE- $\sigma$	ALLFTL	IAMB	TROCHEE
a. hotitana			W <sub>4</sub>	L	L	
b. (ho'ti)(ta'na)		W <sub>1</sub>		2	L	W <sub>2</sub>
c. (ho'ti)(tana)	W <sub>1</sub>			2	L <sub>1</sub>	W <sub>1</sub>
d. (ho'ti)tana			W <sub>2</sub>	L	L	W <sub>1</sub>
→ e. ('hoti)(tana)				2	2	

By itself, this prediction is non-problematic. The language predicted under this ranking is one in which odd-parity words have stress on even-numbered syllables, while even-parity words have stress on odd-numbered syllables. This predicts a stress system with alternating rhythm akin to a simple right-to-left syllabic trochee stress pattern, and since languages with this stress system are attested (e.g., Cavineja, Key 1968), there is at this point no evidence that this prediction is problematic. But problematic predictions do arise from this ranking when foot form constraints that differentially treat iambs and trochees are also high-ranked, because in this case global rhythmic reversal will have visible consequences, causing odd and even parity words to obey different stress generalizations.

For example, according to the asymmetric foot typologies of Hayes (1995), McCarthy and Prince (1986/1996), and others, trochees ideally group elements of equal weight (see also §2.3) while iambs prefer quantitative imbalance. Shortening of stressed syllables is attested in trochaic languages, such as Fijian, but quantity adjustment processes in iambic languages usually involve the opposite, lengthening of a stressed syllable to achieve the ideal foot form (LH) (examples can be found in Hayes 1995:83). This entails the existence of constraints that prefer evenness in trochees and unevenness in iambs. As a consequence, one prediction of the global reversal in (63) is a language in which stressed syllables in even-parity words are shortened, to obey constraints that want trochees to be bal-

anced, while stressed syllables in odd-parity words are lengthened, to satisfy constraints that want iambs to be unbalanced. Stressed syllables in this language will lengthen *or* shorten depending on the parity count of the syllables in the word, ostensibly to obey NONFINALITY in combination with \*CLASH and constraints on foot form. This is illustrated schematically in (64) and (65). In these tableaux I/TL (for Iambic/Trochaic Law, Hayes 1995) stands for the constraint or constraints that enforce quantitative asymmetry in iambs and trochees.

(64) Shortening of stressed heavy syllables in even-parity words

/HLHL/	I/TL	*CLASH	NONFIN	IAMB	MAX- $\mu$
a. (H'L)(H'L)	W <sub>2</sub>		W <sub>1</sub>	L	L
b. ('HL)('HL)	W <sub>2</sub>			2	L
c. (L'L)(L'L)			W <sub>1</sub>	L	2
d. (L'L)('LL)		W <sub>1</sub>		L <sub>1</sub>	2
→ e. ('LL)('LL)				2	2

(65) Lengthening of stressed light syllables in odd-parity words

/LLLLL/	I/TL	*CLASH	NONFIN	IAMB	DEP- $\mu$
a. (L'L)(L'L)L	W <sub>2</sub>				L
→ b. (L'H)(L'H)L					2

As before, adding constraints to CON cannot get rid of this prediction, but eliminating the responsible constraints is not a tenable strategy for the standard theory either: \*CLASH is required to analyze Weṛgaia in parallel OT, NONFINALITY is crucial in the analysis of Axininca and many other languages, and languages with iambic lengthening and trochaic shortening require an asymmetric set of foot form constraints that can compel the insertion or deletion of a mora according to their ranking with respect to DEP- $\mu$  and MAX- $\mu$ . Clearly, a more radical change from the standard theory is required, since we would not expect to find a stress system in natural language that requires length on stressed syllables in words of one parity while prohibiting length in stressed syllables in words of the opposite parity.

This prediction is not reproducible in IFO. In this language a constraint referencing the right edge of the word (NONFINALITY) has conspired with \*CLASH to affect parsing all the way back to the left edge of the word, in opposition to the ostensible direction of parsing in the language. The left-to-right directionality of parsing under this ranking in IFO prohibits NONFINALITY from changing the preferred foot type throughout the word. Furthermore, if the ranking instead favored right-to-left directionality, then words of both parity counts would be affected in the same way by NONFINALITY; it would not be possible to anticipate iambs in one and trochees in the other. The ability of \*CLASH to create non-local stress systems by interacting with NONFINALITY is quite limited in HS/IFO. This is in clear contrast to the behavior of these constraints in the standard theory of parallel OT, in which optimization is performed over all possible metrical parses, and which predicts languages that show non-local constraint tradeoffs as a result.

### 2.4.3 An apparent counterexample

The stress pattern described in the previous section and illustrated in (64) and (65) displays an improbable pattern of stressed syllable shortening and lengthening and is clearly unattested. However, there is one language, Yidij, that is claimed to have a stress system similar enough in some ways to this unattested language to warrant additional discussion. This section describes Yidij stress and briefly discusses why it is a challenge for both HS/IFO and parallel OT. Although Yidij has been used as an argument for parallelism in some previous work (e.g., McCarthy 2002:149-152), the conclusion of this section will be that the stress pattern of Yidij is not currently well enough understood to constitute an argument for or against any theory of stress.

Dixon (1977a,b) provides a detailed description of the stress system of Yidij, a language of Australia. Stress in Yidij is characterized by both strict alternation of

stress by syllables and quantity-sensitivity. Long vowels count as heavy and may appear in any syllable except the first (Dixon 1977b:3, Dixon 1981:15-16, though cf. Patz 1991:254f). For words with an odd number of syllables only the stress pattern in (66a) is found, while for words with an even number of syllables the patterns in (b) and (c) are both permitted. The choice between (b) and (c) for an even-parity word is made on the basis of the distribution of quantity, with stress aligning to syllables with long vowels, though words with no long vowels always have the pattern in (b). Words with an odd number of syllables always have a long vowel in the penult, with the option for a long vowel in other even-numbered syllables as well. This stress system is unusual in being both quantity-sensitive and strictly alternating (cf. Hayes 1995),<sup>32</sup> as well as in the interdependence of stress and vowel length in odd-parity words.

(66) Rhythmic alternation in Yidiṅ

(σ = may contain a long vowel; σ = must contain a long vowel)

- |                         |                |                       |
|-------------------------|----------------|-----------------------|
| a. Odd parity           | b. Even parity | c. Even parity        |
| σ <u>ó</u> σ <u>ó</u> σ | óσ <u>ó</u> σ  | σ <u>ó</u> σ <u>ó</u> |

On the basis of these facts, most previous analyses of Yidiṅ stress<sup>33</sup> assume that words with an odd number of syllables employ iambic feet, while even-parity words are parsed into trochees or iambs depending on the distribution of syllable

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<sup>32</sup>Hayes (1995:72), on the relationship between quantity and alternation in general: “it appears that heavy syllables invariably interrupt any alternating count of light syllables”. In Yidiṅ, a consequence of having both strict alternation and quantity-sensitivity is that when more than one heavy syllable appears in a word, they are always separated by an odd number of syllables (Dixon 1977b:3). In fact, “Each pair of long vowels in a word is in fact separated by *just one* syllable. We have stated the constraint in a more general form (‘an odd number of syllables’) since if a word were encountered in which two long vowels were separated by three (or five...) syllables it would exactly conform to the rather complex phonology patterning permitted by Yidiṅ<sup>y</sup>” (Dixon 1977b:3, fn. 4, emphasis in original).

<sup>33</sup>There have been many analyses since Dixon (1977a,b), including Nash (1979), Hayes (1980, 1982, 1997, 1999), Halle and Vergnaud (1987), Kirchner (1992), Hagberg (1993), Hung (1993, 1994) and Crowhurst and Hewitt (1995b).



weight. Hung (1993, 1994), for example, argues that Yidij is an essentially iambic language and that the preference for trochees in even-parity words is driven by NONFINALITY (though trochees are blocked when a long vowel appears in an even-numbered syllable). This description makes Yidij stress look very similar to the unattested language described in the previous section, and Hung's analysis cannot be reproduced in IFO for the same reason that IFO does not reproduce the unwanted prediction in that section. IFO *can* produce a language that avoids final stress by alternating away from the penult, though it *cannot* produce this stress system by anticipating iambs in words of one parity and trochees in words of another parity.<sup>34</sup> The other difficulty facing an IFO implementation of Hung's analysis is that the constraint against final stress is overridden by a long vowel in *any* even-numbered syllable of an even-parity word (see (66c)).

On the surface, a consideration of Yidij's stress system appears to highlight a dichotomy between a theory that under-generates and a theory that over-generates. The IFO prediction that stress systems should be local makes it difficult to adapt a traditional analysis of Yidij, but parallel OT's global parsing with the standard constraints predicts in addition to Yidij many non-local stress patterns that are unattested, as evidenced by the minimally-different problematic prediction in §2.4.2 and the predictions discussed in §§2.2 and 2.3.

However, there are significant reasons to doubt whether any parallel OT analysis actually *can* account for Yidij's stress system when its additional complexities are taken into account. The central difficulty for an analysis in parallel OT is that

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<sup>34</sup>Most of the other analyses of Yidij stress treat it as an essentially trochaic language that parses a word into iambs just when necessary to meet weight-to-stress requirements. The discussion in this section is framed in terms of Hung's analysis, because it is most similar to the preceding discussion regarding NONFIN, \*CLASH, and contrasts between odd- and even-parity words. In general, adapting the other analyses to IFO would pose similar problems as long as words of differing parity are assumed to receive different default footing, unless such preferences could be assumed to be encoded in the lexicon.

stress and vowel length have a necessary interdependence, but vowel length in Yidij can arise as the opaque result of two processes that target odd-parity words: penultimate vowel lengthening and final syllable deletion. For example, a trisyllabic stem /gindanu/ ‘moon’ surfaces as [gindá:n] in the absolutive (bare) form but as faithful gindanu- in the remainder of its paradigm (Dixon 1977b:13). The vowel length and, crucially, the concomitant stress on the second syllable in the bare form, derive exclusively from the underlying parity of the stem, no longer visible on the surface. This opacity makes a full analysis of Yidij stress in parallel OT almost impossible if the predictable vowel length in forms like [gindá:n] is to be derived by the grammar. Parallel OT’s problem with opacity is well-known and is not limited to a particular constraint set. It is thus difficult to see how Yidij’s stress system could possibly constitute an argument *against* serialism, despite its apparently non-local character.

It is clear that something more will have to be said for a satisfactory analysis of Yidij. In IFO it is possible to analyze Yidij’s stress system without resorting to a mix of iambs and trochees if vowel length can be taken as given. Hayes (1997, 1999) provides some justification for treating predictable vowel length as underlying, based partly on the fact that length is a central player in Yidij’s morphophonology. With vowel length prespecified, an IFO analysis could treat Yidij as a right-aligning trochaic system that requires heavy syllables to be stressed and every word to end in a foot.<sup>35</sup> Alternative analyses not relying on the assumption that vowel length is given may be possible if non-standard representational and/or operational assumptions that have been argued for in previous serial analyses of Yidij are adopted (e.g., Crowhurst and Hewitt 1995b), though such so-

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<sup>35</sup>I thank an anonymous associate editor of *Phonology* for suggesting an analysis along these lines.

lutions would have to be pursued with care to ensure the genuinely problematic predictions discussed in the previous section are not reintroduced as well.

Yidij is sometimes put forth as an argument for parallelism in stress, and the preceding discussion makes it clear why. But closer inspection of its stress system suggests that it cannot in fact be taken as unequivocal evidence in favor of that conclusion. Despite the difficulty for HS/IFO posed by current characterizations of this language, it is quite possible that future work sensitive to the role of morphology in Yidij's stress system could yield new insights that allow it to fall in line with the overwhelming majority of attested stress systems which demonstrate locality.

## **2.5 Alternatives to the standard theory**

The main focus of this chapter has been a comparison between the standard theory of stress in parallel OT and a minimally different variation on the standard theory implemented in Harmonic Serialism. This section aims to supplement the preceding results by broadly distinguishing the model proposed in this chapter from a few other prominent alternatives, though I have not attempted to make a detailed comparison with each one nor to cover the many other alternatives. I first discuss the theory of Hyde (2007), an alternative to the standard theory that is implemented in parallel OT, and then turn to two predecessors in serial stress, the theory of Harmonic Parsing proposed by Prince (1990) and rule-based derivational stress, especially as put forth in Hayes (1995).

### **2.5.1 Non-finality-based parallel OT (Hyde 2007)**

The comparison between IFO and parallel OT in §2.2 began with a discussion of the problem with the standard theory that was also presented by Hyde (2007). On the basis of the standard theory's inadequacy, Hyde concludes that a thorough

revision of the theory of stress constraints and representations is needed, a conclusion that he also pursues in other work (e.g., Hyde 2002). Thus, rather than assuming ranked and violable *PARSE- $\sigma$* , he assumes that exhaustive parsing is a property of *GEN*, and rather than assuming that feet necessarily represent stress, he assumes that the relationship between metrical constituency and prominence is violable. Constraints from the *NONFINALITY* family are argued to govern the alignment of grid marks with respect to the right edges of all levels of prosodic representation (mora, syllable, foot, word), and this combination of assumptions correctly derives the conditional weight-sensitivity of generalized trochee languages and extends to many other areas of stress typology as well.<sup>36</sup>

Throughout, I have identified the problematic predictions discussed in this chapter as evidence that the standard theory of stress constraints and representations functions non-locally in parallel OT and have therefore proposed that HS/IFO offers a different kind of solution. The typological advantages of IFO for the stress interactions discussed in this chapter are less impressive when compared to the quite different theory of Hyde, but IFO nonetheless retains an advantage. Hyde's solution fails to generalize to very similar locality problems in non-metrical domains. IFO on the other hand is couched in Harmonic Serialism, which provides a general solution to the locality problems faced by parallel OT.

The introduction provided an example of a non-metrical locality problem that arises in parallel OT but not in HS (see the references cited in the introduction for additional examples). High-ranked constraints prohibiting syllable-final obstruents and requiring word-final codas can conspire to predict a language with truncation in every word after the rightmost sonorant consonant or not at all in

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<sup>36</sup>In other work, Hyde assumes that all feet are binary and that syllables may be ambi-podal (e.g., Hyde 2001, 2002), but this assumption is not a crucial part of the analysis proposed in Hyde (2007).

words with no sonorant consonants (McCarthy 2006, 2010b). For any given segment in a word of this unattested language, knowing whether deletion will occur depends not just on its local context nor just on information to one side of it, but on information at unbounded distances to both its left and its right simultaneously. This is precisely the sense of non-locality that the standard theory of parallel OT predicts for stress but which HS (with IFO) again solves, as §§2.2-2.4 showed in detail. These non-local predictions can only be described in terms of an omniscient view of the word, with dependencies that extend infinitely in both directions. Processes of this kind are not generally found in the phonological systems of natural languages. If such predictions only arose in parallel OT as a result of the standard view of stress, a stress-specific solution such as the one proposed by Hyde would be preferred as an alternative. But since such problems for parallel OT are pervasive and domain-general, HS has the advantage of being a general solution and solving a wider range of such problems.

Furthermore, other recent work demonstrates that analyzing stress in HS provides solutions to problems beyond those that have been the focus of this chapter, for which Hyde's theory can offer no comparable advantage. McCarthy (2008c) argues that metrically-conditioned syncope cannot be coherently analyzed in a non-derivational theory. Syncope is motivated by the avoidance of unstressed vowels, but without an intermediate step in which foot structure has been assigned, it is nearly impossible to correctly identify the vowels targeted for deletion. HS provides the framework for ordering stress before syncope, and with some additional assumptions about CON it predicts the desired intrinsic ordering of these processes.

Elfner (2009) shows that opaque interactions between stress and epenthesis receive a natural analysis in HS, where derivational steps permit differential treatment of epenthetic and non-epenthetic segments for the purposes of syllabifica-

tion and stress assignment. Elfner cites Kiparsky (to appear) for arguments against extant parallel OT approaches, which typically analyze the attested cases with a positional faithfulness constraint requiring the head of a prosodic constituent to have an input correspondent, on the basis that they make the incorrect prediction that vowels epenthesized into extrametrical positions cannot opaquely affect stress assignment when in fact such cases are attested.

Kimper (2011) shows that serial prosodic structure building in HS can be combined with a theory of variable constraint ranking to analyze attested cases of prosodic local optionality that are not analyzable in parallel OT. Theories of variation in parallel OT have difficulty with local optionality because they predict that all loci of potential application of a process will be treated the same, other things being equal, but the successive evaluations in an HS derivation allow individual loci to be treated differently, successfully accounting for the observed cases. Kimper's proposal accounts for variation in the construction of Minor Phrases in Bengali and the metrically-conditioned but variable process of schwa deletion in French.

Finally, Jesney (to appear) shows that HS solves pathologies arising from positional faithfulness constraints in parallel OT. Positional faithfulness constraints are meant to preferentially preserve contrasts in prominent positions, but parallel OT predicts that a possible way to satisfy a faithfulness constraint referring to a metrically prominent syllable is to move stress to a different syllable (where being faithful does not conflict with high-ranked markedness constraints). Many of the stress patterns that result from the presence of such candidates are unattested and non-local. Jesney shows that HS provides a solution to this problem by allowing privileged positions to be defined on the basis of the previous iteration's output. This prevents candidates from manipulating prosodic structure to avoid positional faithfulness violations and allows these constraints to function as intended.

The evidence presented in this chapter and other recent work suggests that HS consistently solves locality problems which are not limited to stress and that analyzing stress in a framework with serial optimization provides benefits beyond the locality effects discussed in this chapter. Hyde's proposal greatly improves the typological predictions of a parallel OT theory of stress, but in doing so it fails to connect the pathologies of the standard theory with parallel OT's non-local predictions in domains outside of metrical theory. And since Hyde's solution is not derivational, it does not offer solutions to other problems for a parallel OT theory of stress such as metrically-conditioned syncope, opaque stress-epenthesis interactions, local optionality of prosodic structure, and positional faithfulness pathologies. While perfectly matching the observed typology of stress in HS will require continued work, the elimination of parallel OT's locality problems and the other benefits of serial optimization in metrical structure suggest nonetheless that the breadth of problems solved by HS make iterative foot optimization worthy of further consideration.

### 2.5.2 Harmonic Parsing (Prince 1990)

The theory of Harmonic Parsing (HP) developed in Prince (1990) proposes that stress patterns are modeled with a serially-ordered directional parse of syllables into feet based on a metric of foot well-formedness, making it in some ways quite similar to IFO. One of HP's important contributions is the notion of *relative* well-formedness in foot shapes, formalized as 'grouping harmony', which expresses the preference for trochaic feet to group elements of equal weight and iambs to be as large as possible. For trochees, feet are ordered in terms of relative harmony in (67) and for iambs the same is shown in (68) (where  $>$  should be read 'is more harmonic than' or 'is better than'). In both scales, the grouping of two light syllables is treated equivalently to one heavy syllable.

$$(67) \text{ Trochaic feet: } \left\{ \begin{array}{l} ('LL) \\ ('H) \end{array} \right\} > ('HL) > ('L)$$

$$(68) \text{ Iambic feet: } ('LH) > \left\{ \begin{array}{l} (L'L) \\ ('H) \end{array} \right\} > ('L)$$

IFO and HP have in common two main things: serialism and violability in foot-form, which can be appreciated by comparing the very similar analyses of trochaic shortening presented in §2.3.1.1 and in Prince (1990). The HP analysis of trochaic shortening in English involves a serial derivation that first builds an ('HL) foot and then shortens it to ('LL) to improve performance on the grouping harmony scale (in (67)). As we saw in §2.3.1.1, the HS analysis follows essentially the same steps (see also, McCarthy 2008c). In both cases, an unbalanced trochee is first built, introducing a violation of a constraint against unbalanced trochees and thereby feeding the process of shortening.

Unlike IFO however, HP's well-formedness scales are one-dimensional. Since HP antedates a complete theory of constraint violability (Prince and Smolensky 1993/2004), each of the scales in (67) and (68) sets out an ordering of context-independent grouping harmony that is supposed to hold for all languages, modulo the setting of the foot-headedness parameter in the language. In IFO and other work within OT, the relative ordering shown in (67) and (68) can emerge from a combination of constraints on foot form, but the separation of these preferences into constraints on binarity and weight-sensitivity allows them to freely re-rank with respect to one another, correctly accounting for the fact that not all trochaic languages are fully quantity-sensitive. Wergaia is an example of a trochaic language that prefers ('σσ), including ('HL), over ('H), although the well-formedness scale in (67) is not able to capture this. Some foot shapes are also excluded categorically from the scale, including ('LH) trochees, although again generalized trochee languages take advantage of such feet. Violability of the constraints on foot form



also allows HS to provide a uniform explanation for two kinds of trochaic shortening: ('HL) → ('LL) as in Fijian (§2.3), and ('LH) → ('LL) as in Tonkawa and Latin (McCarthy 2008c). These processes cannot be analyzed in the same way in a theory that permits ('HL) but excludes ('LH) categorically.

Finally, although foot well-formedness is presented in terms of relative harmony, HP assumes (with most of its contemporaries in stress theory) that directionality and foot headedness are specified for each language parametrically. For IFO and other OT-based models, the analog of parameter settings emerges from a ranking of violable constraints. The consequence of violable constraints instead of inviolable parameter settings is that the constraints' preferences can be overturned when conflicting constraints are higher ranked. This matches observed typology, which finds that perturbations in foot headedness and alignment can be motivated in contexts where the default option would degrade harmony rather than improve it (Prince and Smolensky 1993/2004:Ch 4). In the analysis of Fijian, for example, IFO permits an ('HL) foot to be built at the word edge only because satisfaction of high-ranked ALIGNWDR (or ALIGNHDR) requires the preference for balanced trochees to be (temporarily) overridden.<sup>37</sup> The analysis of trochaic shortening in HP also goes through a step with an ('HL) foot, but it is not obvious what mechanism is in place to motivate the foot to be built in the first place.

Harmonic Parsing should be recognized as an important predecessor to HS/IFO, but the present theory integrates iterative optimal foot building with subsequent developments in constraint violability within Optimality Theory.

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<sup>37</sup>Any higher-ranked constraint that prefers a disyllabic foot (e.g., PARSE-σ) could in principle account for the same process when its distribution is less restricted.

### 2.5.3 Derivational rule-and-constraint-based theories (Hayes 1995)

Finally, a comparison between IFO and rule-based or rule-and-constraint-based derivational models of stress assignment is warranted. I primarily limit this comparison to the theory of Hayes (1995), since it is widely known and because it is the source of the representational assumptions upon which the standard theory of stress in OT is based, although most of this section will apply to other similar models as well. In this section I will abbreviate Hayes's (1995) theory as MST (for "Metrical Stress Theory").

Throughout the chapter I have adopted the standard theory's representational assumptions, which follow those of MST, and I have defined GEN in a way that recalls the MST foot building algorithm, which builds metrical representations one foot at a time.<sup>38</sup> But while IFO and MST share serialism, representations, and operations, a crucial difference between the theories is that IFO assumes ranked and violable constraints to determine the descriptive dimensions of a stress pattern (foot form, headedness, iterativity, and alignment/directionality), while for MST each of these is parameterized. The parameter settings are treated as inviolable, and each language's stress pattern is described by a set of parameters that is meant to hold true throughout the language. In IFO, implementing constraints as ranked and violable means that a given language need not show a preference for one parameter setting in all contexts categorically. In fact, as suggested in the previous section, such non-uniformity is well-attested in stress and in other domains (McCarthy 2002:§3.2, Pater 2000, Prince and Smolensky 1993/2004).

Violability of foot form constraints is central in OT-based models generally since it permits an account of non-uniformity, but it plays a unique role in HS be-

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<sup>38</sup>In principle, other representational and operational assumptions that have been proposed in derivational models of stress assignment could be explored as alternative ways to implement IFO, though to what extent the predictions in this chapter hold under different definitions of GEN remains largely to be determined. Though see chapter 5 for some discussion along these lines.

cause of intermediate derivational stages. Violability is an important part of the analysis of Fijian shortening in §2.3.1.1, for example, because motivating shortening requires an otherwise-surface-true constraint to be violated at an intermediate step in the derivation. In contrast, a comparison between this analysis and the one adopted by Hayes (1995:145ff) reveals the ramifications of *inviolability*.

MST assumes a static inventory of foot shapes, determined for each language parametrically. The challenge for a serial theory with a static foot inventory is to produce a derivation for metrically-conditioned shortening in which all of the intermediate forms satisfy inviolable foot shape constraints. The derivation  $HL \rightarrow ('HL) \rightarrow ('LL)$  is ruled out on the grounds that  $('HL)$  is not a licit moraic trochee, and the alternative derivation  $HL \rightarrow ('H)L \rightarrow ('L)L \rightarrow ('LL)$  is out because Fijian does not allow degenerate feet. However, the second option can be salvaged by employing “persistent” foot building (Hayes 1995:114). Persistent footing is formalized in MST as a stress system parameter according to which foot building can be essentially unordered with respect to other processes and may occur whenever it can—even in parallel with other processes. Persistent footing saves the illicit derivation  $HL \rightarrow ('H)L \rightarrow ('L)L \rightarrow ('LL)$  by combining steps three and four, resulting in the following licit derivation:  $HL \rightarrow ('H)L \rightarrow ('LL)$ . Hayes’s shortening rule, which triggers re-footing after it has applied, is given in (69).

(69) Fijian trochaic shortening rule (Hayes 1995:146)

$$\sigma_{\mu\mu} \rightarrow \sigma_{\mu} / \text{---} \sigma_i \quad \text{where } \sigma_i \text{ is metrically stray}$$

The result for MST is a kind of non-gradualness, or parallelism, in which shortening and foot-building happen simultaneously. This parallelism is in fact a *consequence* of the inviolability of the constraints against the illicit feet  $('L)$  and  $('HL)$ . When constraints are allowed to be violated, the argument for persistent footing in this case is no longer applicable. Recent work in HS (McCarthy 2008c, McCarthy, Pater, and Pruitt to appear) argues that many original arguments for parallelism

are really aesthetic arguments against ‘ill-formed’ intermediate steps (e.g., Prince and Smolensky 1993/2004:33ff) and concludes that constraint violability, one of the central premises of OT, substantially weakens the force of such arguments. In HS, allowing constraints to be violated presents no inherent problem because ranking ensures minimal violation (McCarthy 2002:134ff). With concrete assumptions about GEN and CON, IFO is able to account for non-uniformity while retaining the ability to analyze languages with strict foot shape requirements even without banning the dispreferred feet categorically. In comparison to MST and other rule-based theories of stress, IFO preserves the locality predictions conferred by serialism while incorporating the advantages of constraint violability.

## 2.6 Chapter summary and conclusion

This chapter has demonstrated the potential for Harmonic Serialism with iterative foot optimization to model rhythmic stress and its interactions with syllable weight, quantity-adjustments, and edge restrictions. When feet are built one at a time in a series of optimizations, stress patterns and their interactions with other phonological processes are predicted to be local, in accordance with what is attested. The standard theory of stress in parallel OT on the other hand predicts for every local process analyzed here non-local counterparts that do not reflect natural language stress systems. As demonstrated throughout, the constraints responsible for the non-local predictions of the standard theory are the same constraints that are required to analyze attested local patterns in parallel OT under standard representational assumptions, suggesting that the standard theory’s overgeneration problems are persistent and pervasive.

Harmonic Serialism provides a way of predicting locality in stress and other areas of phonology because of the requirements of local optimality (each intermediate form is optimal at some stage) and incremental harmonic improvement (op-

erations are only successful when they provide an immediate advantage according to the constraint hierarchy). Local processes are those that can be derived through a series of individually optimal, harmonically improving steps, while non-local processes are those that cannot. As this chapter has shown, these assumptions provide a better fit to the typology of stress systems in natural language and they do so in a way that connects stress typology with other phonological processes under the rubric of locality.

## CHAPTER 3

### PRIMARY STRESS IN GEN

This chapter and the one that follows are dedicated to investigating the formal representation of primary stress in Harmonic Serialism. There are two pieces to this investigation. The first, the topic of this chapter, is how and when primary stress is assigned during a derivation. The second, the topic of the following chapter, is the proper formulation of constraints that refer to primary stress.

#### **3.1 Introduction**

In parallel OT the question of ‘when’ main stress is assigned does not arise, but in a derivational theory it is a fundamental question. Most work in derivational metrical theory has assumed that, at least for the majority of languages, primary stress is assigned only after a basic level of foot construction or stress assignment occurs. Main stress is then situated on one of the lower level heads by a rule that promotes a grid mark or builds a headed word layer over metrical feet or a bracketed grid (Lieberman and Prince 1977, Hayes 1980, Prince 1983, Selkirk 1984, Hammond 1984, Halle and Vergnaud 1987, Hayes 1995). On the other hand, some authors have argued that main stress assignment is best formalized independently of secondary or rhythmic stresses and for these reasons adopt representational and/or operational assumptions that amount to assigning main stress first (van der Hulst 1984, 1997, 2009, Bailey 1995). Hayes (1995) calls these two different ways of assigning primary stress “bottom-up” and “top-down”, respectively.

In HS this issue arises in our definition of GEN. The most basic sense in which a definition of GEN could be “bottom-up” or “top-down” concerns *when* the operation of primary stress assignment can apply, and *what* it can (or must) apply to. If the primary stress operation is one that promotes a secondary stress, we can say that GEN is bottom-up, since in this case the primary stress operation presupposes at least one secondary stress before it can apply. In contrast, if the operation of primary stress assignment does not presuppose existing secondary stress feet, we can say that GEN is top-down. In this case the primary stress operation can apply to a previously stressless syllable, effectively building in one step what bottom-up parsing takes two steps to build.

Which of these is the right way of thinking about primary stress in HS? The diversity of patterns of primary stress among bounded iterative stress systems makes an answer not immediately obvious. In some languages primary stress appears to be autonomous, having properties or obeying restrictions that are different from those of secondary stresses in the language. In order to analyze such systems in HS we would generally need to afford the grammar the opportunity to know when a foot is built that it is or will be the primary stress; this is consistent with a top-down primary stress operation, but not a bottom-up one. In contrast, there are other languages whose primary stress appears to be parasitic on secondary stresses. In these languages it would be difficult to consistently account for the location of primary stress without the metrical structure of the rest of the word in place, and in HS these languages would clearly benefit from bottom-up parsing.

Hayes (1995) notes that most languages do not fall squarely into either of these categories because they would be analyzed equally well with (his version of) top-down or bottom-up parsing. This is because in many languages the primary stress falls to the first foot in a directional parse (Hammond 1985a,b). Since the primary stress foot in such languages looks like the other feet, the pattern could be analyzed

bottom-up by first building the secondary stress feet and then designating the left or rightmost one the primary stress. But since putting primary stress on the ‘first’ foot also means that it falls a fixed short distance from an edge, modulo potential quantity-sensitivity, etc., it would also be possible to locate the syllable for primary stress in the absence of the secondary stresses; in other words, top-down parsing would also account for such languages.

Despite the prevalence of these “either/or” patterns, the existence of languages with autonomous primary stress and languages with parasitic primary stress—which generally by definition are *not* equally amenable to both bottom-up and top-down analyses—is relatively well-established. For this reason, our definition of the primary stress operation in GEN is not an arbitrary choice, and it will need to be able to handle a diverse set of primary stress patterns. I will propose in this chapter a theory of GEN that is basically top-down with respect to the derivation of word stress, but which also has a provision that allows primary stress to move in the course of a derivation. Allowing a foot to be labeled as primary stress simultaneous with its construction permits an account of languages with autonomous primary stress and is the sense in which this definition is top-down, while permitting primary stress relabeling provides a successful means of analyzing languages with parasitic primary stress.

In the next section (§3.2) I describe and illustrate the proposed representational and operational assumptions for describing primary stress in GEN. In §3.3 I show analyses of several languages whose autonomous primary stress pattern suggests the need for the top-down GEN proposed here, and in §3.4 I present evidence that the primary stress relabeling provision is sufficient to account for the attested patterns of parasitic primary stress. In §3.5 I consider an alternative definition of GEN and illustrate its failure in accounting for the full range of attested systems while predicting a reasonably restrictive typology, and, finally, in §3.6 I present an



excursus on the kinds of evidence that are needed to establish the argument for top-down parsing and the extent to which ‘top-down’ and ‘bottom-up’ are really theory-dependent notions.

### 3.2 Proposal

The main proposal I will make here is that primary stress assignment is a free operation. It is free in the sense that it does not require its own step, but may apply in parallel with other operations and at any time in the derivation, provided there is a foot to bear it. The details of this proposal are provided in this section, and justification of various aspects of it are presented in the sections following.

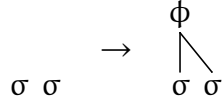
With respect to representations I will assume that primary word stress is the manifestation of headedness at the level of the prosodic word (PWd), and ‘assigning primary stress’ is equivalent to designating a foot as Hd(PWd). The primary stressed syllable is the head syllable of the head foot of the PWd, i.e., Hd(Hd(PWd)). A foot is the only prosodic constituent that can bear PWd headship (i.e., a segment or syllable cannot be the Hd(PWd) except by transitivity), and a PWd can have at most one head, or primary stress. These are fairly standard views of metrical structure and constituency. In general I will assume that the input to the first iteration of stress assignment is a PWd that contains only syllables. Because feet are built by the grammar and are never present in the input (McCarthy and Pruitt to appear), PWds are necessarily headless when they enter the derivation.

I assume that the set of foot-building operations in GEN are those in (70).

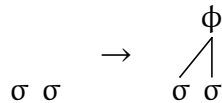
(70) Foot-building operations in GEN

( $\sigma$  = syllable;  $\phi$  = foot; the foot head is the  $\sigma$  vertically aligned with a  $\phi$ )

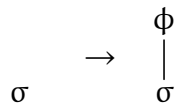
a. Build a Trochee



b. Build an Iamb



c. Build a monosyllabic foot



These operations do not specify whether the foot being built is a primary stress or a secondary stress. The assignment of primary stress is accomplished with a separate operation that applies whenever and wherever it can, even in parallel with other operations. This operation can be stated simply as in (71). By this operation, any foot in any candidate, whether carried over from a previous iteration or newly built, may be designated Hd(PWd), though assignment of Hd(PWd) necessarily applies at most once in any given candidate since Hd(PWd) is unique.

(71) Primary stress assignment (free)

$$\phi \rightarrow \phi_{Hd}$$

With these operations, (72) presents for the purposes of illustration an exhaustive list of stress candidates available at the first iteration of stress assignment for a five-syllable input. (More precisely, this list shows schematically a subset of the candidates under consideration whenever there is a five-syllable local input that is stressless.) The list includes two varieties of foot-added candidates—those with a secondary stress foot and those with a primary stress foot. Candidates with a newly built secondary stress foot are generated by the application of one of the operations in (70), but in these candidates (71) has not applied. The candidates

with a primary stress foot in contrast have undergone both a foot-building operation from (70) and free primary stress assignment with (71). Although the primary stress assignment operation can apply at any time, it is not required to apply in every candidate.<sup>1</sup>

(72) Candidates for first foot in a five-syllable word

<b>Operation</b>	<b>Candidates</b>
None (faithful)	$\sigma\sigma\sigma\sigma\sigma$
Mono- $\sigma$ foot added	$(, \sigma)\sigma\sigma\sigma\sigma \quad \sigma(, \sigma)\sigma\sigma\sigma \quad \sigma\sigma(, \sigma)\sigma\sigma \quad \sigma\sigma\sigma(, \sigma)\sigma \quad \sigma\sigma\sigma\sigma(, \sigma)$
Di- $\sigma$ trochee added	$(, \sigma\sigma)\sigma\sigma\sigma \quad \sigma(, \sigma\sigma)\sigma\sigma \quad \sigma\sigma(, \sigma\sigma)\sigma \quad \sigma\sigma\sigma(, \sigma\sigma)$
Di- $\sigma$ iamb added	$(\sigma, \sigma)\sigma\sigma\sigma \quad \sigma(\sigma, \sigma)\sigma\sigma \quad \sigma\sigma(\sigma, \sigma)\sigma \quad \sigma\sigma\sigma(\sigma, \sigma)$
Mono- $\sigma$ foot + Hd(PWd)	$(\sigma)\sigma\sigma\sigma\sigma \quad \sigma(\sigma)\sigma\sigma\sigma \quad \sigma\sigma(\sigma)\sigma\sigma \quad \sigma\sigma\sigma(\sigma)\sigma \quad \sigma\sigma\sigma\sigma(\sigma)$
Di- $\sigma$ trochee + Hd(PWd)	$(\sigma\sigma)\sigma\sigma\sigma \quad \sigma(\sigma\sigma)\sigma\sigma \quad \sigma\sigma(\sigma\sigma)\sigma \quad \sigma\sigma\sigma(\sigma\sigma)$
Di- $\sigma$ iamb + Hd(PWd)	$(\sigma'\sigma)\sigma\sigma\sigma \quad \sigma(\sigma'\sigma)\sigma\sigma \quad \sigma\sigma(\sigma'\sigma)\sigma \quad \sigma\sigma\sigma(\sigma'\sigma)$

At the second iteration of stress assignment a foot will be present in the local input, and the operations in (70) and (71) apply in more or less the same way to generate candidates as they did at the first iteration. If the local input has a primary stress already, the primary stress assignment operation is not prevented from applying, but because a PWd can have at most one head, the application of the primary stress operation entails demotion of an existing primary stress. Thus, the foot-added candidates at the second iteration will either add a secondary stress foot and leave the primary stress in place, or they will add an additional foot, assign primary stress to it, and demote the primary stress from the foot that was

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<sup>1</sup>Although the requirement for all words to have a primary stress is not built in to this definition of GEN, the assumptions I will make about CON, which are presented in detail in chapter 4, will ensure that a candidate with primary stress is more harmonic than an equivalent candidate with only secondary stress, other things being equal. (Specifically, the proposal of chapter 4 will be for primary stress constraints to disallow vacuous satisfaction.) See also §3.4.3 below.

in the input.<sup>2</sup> It is possible to think of the latter situation as a kind of ‘relabeling’ of Hd(PWd), and I will generally refer to it in that way through the rest of this chapter.

With this assumption the candidates under consideration when a local input already has a primary stress will be those in (73), assuming the previously-built foot is a left-aligned disyllabic trochee. Primary stress relabeling—or, equivalently, the application of (71) and concomitant demotion of a previous Hd(PWd)—multiplies the candidates available at a given iteration so that all combinations of building a single foot and (re)assignment of Hd(PWd) are considered.

(73) Candidates for second foot in a five-syllable word with local input ('σσ)σσσ

<b>Operation</b>	<b>Candidates</b>
None (faithful candidate)	('σσ)σσσ
Mono-σ foot added	('σσ)(,σ)σσ ('σσ)σ(,σ)σ ('σσ)σσ(,σ)
Di-σ trochee added	('σσ)(,σσ)σ ('σσ)σ(,σσ)
Di-σ iamb added	('σσ)(σ,σ)σ ('σσ)σ(σ,σ)
Mono-σ foot + Hd(PWd)	(,σσ)('σ)σσ (,σσ)σ('σ)σ (,σσ)σσ('σ)
Di-σ trochee + Hd(PWd)	(,σσ)('σσ)σ (,σσ)σ('σσ)
Di-σ iamb + Hd(PWd)	(,σσ)(σ'σ)σ (,σσ)σ(σ'σ)

To complete this illustration, if ('σσ)(,σσ)σ is optimal among the candidates listed in (73), the candidates at the following (third) iteration will be those in (74). I adopt here the simplest hypothesis regarding primary stress relabeling and assume that it is essentially unrestricted. Candidates will include all possible ways of shifting the primary stress without building a foot and shifting the primary stress while building a foot

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<sup>2</sup>At present, there seems to be no reason that reassigning the primary stress in this way would violate a faithfulness constraint. Markedness constraints on primary stress will favor or disfavor relabeling, depending on their ranking, and stress faithfulness constraints are perhaps not needed in the grammar at all (see McCarthy and Pruitt to appear).

(74) Candidates for third foot in five syllable word with local input ('σσ)(,σσ)σ

Operation	Candidates
None (faithful candidate)	('σσ)(,σσ)σ
Hd(PWd) relabeling	(,σσ)('σσ)σ
Mono-σ foot added	('σσ)(,σσ)(,σ)
Mono-σ foot + Hd(PWd)	(,σσ)('σσ)(,σ)    (,σσ)(,σσ)('σ)
Di-σ trochee added	n/a
Di-σ iamb added	n/a

The definition of GEN adopted here places no restrictions on the assignment and reassignment of primary stress except that there can be no more than one head foot per PWd, consistent with the general concept of headedness. Under this proposal, the grammar is, in a sense, always evaluating every possible 'landing site' for primary stress. This hypothesis is conceptually similar in some respects to McCarthy's (2007a, 2010b) proposal that syllabification is a "faithful" operation, meaning it can apply without cost, in parallel with other operations or alone. McCarthy (2010b) argues that syllabification must be free so that the consequences of syncope are realized immediately; this accounts for the myriad cases in which syncope is blocked when an unsyllabifiable sequence of segments would result. The reasons for treating primary stress assignment as a free operation are analogous; as I discuss at length in §3.3, it is important to know when a foot is built whether it is the bearer of primary stress so that constraints on primary stress are active right away in determining where it is constructed.

Although the primary stress assignment operation is available at any time, there is no *requirement* in GEN that it apply; it is active in generating candidates, but it does not need to have a hand in generating every licit candidate. Because of this it might seem that this definition of GEN is "top-down" in name only, as the availability of candidates with only secondary stresses suggests that bottom-

up derivations (those that first build secondary stress feet and later designate one as primary stress) might be possible. This point is addressed more fully in §3.4.3, but to summarize briefly here, the reason that calling this definition of GEN “top-down” is not a contradiction is that a bottom-up derivation, while not prohibited by any restriction on GEN, turns out not to be possible as long as the top-down option exists. With the independently needed assumption that no primary stress constraints in CON can be vacuously satisfied (which will be discussed and argued for in chapter 4), top-down parsing is more or less guaranteed by the grammar even though GEN itself only provides it as one option.

More pertinently for now though, the relevant sense in which this definition is “top-down” is that the primary stress can be assigned to a foot at the same time that it is built. This property will be shown to be essential in analyzing languages with autonomous primary stress in §3.3. Furthermore, allowing free relabeling of the primary stress to new feet as they are created permits an analysis of languages whose primary stress is parasitic in that it *cannot* be predicted without knowing the location of secondary stresses. In §3.4 I show languages that require this analysis and illustrate why the constant availability of primary stress prevents a ‘traditional’ bottom-up analysis of parasitic primary stress and requires the provision that can move or reassign the primary stress during a derivation.

### **3.3 Free assignment of Hd(PWd) Part I: Autonomous primary stress**

Evidence for top-down stress comes from languages whose primary stress shows up in a location where the regular parsing algorithm for secondary stress would not consistently put a foot. For our purposes, the effect can be seen as the primary stress obeying a different set of restrictions or overriding the preferences for foot shape or alignment seen in secondary stresses. In order to successfully

analyze such systems it needs to be the case that the grammar includes constraints that are specific to primary stress—a relatively uncontroversial hypothesis—but it must also be the case that these constraints are permitted to actively affect footing, and for this we need the top-down GEN described in §3.2. Below I present analyses of languages that exhibit autonomous primary stress and illustrate how they are handled in HS with these assumptions.

### 3.3.1 Finnish

Finnish displays an asymmetry in the treatment of its primary and secondary stress feet.<sup>3</sup> The primary stress in Finnish always falls on the first syllable, modulo some exceptional words, and rhythmic secondary stresses alternate rightward from the primary. Because primary stress is fixed with respect to the word edge, it is essentially quantity-insensitive, but secondary stresses exhibit partial quantity-sensitivity; when the alternating count would place a secondary stress on a light syllable immediately preceding a heavy syllable, the stress shifts rightward onto the heavy syllable, interrupting and resetting the alternating count.<sup>4</sup> In Finnish, syllables ending in a short vowel are light, and syllables with a long vowel, diphthong, and/or coda are heavy.

The data in (75) illustrate this pattern. The words in (a) have only light syllables and show left-to-right trochaic parsing; the words in (b) begin with a light-heavy sequence, but the primary stress is not affected; the words in (c) show that a non-word-initial light-heavy sequence causes stress to shift onto the heavy syllable. The light-heavy sequences in (b) and (c) are underlined.

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<sup>3</sup>The stress pattern I describe here is based on the descriptions of Finnish found in multiple sources (Kager 1992b, Hanson and Kiparsky 1996, Alber 1997, Elenbaas 1999, Elenbaas and Kager 1999); but see Karvonen (2005) for a different perspective.

<sup>4</sup>There are other details of Finnish stress that will not be addressed here, especially regarding optionality and the role of morphology in determining the stress pattern.

## (75) Finnish stress (Elenbaas 1999:Appendix B)

	Word	Gloss	Proposed foot structure
a.	périjä	‘inheritor (nom.)’	(‘LL)L
	répeämä	‘crack, rupture (nom.)’	(‘LL)(,LL)
	áteriani <sup>5</sup>	‘meal (nom. 1sg)’	(‘LL)(,LL)L
b.	rávintola	‘restaurant (nom.)’	(‘LH)(,LL)
	ávaiméeni	‘key (ill. 1sg)’	(‘LH)(,HL)
	ópiskèlija	‘student (nom.)’	(‘LH)(,LL)L
c.	pühelímèt	‘telephones (nom.)’	(‘LL)L(,H)
	kúnnallisèlla	‘council (adess.)’	(‘HH)L(,HL)
	mátematíikka	‘mathematics (nom.)’	(‘LL)L(,HL)

In typical analyses, Finnish is a trochaic language that avoids feet of the form (‘LH), but the primary stress is immune to this requirement, obeying instead a preference for left-alignment at the expense of an (‘LH) foot. Other than the avoidance of (‘LH) feet Finnish is largely quantity-insensitive; heavy syllables do not actively attract stress, as evidenced by the fact that they are not stressed in clash. The prohibition on word-medial (‘LH) has been captured in the previous OT analyses of Finnish by assuming a constraint that is violated specifically by an (‘LH) trochee (Hanson and Kiparsky 1996, Elenbaas 1999, Elenbaas and Kager 1999). Hanson and Kiparsky (1996) call this constraint *EUPODY*, while Elenbaas (1999) and Elenbaas and Kager (1999) simply refer to it as *\*('LH)*.<sup>6</sup>

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<sup>5</sup>This word, along with some other words of similar shape, has an optional pronunciation of [áteriäni] also listed. See Elenbaas (1999) or Karvonen (2005) for further discussion of ternarity in Finnish not driven by quantity.

<sup>6</sup>A different strategy is employed by Alber (1997), who proposes to account for this aspect of Finnish stress with the constraints *\*CLASH*, *WSP*, and *ITL*. *ITL*, short for Iambic/Trochaic Law, is violated by trochees of the form (‘LH) and (HL). Alber’s analysis treats Finnish as a language which generally parses heavy syllables into the heads of (H) feet and under-parses to avoid *\*CLASH* violations.



The \*('LH) strategy also works in HS to successfully account for the asymmetry in the treatment of primary and secondary stress with respect to quantity-insensitivity in Finnish. \*('LH), which is not specific to primary or secondary stress, is defined in (76).

(76) \*('LH)

Assign one violation mark for a foot of the form ('LH)

Because we have assumed a top-down GEN, the analysis is relatively straightforward. At the first iteration of stress assignment the grammar evaluates whether to assign a primary stress and where to put it. Because the first foot can be designated Hd(PWd) when it is built, constraints specific to primary stress are active right away in determining which foot is optimal. Of principal relevance here is the constraint that governs primary stress alignment. I assume this constraint is ALIGNHdL, defined in (77). This constraint references the stressed syllable itself rather than the foot; although this is not crucial for the analysis of Finnish, it does play a role in some of the other analyses of autonomous primary stress discussed in this chapter and some additional discussion of its formulation is undertaken in chapter 4. In order to ensure that primary stress is assigned we will also want a high-ranked constraint against headless PWds, as defined in (78).<sup>7</sup>

(77) **ALIGNHdL**

Assign a violation mark for every syllable separating the primary stress syllable from the left edge of the PWd

(78) **HEADEDNESS(PWd) (Hd(PWd))**

Assign one violation mark for a PWd without a head

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<sup>7</sup>In chapter 4 I argue for a slightly different formulation of ALIGNHd and other constraints on primary stress in order to prevent vacuous satisfaction. Using the updated definitions here would obviate the need for high-ranked Hd(PWd) in this and the following analyses but otherwise does not affect them. (As chapter 4 will address in detail, the argument for the redefining the constraints is driven by a consideration of their typological predictions.)

At the first iteration of stress assignment for the input /ravintola/ a left-aligned trochee is chosen despite its violation of \*('LH), as shown in (79). The primary stress alignment constraint ALIGNHbL dominates \*('LH), because being left-aligned is more important for the primary stress than obeying the general constraint against ('LH) feet. We must also assume that Hd(PWD) dominates \*('LH) to rule out candidates without primary stress, as in (a). The second iteration builds another trochee adjacent to the first because this best satisfies the remaining constraints and adds no violations of \*('LH). The general ranking for iterative left-to-right trochees is assumed (TROCHEE, PARSE-σ » ALLFtL » ALLFtR).

(79) Word-initial LH parsed as ('LH)

/ravintola/ 1st iteration	H <sub>b</sub> (P <sub>WD</sub> )	ALIGNH <sub>b</sub> L	*('LH)	PARSE-σ	ALLF <sub>t</sub> L
a. ravintola	W <sub>1</sub>		L	W <sub>4</sub>	
b. (,ravin)tola	W <sub>1</sub>		1	2	
c. ('ravin)tola			1	2	
d. ra('vinto)la		W <sub>1</sub>	L	2	W <sub>1</sub>
e. ra(,vinto)la	W <sub>1</sub>		L	2	W <sub>1</sub>
<b>2nd iteration</b>					
e. ('ravin)tola			1	W <sub>2</sub>	L
f. ('ravin)(,tola)			1		2
g. (,ravin)('tola)		W <sub>2</sub>	1		2

(Convergence step not shown)

→ **Output:** [( 'ravin)(,tola)]

When a word has a non-initial light-heavy sequence the situation is different. Since ALIGNHbL is no longer at issue (because it has already been satisfied), a secondary stress will be shifted rightward to avoid an (,LH) foot, because \*('LH) dominates ALLFtL. A non-word-initial sequence of light-heavy is parsed L(Hσ) or L(H), as shown in (80) for the input /puhelimet/. \*('LH) must also dominate PARSE-σ as (80) shows because the rightward-shifted stress in [( 'puhe)li(,met)] leaves a syllable unparsed (at least optionally; see e.g. Hanson and Kiparsky 1996:301).

(80) Non-word-initial LH parsed as L(<sub>i</sub>H...)

	( <sub>i</sub> puhe)limet 2nd iteration	*( <sub>i</sub> LH)	PARSE- $\sigma$	ALLFTL
a.	( <sub>i</sub> puhe)limet		$W_2$	L
b.	( <sub>i</sub> puhe)( <sub>i</sub> limet)	$W_1$	L	$L_2$
→ c.	( <sub>i</sub> puhe)li( <sub>i</sub> met)		1	3

The general schema ALIGN<sub>HD</sub> » MARKEDNESS-C » ALIGN<sub>FT</sub> provides a formula for allowing the primary stress foot (or the primary stress syllable) to violate a general stress markedness constraint in order to be better aligned, while secondary stress feet tolerate imperfect alignment in order to avoid violation of the markedness constraint. This ranking can only have the desired effect when it is evident right away that the foot being built is the primary stress foot. It can be confirmed by considering the tableaux in (79) that if candidates with primary stress were not available in the candidate set at the first iteration, the winner would incorrectly be predicted to be \*[ra(<sub>i</sub>vinto)la], which would preclude eventual assignment of the primary stress to the initial syllable. Clearly in this case, top-down stressing—that is, permitting primary stress to be assigned right away—allows an elegant solution for the asymmetry between primary and secondary stress in Finnish. Alternative analyses not relying on the assumption that primary stress assignment is top-down, including those that use a constraint like ALIGN<sub>WDL</sub>, will be discussed in detail in §3.5 below.

The proposal in §3.2 permits complete freedom in the assignment of the primary stress, and this freedom has essentially two manifestations. The first is the allowance of “top-down” stressing at the first iteration and the second is allowing the primary stress to be reassigned throughout the derivation. Autonomous primary stress languages like Finnish rely on the first provision. Because candidates with primary stress are considered right away, it is not necessary to use two separate steps to build a foot and assign primary stress to it, and primary stress con-

straints can favor putting the foot in a place it would not otherwise go. In contrast, Hd(PWd) relabeling plays little to no role in the analysis of autonomous primary stress. In general, high-ranked constraints on primary stress are a prerequisite for analyzing autonomous primary stress languages, but their high rank generally also means that later iterations will not find candidates with Hd(PWd) relabeling optimal, other things being equal. That is, in languages with autonomous primary stress, the primary stress constraints are high enough ranked to determine the optimal location for primary stress to begin with, so subsequent Hd(PWd) relabeling will not improve harmony. In my analyses of the other autonomous primary stress languages I will suppress candidates that show Hd(PWd) relabeling since they are not optimal under rankings that favor autonomous stress. Once the discussion turns to parasitic primary stress in §3.4 we will see that the freedom to relabel Hd(PWd) is indispensable.

### 3.3.2 Tübatulabal

Tübatulabal is a Uto-Aztecan language that was spoken in Southern California (Voegelin 1935). In Tübatulabal, primary stress generally falls on the final syllable regardless of its weight, and quantity-sensitive secondary stresses alternate leftward away from the primary stress (syllables with long vowels are heavy and syllables with short vowels are light, even if closed by a consonant).<sup>8</sup> The data in (81) illustrate. The forms in (a) end in a heavy syllable, while the forms in (b) end in a light syllable. The parsing of a word is the same in both cases.

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<sup>8</sup>Voegelin (1935) says of the word-final “main stress” in Tübatulabal that it “is not acoustically more prominent than other stressed vowels, but merely serves as a convenient point of departure in describing the rhythmical pattern” (Voegelin 1935:75). Nonetheless, Hayes (1995:265) reports that the word-final stress is clearly audible as the primary stress on a recording of Tübatulabal in the UCLA archives and he cites several sources that concur with his judgment. I follow Hayes in considering the final stress to be primary.

## (81) Stress in Tübatulabal (Voegelin 1935:65,75-76)

	Word	Gloss	Proposed foot structure
a.	ú:gibí:l	‘the bunch grass’	(,H)L(‘H)or (,HL)(‘H)
	tiŋjálá:p	‘on the red thistle’	L(,LL)(‘H)
	ibí:mijá:l	‘the flower-mouth’	L(,H)L(‘H) or L(,HL)(‘H)
b.	tʃíŋjál	‘the red thistle’	(,LL)(‘L)
	ná:wifól	‘the pine-nut pole’	(,H)L(‘L) or (,HL)(‘L)
	tʃá:míjɪʔíŋ	‘your acorn gravy (obj.)’	(,H)(,LL)(‘L)
	wítaŋhatál	‘the Tejon Indians’	L(,LL)(‘L)
	jú:dú:jú:dát	‘the fruit is mashing’	(,H)(,H)(,H)(‘L)
	wítaŋhátalá:batsú	‘away from the Tejon Indians’	(,LL)(,LL)(,H)L(‘L)

Hayes (1995) analyzes Tübatulabal with right-to-left moraic trochees, assuming that ‘trapped’ light syllables are unfooted, as in [(,u)gi(‘bi:l)] ‘the bunch grass’. Another possible analysis would be to allow (‘HL) feet, [(,u:gi)(‘bi:l)]; since parsing is right-to-left, these footings are equivalent in the stresses they assign (Prince 1990). Hayes’s analysis is based on his proposed foot inventory, which does not include (‘HL), but since I do not assume a static foot inventory there is no reason not to posit (‘HL) feet here. In any case, I follow Hayes in assuming that Tübatulabal stress is trochaic.<sup>9</sup>

As the examples in (81) show, in order for primary stress to consistently fall on the final syllable given a trochaic analysis, a monosyllabic foot is necessary. When the final syllable is light, primary stress occupies a degenerate foot, (‘L). Because degenerate feet are otherwise not utilized in a trochaic analysis of Tübatulabal, we can account for the conditional allowance of degenerate feet in final position as a consequence of a high-ranked constraint that wants the primary stress syllable to

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<sup>9</sup>Though see Crowhurst (1991a,b), whom Hayes cites for proposing an iambic analysis of Tübatulabal.

be right-aligned, ALIGNHDR, as defined in (82). This constraint is the mirror image of ALIGNHDL, used in the analysis of Finnish above. Unlike in Finnish, however, the syllable-referring (as opposed to foot-referring) quality of this constraint is important in the analysis of Tübatulabal.

(82) **ALIGNHDR**

Assign a violation mark for every syllable separating the primary stress syllable from the right edge of the PwD

As shown in (83), ALIGNHDR, along with TROCHEE, has to dominate FTBIN and PARSE- $\sigma$  in order for the final ('L) foot to be optimal. Regular parsing will avoid degenerate feet because FTBIN dominates PARSE- $\sigma$ .

(83) Final stress in Tübatulabal

	/witaŋhatal/ 1st iteration	TROCHEE	ALIGNHDR	FTBIN	PARSE- $\sigma$
↙	a. witaŋha('tal)			1	3
	b. witaŋ('hatal)		W <sub>1</sub>	L	L <sub>2</sub>
	c. witaŋ(ha'tal)	W <sub>1</sub>		L	L <sub>2</sub>
→	<b>2nd iteration</b>				
	d. witaŋha('tal)				W <sub>3</sub>
↙	e. wi( <sub>i</sub> taŋha)('tal)				1
→	<b>3rd iteration</b>				
↙	f. wi( <sub>i</sub> taŋha)('tal)				1
	g. ( <sub>i</sub> wi)( <sub>i</sub> taŋha)('tal)			W <sub>1</sub>	L
→	<b>Output:</b> [wi( <sub>i</sub> taŋha)('tal)]				

Without a constraint wanting the primary stress to be maximally right-aligned, we would fail to account for the conditional allowance of degenerate feet found in Tübatulabal. Importantly in the present context, such a constraint would not be able to effect a change in stress pattern if primary stress were not able to be assigned when the first foot is built. As shown in (84), the other constraints active in Tübatulabal will not force a stress at the right edge unless it is the primary stress.

(84) Final stress not motivated without primary stress

/witaŋhatal/ 1st iteration	TROCHEE	FTBIN	PARSE- $\sigma$
⊖ a. witaŋha(,tal)		1	3
→ b. witaŋ(,hatal)			2
c. witaŋ(ha,tal)	1		2

Like Finnish, Tübatulabal's stress pattern is an example of an ALIGN<sub>HD</sub> constraint dominating a markedness constraint, principally FTBIN here, which in turn dominates other general stress constraints, including PARSE- $\sigma$ . This ensures that FTBIN can be violated just when it is necessary to force perfect alignment of the main stress, but otherwise it is satisfied. The result is a language that, like Finnish, appears to be quantity-sensitive only in its secondary stresses because of the more stringent demand placed on its primary stress to be edge-aligned.

### 3.3.3 Huariapano

A formally similar example involving a quantity-asymmetry in primary and secondary stress arises in Huariapano, a Panoan language formerly spoken in Peru (Parker 1994, 1998). Primary stress is quantity-sensitive and aligned to the right-edge, while secondary stresses are quantity-insensitive. Huariapano primary stress follows the Latin stress rule without extrametricality (for a list of languages with Latin-like stress, see Hayes 1995:180ff); the final syllable receives primary stress if heavy and otherwise the primary stress surfaces on the penult. Vowel length is not contrastive and only appears in monosyllabic words to satisfy a bimoraic word minimum, but syllables closed by a consonant are heavy, attracting stress in final position. The examples in (85) illustrate this pattern. The words in (a) end with a light syllable and receive penult stress, while the words in (b) have a final heavy

which receives the primary stress.<sup>10</sup> Huariapano primary stress can, like Latin, be analyzed with the moraic trochee as the basic foot type (i.e., ('H) or ('LL)).

(85) Huariapano primary stress (Parker 1994:98; Parker 1998:4)<sup>11</sup>

	Word	Gloss	Proposed foot structure
a.	tápoʔ <sup>12</sup>	'cot'	('LL)
	kóʃni	'beard'	('HL)
	kanóti	'bow (weapon)'	L('LL)
	ràmboʃóʃo	'knees'	(,HL)(,LL)
b.	hõntsís	'claw, fingernail'	H('H)
	yawíʃ	'opposum'	L('H)
	ʃomóʃ	'needle'	L('H)
	ʃaʃín	'bee'	L('H)

Unlike primary stress, secondary stresses in Huariapano are quantity-insensitive and are best described with syllabic trochees. Parker (1998) reports that the secondary stresses may be either right-aligned or left-aligned (that is, iterating right-to-left away from, or left-to-right toward, the primary stress foot), determined lexically (and apparently arbitrarily) on the basis of the root. The data in (86) demonstrate the secondary stress pattern that emerges in longer words (par-

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<sup>10</sup>Parker (1994, 1998) reports that there is a non-trivial minority of words in Huariapano that have primary stress on a light final syllable. Some of these end in a nasalized vowel that plausibly derives from an underlying VN sequence, as Parker argues, which makes their final stress opaque (see McCarthy 2000 as well as Elfner 2010 for some discussion of opacity in HS). Another group of words appears to have transparently exceptional final stress, and these would need to be treated as lexically-marked in some way (see McCarthy and Pruitt to appear for some discussion of lexical stress in HS and Pater 2000 for lexical stress generally). No words ending in a heavy syllable are reported to have exceptional penult stress.

<sup>11</sup>The symbol [ʃ] corresponds to [ʃ̠] in Parker's (1994, 1998) transcriptions, which he describes as a voiceless retroflex alveopalatal fricative.

<sup>12</sup>Glottal stop is not phonemic and does not contribute to weight in coda position (Parker 1994, 1998).



ticularly verbs). The forms in (b) show left-alignment of secondaries, while the forms in (c) show right-alignment, and the forms in (a) are consistent with both.

(86) Huariapano secondary stress (Parker 1998:6ff)

	Word	Gloss	Proposed foot structure
a.	hàβombíβi	‘they’	(,LH)(‘LL)
	inawkónra	‘jaguar (topic)’	(,LH)(‘HL)
b.	mùrayβaşıki	‘we found’	(,LH)L(‘LL)
	kùβyayβaşıki	‘I cooked’	(,HH)L(‘LL)
c.	miβòmbirána	‘you (plural)’	L(,HL)(‘LL)
	βismànohkònosi <sup>13</sup>	‘I forgot’	H(,LH)(,LL)(‘LL)

Parker’s (1998) analysis (also adopted by McGarrity 2003) captures the quantity asymmetry between primary and secondary stress in Huariapano with a constraint that explicitly favors primary stress on a heavy syllable rather than a light syllable (PκPROM; Prince and Smolensky 1993/2004). Here though I will analyze Huariapano in a way that makes it much more similar to Finnish and Tübatulabal, languages with primary-stress-alignment-driven quantity asymmetries.

The analysis of Huariapano primary stress I adopt is based partly on Pater’s (2000) analysis of the primary stress pattern in the class of English words that exhibit the Latin stress rule. Thus, rather than adopting the PκPROM constraint used by Parker (1998), I will motivate right-edge primary stress quantity-sensitivity in Huariapano with ALIGNHDR. In Tübatulabal we saw that the primary stress appeared on the final syllable by virtue of ALIGNHDR, which is able to force a violation of constraints like FTBIN. This made Tübatulabal’s primary stress appear

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<sup>13</sup>Word-medial [h] is epenthetic in Huariapano, but because secondary stresses are quantity-insensitive it is difficult to say whether coda [h] contributes to syllable weight. I have marked the syllable with [h] as heavy here, but this is hypothetical and does not really affect the content of the present analysis either way. For extensive discussion of [h]-epenthesis in Huariapano, see Parker (1994).

quantity-insensitive even though its other feet were quantity-sensitive (and similarly for Finnish with a different foot template at the left edge). But if FTBIN instead dominates ALIGNHDR we get the pattern in Huariapano: assuming a basically trochaic language, primary stress surfaces as far to the right as possible while obeying FTBIN. When the final syllable is heavy, FTBIN, TROCHEE, and ALIGNHDR can be simultaneously satisfied with a final ('H) foot. But when the final syllable is light, at least one of these constraints is violated. Tübatulabal selects a final  $\sigma$ ('L) sequence to satisfy ALIGNHDR at the expense of FTBIN, while Huariapano selects (' $\sigma$ L) to satisfy FTBIN and tolerates minimal violation of ALIGNHDR.

The analysis works out as follows. For Huariapano, TROCHEE and FTBIN are undominated. Any attempt to place the primary stress at the right edge will have to do so without creating an iamb or a degenerate foot. When a word ends in a light syllable, penult stress is preferred—although it is not perfectly right-aligned, it surfaces as far to the right as possible without violating the other constraints, as the tableau in (87a) shows. But when the final syllable is heavy, the opportunity arises for a non-degenerate monosyllabic foot in final position. As shown in (87b), ALIGNHDR favors a quantity-sensitive foot because it permits better alignment of the primary stress syllable. The outcome in (87b) also shows that ALIGNHDR and TROCHEE must dominate PARSE- $\sigma$ , since the monosyllabic ('H) leaves more syllables unparsed.

(87) a. Penult stress when final syllable is light

<i>/kanoti/</i> 1st iteration	TROCHEE	FTBIN	ALIGNHDR	PARSE- $\sigma$
→ a. ka('noti)			1	1
b. ka(no'ti)	W <sub>1</sub>		L	1
c. kano('ti)		W <sub>1</sub>	L	W <sub>2</sub>

b. Final stress when final syllable is heavy

/yawif/ 1st iteration	TROCHEE	FTBIN	ALIGNHDR	PARSE-σ
→ a. ya('wif)				1
b. ('yawif)			W <sub>1</sub>	L
c. (ya'wif)	W <sub>1</sub>			L

In order for this analysis to work, we must know when it is built that the foot at the right edge is the primary stress; that is, parsing must be top-down. If the foot is *not* Hd(PWd) when it is built, the ALIGNHD constraint does not apply and there is no motivation for the stress to be placed on the final syllable, even when it is heavy. The tableau in (88) illustrates this point. If the only options are to build secondary stress feet, the general parsing constraints will favor quantity-insensitive trochaic parsing. Since regular stress is not quantity-sensitive, there are no other high-ranked constraints that favor ('H) over ('σσ), so the right-edge quantity-sensitivity can only be due to a constraint on primary stress.

(88) No motivation for final stress when parsing is not top-down

/yawif/ 1st iteration	TROCHEE	FTBIN	PARSE-σ
⊖ a. ya(wif)			W <sub>1</sub>
→ b. (,yawif)			
c. (ya,wif)	W <sub>1</sub>		L

The alternative analysis of Huariapano primary stress adopted by Parker (1998) (see also McGarrity 2003) uses a primary-stress-specific version of the constraint PKPROM, which favors stressed heavy syllables over stressed light syllables. The formulation provided by Parker (1998:13), which derives from the proposal of Prince and Smolensky (1993/2004:Ch. 4), is provided in (89).

(89) **PKPROM<sub>MAIN</sub>**

With respect to main stress,  $\acute{H} > \acute{L}$

Under this analysis, [ya('wif)] is favored over \*[('yawif)] because it performs better with respect to  $P_{\kappa PROM MAIN}$ , and [rambo('ʒoβo)] is favored over \*[('rambo)ʒoβo] because a constraint that wants the primary stress foot to be aligned with the right word edge ( $MAIN_{RT}$  in Parker 1998) outranks  $P_{\kappa PROM MAIN}$  in turn. The general  $P_{\kappa PROM}$  constraint is assumed to be too low ranked to affect secondary stress footing in a similar way, and so this analysis predicts the primary-stress-specific quantity-sensitivity seen in Huariapano.

This analysis is a viable alternative to the one I presented above, but it too relies on top-down stress assignment—in both cases a constraint that is specific to primary stress ( $ALIGN_{HDR}$  or  $P_{\kappa PROM MAIN}$ ) alters the foot type that appears at the right word edge in order to account for the quantity asymmetry.<sup>14</sup> Since the primary stress is treated differently from the other feet, it must be the case that the grammar knows that the foot is the main stress when it is built. If it did not, then the foot at the right edge would obey the same constraints as all the other feet, which in this case would entail that it is quantity-insensitive, counter to fact.

As far as I know the data are accounted for equally well by both accounts. I have adopted the the analysis using  $ALIGN_{HDR}$  because it connects Huariapano to Tübatulabal and Finnish; in all three cases an alignment constraint on primary stress causes an asymmetry in the quantity distinctions made by primary and secondary stress. But if there is independent evidence that a constraint like  $P_{\kappa PROM MAIN}$  is also needed, then either analysis would be sufficient when parsing is top-down as I have proposed.

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<sup>14</sup>Parker's (1998) analysis is formulated within parallel OT, so the fact that primary stress is assigned to a foot at the same time that it is built receives no special discussion.

### 3.3.4 Bidirectional stress systems

Bidirectional stress systems present a final example of primary-stress-specific alignment contrasting with general foot alignment. In bidirectional systems the primary stress is aligned to one edge while non-primary stresses align to the opposite edge (for recent general discussion of bidirectional stress systems, see Kager 2001, Alber 2005, Hyde 2008).<sup>15</sup> The examples in (90) illustrate one kind of bidirectional system, from Piro, an Arawakan language of Peru (Matteson 1965). In Piro the primary stress is on the penultimate syllable, secondary stress is word-initial, and tertiary stresses appear on odd-numbered syllables counting from the left in long enough words, though the syllable immediately preceding the primary stress never receives stress. This is analyzed by assuming quantity-insensitive trochees (Hayes 1995:201, among others); the primary stress foot is right-aligned while non-primary stress feet align toward the left word edge, as the data and proposed footing in (90) show. (I will collapse the secondary/tertiary distinction here.)

(90) Bidirectional stress in Piro (Matteson 1965:21) with proposed footing<sup>16</sup>

ru(ˈtɛtɛ)	‘he observes taboo’
(ˈtʃija)(ˈhata)	‘he cries’
(ˌsarua)je(ˈhkakna)	‘they visit each other’
(ˌpɛtʃi)(ˈtʃhima)(ˈtrona)	‘they say they stalk it’
(ˌrusru)(ˌnoti)ni(ˈtkana)	‘their voices already changed’
(ˌsapre)(ˌuhima)(ˌmtana)(ˈtnaka)	‘they say he went along screaming again’
(ˌkaçruː)(ˌkakhi)(ˌmana)ta(ˈtkana)	‘they were joking together then, it is said’

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<sup>15</sup>For discussion of possible cases in which the foot at the non-iterating edge is *not* the primary stress, see §3.5.2 below.

<sup>16</sup>Matteson (1965) suggests that the syllable template in Piro places all intervocalic consonant clusters into onset position. This is based on the fact that all intervocalic consonant sequences can

With top-down parsing in HS, the stress pattern of Piro is derived by first building the lone primary stress foot at the right edge and then iterating the secondary stresses from the other direction, as in (91).

(91) Derivation of bidirectional stress in Piro

/rusrunotinitkana/ → rusrunotini('tkana) → (,rusru)notini('tkana)  
 → (,rusru)(,noti)ni('tkana) → [(,rusru)(,noti)ni('tkana)]

This derivation is achieved by ranking the general parsing constraints to prefer disyllabic left-aligned trochees (FTBIN, TROCHEE » PARSE-σ » ALLFTL » ALLFTR) and by assuming an additional crucial ranking, ALIGNHDR » ALLFTL. At the first iteration, the ALIGNHD constraint will be active in selecting an optimal candidate, and because ALIGNHDR outranks ALLFTL, the most right-aligned foot wins. This is shown in (92).

(92) Derivation of bidirectional stress in Piro

/rusrunotinitkana/ 1st iteration	FTBIN	TROCHEE	PARSE-σ	ALIGNHDR	ALLFTL
→ a. rusrunotini('tkana)			5	1	5
b. ('rusru)notinitkana			5	W <sub>6</sub>	L
c. rusrunotini(tka'na)		W <sub>1</sub>	5	L	5
d. rusrunotinitka('na)	W <sub>1</sub>		W <sub>6</sub>	L	6

At subsequent iterations regular iterative parsing will begin at the left edge of the word and continue rightward. Because the first iteration selected a candidate that already maximally satisfies ALIGNHDR (modulo TROCHEE and FTBIN), the ALIGNHD constraint will not affect regular parsing, which falls instead to the other

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also occur word-initially and the observation that all words in Piro end in a vowel. Where relevant, I follow Matteson's syllabification.

constraints. The derivation continues building syllabic trochees from left to right as in (93).

(93) Derivation of bidirectional stress in Piro, continued

	<i>F<sub>T</sub>BIN</i>	<i>PARSE-σ</i>	<i>ALIGN<sub>HdR</sub></i>	<i>ALL<sub>FTL</sub></i>
<b>rusrunotini('tkana)</b> <b>2nd iteration</b>				
a. rusrunotini('tkana)		W <sub>5</sub>	1	5
b. (,rusru)notini('tkana)		3	1	5
c. rusruno(,tini)('tkana)		3	1	W <sub>8</sub>
<b>3rd iteration</b>				
d. (,rusru)notini('tkana)		W <sub>3</sub>	1	L <sub>5</sub>
e. (,rusru)(,noti)ni('tkana)		1	1	7
f. (,rusru)no(,tini)('tkana)		1	1	W <sub>8</sub>
<b>4th iteration</b>				
g. (,rusru)(,noti)ni('tkana)		1	1	7
h. (,rusru)(,noti)(,ni)('tkana)	W <sub>1</sub>	L	1	W <sub>11</sub>
<b>Output:</b> [(,rusru)(,noti)ni('tkana)]				

The analysis of Piro shows that an *ALIGN<sub>Hd</sub>* constraint can overcome the general foot alignment preferences when higher ranked, yielding a bidirectional parse. If the primary stress could not be assigned right away, the ranking shown in (92) and (93) would select a *left*-aligned disyllabic trochee as optimal at the first iteration. It would not be possible to treat the main stress foot differently if it is not yet known to the grammar which foot is the main stress. Thus, Piro and other bidirectional stress systems require the freedom to label a foot as *Hd*(PWd) when it is built. An alternative analysis that relies on the constraint *ALIGN<sub>WdR</sub>* without top-down parsing is discussed below in §3.5.2.

All the examples considered thus far—Finnish, Tübatulabal, Huariapano, and Piro—are examples in which the main stress alignment constraint is responsible for creating a primary stress foot that does not obey the same requirements as other feet. In Finnish and Tübatulabal the effect is to make primary stress appear quantity-insensitive while the secondary stresses are (partially-)quantity-sensitive.

In Huariapano the effect on the surface is the opposite—primary stress acts as though it were quantity-sensitive in order to get closer to the right edge while obeying TROCHEE and FTBIN, while secondary stresses are quantity-insensitive. And in quantity-insensitive bidirectional systems like Piro the primary and secondary stresses align to opposite edges of the word, hence the term *bidirectional*, though no asymmetries in quantity-sensitivity are observed

Primary stress alignment can also interact with other constraints to influence parsing. The next section shows an additional example that supports the hypothesis that parsing is top-down.

### 3.3.5 Latin

Latin presents another example of a language with autonomous primary stress. The placement of the primary stress foot must be determined with reference to a primary-stress-specific version of NONFINALITY—a constraint which prohibits a word-final stress/foot—otherwise the surface foot structure cannot correctly account for the placement of primary stress.

The well-known primary stress pattern of Latin is exemplified in (94). In words of one or two syllables the initial (or only) syllable is stressed (as in (a)). In words of three or more syllables the penultimate syllable is stressed if it is heavy (as in (b)), and otherwise stress falls on the antepenultimate syllable (as in (c)) (Allen 1965, 1973). Syllables with long vowels and those closed by consonants are considered heavy in the calculation of stress.



(94) Latin primary stress (Mester 1994, Allen 1973)

- |    |             |                               |
|----|-------------|-------------------------------|
| a. | spé:        | ‘hope, abl.sg.’               |
|    | béne        | ‘good’                        |
|    | ámo:        | ‘love, 1sg.pres.’             |
|    | pútat       | ‘believe, 3sg.pres.’          |
|    | mánda:      | ‘entrust, 2sg.pres.imper.’    |
| b. | amí:kus     | ‘friend, nom.sg.’             |
|    | reféktus    | ‘reconstructed, masc.nom.sg.’ |
|    | pepérki:    | ‘forbear, 1sg.perf.’          |
|    | adoptá:tus  | ‘adopted, nom.sg.’            |
|    | inimí:kus   | ‘enemy, nom.sg.’              |
| c. | légere      | ‘read, pres.inf.’             |
|    | tímide:     | ‘timid, masc.voc.sg.’         |
|    | dí:kito:    | ‘say, 2/3sg.fut.imp.’         |
|    | ministérium | ‘service, nom/acc.sg.’        |
|    | ami:kítiam  | ‘friendship, acc.sg.’         |
|    | refikio:    | ‘remake, 1sg.pres.’           |
|    | refikere    | ‘remake, pres.inf.’           |
|    | kapítibus   | ‘head, dat/abl.sg.’           |

As these data indicate, primary stress in Latin avoids the final syllable in two ways. First, the primary stress never falls on the final syllable unless the word is monosyllabic. Even in disyllabic words with an initial light syllable and a final heavy, the primary stress falls on the initial syllable rather than on the final (e.g., [ámo:]). Second, the final syllable is routinely excluded from the primary stress foot. Antepenultimate stress in a word like [légere] results from the foot structure (‘LL)σ, in which the primary stress foot has moved leftward to avoid parsing the final syllable. Prince and Smolensky (1993/2004) propose that the constraint

NONFINALITYHD militates against final primary stress, as defined in (95). This constraint penalizes both a word-final primary stress and a word-final primary stress foot. Moreover, it does so additively, by assigning two violation marks for a candidate like [...σ('σ)] and just one violation mark for a candidate like [...('σσ)].<sup>17</sup>

(95) **NONFINALITYHD**

“No prosodic head of PrWd is final in PrWd” (Prince and Smolensky 1993/2004:68)

With NONFINHD, we can account for the Latin primary stress pattern in HS with an adaptation of Prince and Smolensky’s (1993/2004:Ch4) analysis. NONFINHD ensures that primary stress will not fall on a final syllable except as a last resort (as in monosyllabic words) and that the final syllable will not be included in the primary stress foot unless the word is disyllabic and the penult is light (because FTBIN » NONFINHD), as shown in the tableau in (96a). An ('LH) foot is erected on /amo:/, and thus NONFINHD must also dominate a constraint against having a heavy syllable as the weak member of a foot, WSP (for the ‘Weight-to-Stress Principle’, Prince 1990, Prince and Smolensky 1993/2004). In (96b) the penult is heavy, so a monosyllabic foot on the first syllable of /manda:/ is preferred because it avoids parsing the final syllable while not violating FTBIN.

(96) a. Disyllabic word with light penult

/amo:/ 1st iteration	HD(PWD)	FTBIN	NONFINHD	WSP
a. amo:	W <sub>1</sub>		L	1
→ b. ('amo:)			1	1
c. ('a)mo:		W <sub>1</sub>	L	1
d. a('mo:)			W <sub>2</sub>	L

<sup>17</sup>The additive property of this constraint is not really crucial here. The analysis would be the same if NONFINALITYHD were divided into separate constraints—one referencing the head foot and one referencing the head syllable.

b. Disyllabic word with heavy penult

/manda:/ 1st iteration	HD(PWD)	FTBIN	NONFINHD	WSP
a. manda:	W <sub>1</sub>			W <sub>2</sub>
b. ('manda:)			W <sub>1</sub>	1
→ c. ('man)da:				1
d. man('da:)			W <sub>2</sub>	1

However, the constraint favoring right-alignment of primary stress, ALIGNHD-R, will ensure that primary stress falls as far to the right as possible within the restrictions laid out by the higher ranking constraints. In a word with three or more syllables, a heavy penult permits satisfaction of FTBIN and NONFINHD with minimal violation of ALIGNHDR; as shown in (97a), /ami:kus/ maps to [a('mi:kus)]. When the penult is light, it is necessary to settle for antepenultimate stress to ensure a licit foot, ('LL)σ or ('H)σσ; as shown in (97b), /ami:kitiam/ is parsed as [am:(('kiti)am)].

(97) a. Longer word with heavy penult

/ami:kus/ 1st iteration	HD(PWD)	NONFINHD	ALIGNHDR
a. ami:kus	W <sub>1</sub>		L
→ b. a('mi:kus)			1
c. ('ami:kus)			W <sub>2</sub>
d. a('mi:kus)		W <sub>1</sub>	1
e. ami:(('kus)		W <sub>2</sub>	L

b. Longer word with light penult

/ami:kitiam/ 1st iteration	HD(PWD)	NONFINHD	ALIGNHDR
a. ami:kitiam	W <sub>1</sub>		L
→ b. ami:(('kiti)am)			2
c. a('mi:kitiam)			W <sub>3</sub>
d. ami:ki('tiam)		W <sub>1</sub>	L <sub>1</sub>

These constraints account for the primary stress pattern in Latin with the assumption that the primary stress is assigned right away. Secondary stress in Latin is a more contentious issue. Nonetheless, Mester (1994) convincingly demon-

strates that foot structure must be present beyond the primary stress foot. He cites the process of cretic shortening, in which words with the shape HLH, e.g., /di:kito:/, are scanned as HLL in pre-classical meter (particularly that of Plautus), as evidence that such words are parsed with a monosyllabic foot on the heavy antepenult and a disyllabic foot following: ('H)(LH). The shortening process is motivated by the fact that ('LH) makes a bad trochee, and as such, non-primary stress footing must have existed in Latin in order to account for it.<sup>18</sup> On the relationship between the pre-classical meter and the actual prosody of the language, Mester says, "It is widely agreed that the Latin encountered these works was much closer to the spoken language than the later strictly regulated classical idiom" (1994:3).

If we assume, then, that secondary stress feet did exist in Latin, the question we must ask is whether the principles that account for the distribution of secondary stresses would consistently put a foot in the correct place for primary stress were parsing to proceed strictly bottom-up (that is, without primary stress being assigned at the first iteration of foot building). Although generalizations about the distribution of secondary stresses in all word types in Latin are elusive, the shortening facts discussed above are sufficient to establish that secondary stress feet differ from primary stress feet in one crucial way—their failure to obey NONFINALITY. In order to account for cretic shortening, a word like /di:kito:/ must be parsed [(di:)(kito:)] so that shortening is then triggered by the introduction of a violation of a constraint against ('LH) feet. Parsing and shortening are assumed to proceed as in (98). Thus, word-final secondary stress feet are not prohibited in Latin.

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<sup>18</sup>The logic behind the foot-based analysis of shortening is discussed in detail by Mester (1994), as well as by Prince and Smolensky (1993/2004) from an OT perspective. One argument in support of this analysis is that the shortening process is not limited to cretic words but is also found in iambic words, LH being scanned as LL (also known as *Brevis Brevis*), as well as in some pre-tonic light-heavy sequences when the light syllable could not otherwise have been footed, e.g., ami:kitiam, which can be scanned as ami:kitiam. For more on these shortening processes, see Allen (1973), Devine and Stephens (1980), Prince (1990), Mester (1994), Prince and Smolensky (1993/2004).

(98) Derivation of cretic shortening in Latin

/di:kito:/ → ('di:)kito: → ('di:)(kito:) → ('di:)(kito) → [('di:)(kito)]

The failure of secondary stress feet to obey NONFINALITY means that the general (that is, non-primary-stress-specific) version of this constraint is low-ranked. As a result, if bottom-up parsing proceeds right-to-left, there is no reason to avoid parsing the final syllable into a foot at the first iteration. However, the foot structures we are aiming for (to ensure correct placement of the primary stress) do not arise from these assumptions.<sup>19</sup> Consider the contrast between cretic words, which should ultimately be parsed ('H)(,LH) and anapestic words (those with a light-light-heavy sequence, e.g., /timide:/), which should ultimately be parsed ('LL)(,H). Both word types end with a light-heavy sequence, but only in cretic words is this sequence parsed into a single foot. Without the conflict between ALIGNHDR and NONFINALITY being active right away, we incorrectly predict that cretic and anapestic words will both be parsed the same way—either as  $\sigma(,LH)$  or as  $\sigma L(,H)$ , depending on the ranking—at the first step. Similarly, any word ending in three light syllables should receive primary stress on its antepenult. But if the first layer of parsing does not avoid final syllables, we predict a word like /refikere/ to be parsed as (,refi)(,kere) before primary stress is assigned, providing no foundation for the antepenultimate primary stress that we actually find in such words. There is no way to begin with this parse and end up with the desired [re('fike)re] instead.

Because the secondary stress facts of Latin are not well-understood it is quite possible that secondary stresses are left-aligned rather than right-aligned.<sup>20</sup> Left-

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<sup>19</sup>Prince and Smolensky (1993/2004:70) make a similar point, although they suggest this is evidence for parallelism in general. Here I acknowledge the evidence Latin provides for parallelism within the assignment of primary stress (where 'top-down' primary stress assignment can be seen as a kind of parallelism) but I do not take this to necessarily entail parallelism of the entire grammar.

<sup>20</sup>There are in fact some suggestions that a secondary stress remained on the initial syllable, which held the primary accent earlier in the history of the language (Allen 1973).

to-right parsing would achieve the correct foot structures for cretic (/di:kito:/→(,di:)kito→(,di:)(,kito)→[(‘di:)(,kito)]) and anapestic (/timide:/→(,timi)de:→(,timi)(,de:)→[(‘timi)(,de:)]) words. But parsing left-to-right produces the same incorrect outcome in a word with four light syllables like /refikere/ that right-to-left parsing does, i.e., \*[(‘refi)(,kere)]. In essence, antepenultimate primary stress is difficult to motivate when parsing is not top-down because it arises from a conflict between NONFINHD and ALIGNHDR, neither of which can be active until primary stress is assigned. Regardless of one’s assumptions about the directionality of secondary stress feet in Latin, top-down parsing is necessary in order to consistently account for the location of the primary stress.

### 3.3.6 Summary

The case studies in this section have demonstrated the need for the grammar to be able to designate a foot as the primary stress (or Hd(PWd)) at the same time that it is built. Without such an option all feet will be treated the same in the course of parsing, but these cases show that the primary stress foot sometimes appears in a location or with characteristics that are not consistent with the generalizations about secondary stress in the language. In these languages primary stress does not appear to be just secondary stress ‘plus something extra’ (Bailey 1995), but instead obeys autonomous principles. In Optimality Theory this suggests that primary stress is subject to different or additional constraints, but as we have seen in this section we must also adopt a definition of GEN that permits those constraints to actively affect foot-building.

## 3.4 Free assignment of Hd(PWd) Part II: Parasitic primary stress

In §3.2 I proposed that the operation that assigns primary stress applies freely, anywhere and any time it can. Languages with autonomous primary stress, as

discussed in the previous section (§3.3), benefit from this assumption because the primary stress can be assigned to a foot at the same time it is built. This section turns to parasitic primary stress systems and argues that they too rely on the assumption that primary stress is assigned and reassigned freely.

### 3.4.1 Parasitic primary stress

The assumption that the location of primary stress can be straightforwardly determined without reference to any secondary stresses is accurate for many languages, but there is a small but well-documented class of exceptions in which primary stress is parasitic on secondary stresses. Hayes (1995:36) calls these languages “bottom-up” because they are cases in which the location of primary stress cannot be determined without knowing the location of secondary stress feet. The basic diagnostic of such systems is that primary stress is assigned near one edge of the word, but exactly which syllable it is assigned to is determined by the number of syllables separating it in the *opposite* direction from the word edge or a heavy syllable. (Van der Hulst 2009 calls these “count” systems for this reason.)

Unlike autonomous primary stress, which manifests itself in different ways for different languages, all languages with parasitic primary stress share this basic characteristic. Hayes (1995:36) lists Cairene Arabic, Seminole/Creek, Wargamay, Munsee/Unami, Eastern Ojibwa, and Malecite-Passamaquoddy as languages that have parasitic primary stress, though this does not appear to be an exhaustive list. Two additional examples are Nyawaygi, which is reported to have a stress pattern identical to neighboring Wargamay (Dixon 1983), and Asheninca, which has left-aligned secondary stresses with primary stress appearing on a rightmost foot (Pichis dialect: Payne 1990, Elsmann 2010; Apurucayali dialect: Payne, Payne, and Santos 1982, McCarthy and Prince 1993b).

Descriptions of primary stress placement in such stress systems invariably sound non-local, but metrical theory permits analyses of them which straightforwardly rely on the location of feet (McCarthy 1979). Analyzing these languages requires building feet left-to-right or right-to-left and assigning the primary stress to the rightmost or leftmost foot, respectively (or, equivalently, to the foot at the ‘end’ of the directional parse). In this section I illustrate how this class of languages can be analyzed in HS using Cairene Arabic as an example. The analysis of Cairene can be extended to the other parasitic primary stress languages with the necessary adjustments in ranking for different foot types (whether trochaic, iambic, quantity-sensitive or not, etc.). Given the assumptions of a top-down GEN adopted thus far, relabeling of the primary stress must be permitted throughout the derivation to account for these languages, a point which is discussed in detail below.

### 3.4.2 Cairene Arabic

The data in (99) from Cairene Arabic demonstrate a pattern that is typical of languages with parasitic primary stress. These data, from Mitchell (1975) via McCarthy (1979), illustrate the pronunciation of Classical Arabic words in the dialect of speakers educated in Cairo. The Cairene dialect of Arabic shows quantity-sensitive trochaic parsing (CVC and CV: are heavy) with a prohibition on final stress except when the final syllable is superheavy (CVCC or CV:C). When the final syllable is not superheavy, the stress pattern is as follows: stress the penult if it is heavy, as in (a), but when the penult is light stress either the penult (b) or the antepenult (c), whichever is an even number of syllables away from the rightmost heavy syllable or the beginning of the word.



(99) Stress in Cairene Arabic<sup>21</sup> (McCarthy 1979:447)

	Word	Gloss	Proposed foot structure
a.	katábta	'you (m. sg.) wrote'	L('H)L
	ha:ðá:ni	'these (m. du.)'	(,H)(,H)L
b.	faʕalátun	'deed (nom.)'	(,LL)(,LH)
	ʕaʕaratuhúma:	'their (du.) tree (nom.)'	(,LL)(,LL)(,LH)
	qattála	'he killed'	(,H)(,LL)
	ʔadwijatúhu	'his drugs (nom.)'	(,H)(,LL)(,LL)
c.	kátaba	'he wrote'	(,LL)L
	ʕaʕarátuhu	'his tree (nom.)'	(,LL)(,LL)L
	ʔinkásara	'it got broken'	(,H)(,LL)L
	ʔadwijatúhuma:	'their (du.) drugs (nom.)'	(,H)(,LL)(,LL)H

As this description suggests, determining the location of primary stress in Cairene Arabic appears to require counting syllables, but McCarthy (1979) shows that the pattern is naturally described by positing left-to-right quantity-sensitive foot construction and a right-branching word tree (that is, primary stress on the right-most foot). Clearly these data are a problem for any theory that assumes the location of main stress is always determined by autonomous principles. The challenge for such a theory is to consistently find the correct syllable on which to place the primary stress without yet knowing where the secondary stresses will be.<sup>22</sup>

The principal mechanism that was argued in §3.3 to account for autonomous primary stress—freedom to assign a foot the status of Hd(PWd) at any time—is extended straightforwardly to account for parasitic primary stress with the assump-

<sup>21</sup>Secondary stresses are not marked, but McCarthy (1979) cites evidence from the pitch contour of longer words as described by Mitchell (1975) that suggests evidence of alternating emphasis on strings of light syllables. This is taken by McCarthy to be further evidence that metrical structure is present throughout the word.

<sup>22</sup>Cf. van der Hulst (1997, 2009), Hammond (1985a) for efforts to explain parasitic primary stress in other ways.

tion that *reassignment* of primary stress is possible. In §3.2 this was described as a process of Hd(PWd) relabeling, in which the application of primary stress assignment demotes any primary stress in the local input to secondary. Just as the assignment of primary stress to a foot at the first iteration is ‘free’, in that it does not require its own step, the (re)assignment and concomitant demotion at subsequent iterations is free in the same sense.

The analysis of Cairene Arabic that I present below shows how this set of assumptions captures parasitic primary stress. There is a further detail that I will delay discussing until after the analysis, namely, why Hd(PWd) relabeling is required given that the definition of GEN I have assumed does not prevent candidates with only secondary stresses, which would suggest potential compatibility with ‘traditional’ bottom-up analyses. The reasons for this principled exclusion are discussed below, but for the presentation of the analysis of Cairene Arabic I will stipulate that no candidate can be without primary stress.

For Cairene the general pattern for feet is left-aligned trochees, which is achieved with TROCHEE, PARSE- $\sigma$  » ALLFTL » ALLFTR.<sup>23</sup> The primary stress ends up on the rightmost foot, not the leftmost one, so ALIGNHDR must dominate ALIGNHDL. However, in order to prevent ALIGNHDR from affecting the location of the first foot, it must itself be dominated by ALLFTL. The first iteration is shown in (100).

(100) Left-aligned first foot in Cairene Arabic

	/faɕaratuhu/ 1st iteration	PARSE- $\sigma$	ALLFTL	ALIGNHDR
a.	faɕaratuhu	W <sub>5</sub>		L
→ b.	( <sup>1</sup> faɕa)ratuhu	3		4
c.	faɕara( <sup>1</sup> tuhu)	3	W <sub>3</sub>	L <sub>1</sub>

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<sup>23</sup>We will want constraints that govern the quantity-sensitivity of feet as well, but I have chosen a word with only light syllables in (100)-(102) to illustrate the basic analysis of parasitic primary stress in HS.

At the next iteration, the candidate set will include two candidates for every possible way of building a foot—one that adds a foot and does not relabel Hd(PWd) at the same time, and one that adds a foot and does relabel the Hd(PWd). As shown in (101), because ALLFTL » ALLFTR & ALIGNHDR, the next foot built will be left-aligned like the last one. But because shifting the primary stress to the new foot is free and ALIGNHDR dominates ALIGNHDL, the optimal candidate is (d), the one that adds the left-aligned trochee and shifts the primary stress onto it.

(101) Relabeling of Hd(PWd) as parsing proceeds

	('faɕa)ratuhu 2nd iteration	PARSE-σ	ALLFTL	ALIGNHDR
a.	('faɕa)ratuhu	W <sub>3</sub>	L	W <sub>4</sub>
b.	('faɕa)(,ratu)hu	1	2	W <sub>4</sub>
c.	('faɕa)ra(,tuhu)	1	W <sub>3</sub>	W <sub>4</sub>
→ d.	(,faɕa)('ratu)hu	1	2	2
e.	(,faɕa)ra('tuhu)	1	W <sub>3</sub>	L <sub>1</sub>

At the next step the derivation converges on [(,faɕa)('ratu)hu], as shown in (102), because adding a word-final stress in a monosyllabic foot violates both FTBIN and NONFINALITY. Both constraints must be high ranked in Cairene Arabic (NONFINALITY is only violated when the final syllable is superheavy; FTBIN is never violated), so either one could be used to rule out candidates (b) and (c) in (102). Although candidate (c), which shifts stress further to the right, maximally satisfies ALIGNHDR, its violation of FTBIN and NONFINALITY is fatal, so antepenultimate primary stress optimal. To emphasize that primary stress reassignment is completely unrestricted, I have also included a candidate which shifts primary stress back to the first foot, (b), though it has no chance of being optimal since the same form was also a failed candidate at the previous iteration (in (101)).

(102) Not optimal to parse final syllable

	(,faʕʕa)(ˈratu)hu 3rd iteration	FTBIN or NONFIN	PARSE-σ	ALLFTL	ALIGNHDR
→ a.	(,faʕʕa)(ˈratu)hu		1	2	2
b.	(ˈfaʕʕa)(,ratu)hu		1	2	W <sub>4</sub>
c.	(,faʕʕa)(ˈratu)(,hu)	W <sub>1</sub>	L	W <sub>6</sub>	2
d.	(,faʕʕa)(,ratu)(ˈhu)	W <sub>1</sub>	L	W <sub>6</sub>	L

With free relabeling of Hd(PWd) this analysis of Cairene Arabic presents a minimal contrast in ranking with the bidirectional system of Piro (§3.3.4). In Piro ALIGNHDR dominates ALLFTL causing the first foot, the Hd(PWd), to be right-aligned contrary to the preferences of the general foot alignment constraint. But later iterations select left-aligned secondary stress feet in accordance with ALLFTL because ALIGNHDR has been maximally satisfied (modulo high-ranking TROCHEE and FTBIN). In Cairene Arabic, in contrast, ALLFTL dominates ALIGNHDR. Assigning a left-aligned primary stress at the first iteration introduces violations of ALIGNHDR, but this constraint favors rightward relabeling as the derivation progresses. Although ALIGNHDR cannot *overcome* the preference of higher-ranked ALLFTL in Cairene Arabic, it nonetheless is able to move the primary stress rightward to the last available foot.

With these assumptions, then, parasitic primary stress systems are able to be analyzed successfully in Harmonic Serialism, even as the basic mode of primary stress assigned can be characterized as ‘top-down’.

### 3.4.3 Permitting top-down precludes bottom-up

We are now in a position to address the question of why parasitic primary stress languages cannot be given a more traditional bottom-up analysis by delaying the assignment of primary stress, since nothing in the GEN I have proposed prevents candidates with only secondary stresses. That is, could an analysis of Cairene that follows either of the derivations in (103) be optimal under some ranking?

This alternative is worth considering because it would obviate the need to *reassign* primary stress in the course of the derivation.

(103) Hypothetical “bottom-up” derivations for parasitic primary stress

a. /ʃaɕʒaratuhu/ → (ʃaɕʒa)ratuhu → (ʃaɕʒa)(,ratu)hu → (ʃaɕʒa)(ˈratu)hu  
→ [(ʃaɕʒa)(ˈratu)hu]

b. /ʃaɕʒaratuhu/ → (ʃaɕʒa)ratuhu → (ʃaɕʒa)(ˈratu)hu → [(ʃaɕʒa)(ˈratu)hu]

The main issue in assessing the viability of this alternative is whether there is a ranking that would consistently deliver one of these derivations for words in Cairene and similar languages given our other assumptions. In other words, is there a ranking that favors delaying the assignment of primary stress in order to build the secondary stress feet that are requisite for determining the location of primary stress? The short answer is no; when GEN provides a “top-down” option (that is, primary stress is in principle available right away), any ranking that disfavors candidates with primary stress at the first iteration will generally continue to do so at subsequent iterations. If primary stress is to be assigned at all, it will be optimal to do so at the first iteration with the assumptions adopted thus far.

An illustration of this point will use data from Wargamay (Dixon 1981), a language with parasitic primary stress similar to Cairene Arabic but with opposite directionality (right-to-left trochees with primary stress on the leftmost foot, setting aside quantity).<sup>24</sup> One might imagine that assigning primary stress right away in parasitic languages egregiously violates the dominant ALIGN<sub>HD</sub> constraint. Thus, perhaps primary stress is delayed until the last moment (i.e., the end of the stress derivation) in order to violate ALIGN<sub>HD</sub> the least.

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<sup>24</sup>Wargamay’s quantity-sensitivity, which will not be addressed here, takes the following form: if the initial syllable is heavy it receives primary stress and secondary stresses continue to alternate rightward away from the primary (Dixon 1981). Heavy syllables are restricted to initial position.

As shown in (104), this strategy does indeed work for an input like /jawujmbari/ ‘male kangaroo’ from Wargamay (Dixon 1981:21). Candidate (c) loses at the first iteration because unlike (d) it introduces violations of the dominant head alignment constraint, ALIGNHDL. At the second iteration candidate (g) wins because assigning primary stress to the leftmost foot introduces no violations of ALIGNHDL and permits satisfaction of HEADEDNESS(PWD). Thus, here we have managed to use the markedness of a mis-aligned primary stress to delay primary stress assignment until the end of the parse for a derivation resembling that of (103b).

(104) Delayed primary stress assignment

/jawujmbari/ 1st iteration	PARSE- $\sigma$	ALLFTR	ALIGNHDL	HD(PWD)
a. jawujmbari	$W_4$			1
b. ('jawuj)mbari	2	$W_2$		L
c. jawuj('mbari)	2		$W_1$	L
d. jawuj(,mbari)	2			1
2nd iteration				
e. jawuj(,mbari)	$W_2$	L		$W_1$
f. ('jawuj)(,mbari)		2		$W_1$
g. ('jawuj)(,mbari)		2		

(Convergence step not shown)  
 → **Output:** [('jawuj)(,mbari)]

Unfortunately, this strategy is not sufficiently general to produce consistent bottom-up derivations for Wargamay or any other parasitic primary stress language. The derivation in (104) relies on an arbitrary property of this particular input, namely, that it has an even number of syllables. Only in this case will a right-to-left parse into disyllabic trochees yield a foot head perfectly aligned to the left edge of the word as required to satisfy ALIGNHDL non-vacuously. When the input has instead an odd number of syllables, any available foot head in a right-to-left trochaic parse will introduce at least one violation of ALIGNHDL when promoted to primary stress, as exemplified in (105) for the three-syllable input /gagara/ ‘dilly

bag' (Dixon 1981:20). This input is wrongly mapped to output \*[ga(,gara)] because violations of high-ranked ALIGNHDl are introduced otherwise.

(105) Primary stress not optimal

/gagara/ 1st iteration	PARSE- $\sigma$	ALLFTR	ALIGNHDl	Hd(PWD)
a. gagara	W <sub>3</sub>			1
b. ga('gara)	1		W <sub>1</sub>	L
c. ('gaga)ra	1	W <sub>1</sub>		L
d. ga(,gara)	1			1
2nd iteration				
e. ga(,gara)	1			1
f. ga('gara)	1		W <sub>1</sub>	L

→ Output: [ga(,gara)]

Delaying primary stress assignment does not work for Wargamay because ALIGNHDl is not guaranteed to be perfectly satisfied when it comes time to assign primary stress, and such a guarantee is in fact impossible. It would also have no hope of accounting for Cairene Arabic stress, since ALIGNHDl is the dominant ALIGNHD constraint but it is never perfectly satisfied unless the final syllable is superheavy. In parasitic primary stress languages, any attempt to have a constraint delay the assignment of primary stress is foiled by that constraint's continued antagonism toward primary stress, even after the point at which it 'ought' to be assigned.

Ranking prevents bottom-up stress derivations from being realized when the grammar could just as well assign primary stress top-down. Instead of having some rankings that produce top-down parsing and some that produce bottom-up parsing, we have some rankings that produce primary stress in all words (i.e., those where constraints antagonistic toward primary stress are low ranked) and some rankings that do not produce primary stress in all words (i.e., those where constraints antagonistic toward primary stress are high ranked). This is obviously an undesirable prediction. In chapter 4 (§4.3) I argue that this is a consequence of

the potential for vacuous satisfaction of constraints on primary stress, including ALIGN<sub>HD</sub>, and I present schemata for redefining constraints on primary stress to prevent vacuous satisfaction. The consequence for the present discussion is that preventing vacuous satisfaction of constraints on primary stress well-formedness reverses their contextual antagonism toward primary stress and makes it so that assigning primary stress is always preferred.

Thus, top-down parsing cannot be suppressed when it is an available option. No ranking of any standard constraints will favor bottom-up derivations like those in (103) with temporary suppression of primary stress assignment. Vacuously satisfiable constraints on primary stress well-formedness can behave antagonistically toward primary stress for part of a derivation and the results can sometimes look like a bottom-up derivation, but there are no rankings that will *consistently* deliver a bottom-up derivation for all inputs. Furthermore, the non-vacuous redefinitions of primary stress constraints that I will propose in chapter 4 (§4.3) prevent primary stress constraints from ever behaving antagonistically, removing all barriers to primary stress assignment at the first iteration of foot building under any ranking. In other words, as long as top-down parsing is an option it will be optimal at the first iteration, and therefore relabeling of primary stress *must* be allowed for languages with parasitic primary stress.

#### **3.4.4 Why is relabeling free?**

Throughout I have assumed that the primary stress (re)assignment operation is ‘free’ in the sense that it does not require its own step. It is clear that this is necessary at the initial application of Hd(PWd) labeling, as the analyses of autonomous primary stress languages in §3.3 showed. But how crucial is it for the analysis of parasitic primary stress that *reassignment* also be free? The answer, at least at this



junction, appears to be ‘not very’, though there are theoretical reasons for favoring free relabeling.<sup>25</sup>

The languages that I am aware of with parasitic primary stress would be analyzed equally well if primary stress relabeling were relegated to its own step, to be interleaved with foot-building instead of applying simultaneous with it. Why, then, assume that Hd(PWd) relabeling is free? Since Hd(PWd) labeling at the first iteration of stress assignment must be free to account for languages with autonomous primary stress, the simplest assumption is that *relabeling* of primary stress is also free. This allows us to very simply conceptualize the primary stress assignment operation as one that applies whenever and wherever it can. The only special consideration we must make is what happens when primary stress is assigned, via this free operation, to a word that already has a primary stress. This cannot be prohibited, given the need to move the primary stress for parasitic languages. But it seems consistent with other work in metrical theory to assume that demotion or deletion of primary stress is the consequence of designating a head elsewhere in the same constituent, as I have framed it here. Were relabeling not free it would be necessary to stipulate that the (free) primary stress assignment that occurs at the first iteration is not the same operation that applies to move the primary stress at later iterations, since they have different conditions on their application.

It thus seems more straightforward to assume that assignment of primary stress is a unary operation, and it is coupled with the ability to demote a primary stress in the local input in order to simulate the movement of primary stress.

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<sup>25</sup>Elsman (2010) presents an argument for free relabeling of primary stress in Pichis Asheninca; however, her argument assumes a different primary stress constraint. See chapter 4 (§4.2.2) for some discussion.

### 3.4.5 Typological consequences of Hd(PWd) relabeling

Another reasonable question to ask in response to the proposal laid out here is whether moving the primary stress during a derivation, freely or otherwise, might have unintended consequences for stress typology. Although it is difficult to prove that negative consequences could *never* result, what I will claim here is that the most obvious examples of such negative consequences do not in fact arise.

For example, it does not appear to be possible for primary stress assignment to trigger some operation that applies at each syllable that the primary stress occupies while deriving a parasitic stress pattern. Such a language would leave a ‘trail’ of opaque process application at all the sites that previously held the primary stress. An example that seems plausible but which is nonetheless impossible with the current assumptions is one in which a constraint wanting primary stressed syllables to be heavy (e.g., primary-stress-specific STRESS-TO-WEIGHT or S<sub>1</sub>-TO-W, McGarrity 2003) causes lengthening in all foot heads, not just the primary stress, because each secondary stress foot was once the site of the primary stress. An imagined derivation with an opaque pattern of trochaic lengthening is shown in (106).

(106) Opaque trochaic lengthening

/patakamasana/ → ('pata)kamasana → ('pa:ta)kamasana →  
(,pa:ta)('kama)sana → (,pa:ta)('ka:ma)sana → (,pa:ta)(,ka:ma)('sana) →  
(,pa:ta)(,ka:ma)('sa:na) → [(,pa:ta)(,ka:ma)('sa:na)]

The outcome illustrated in (106) might be a problem from the standpoint of stress typology because the heads of all trochaic feet have undergone lengthening. Lengthening of vowels in primary stress syllables is attested in some trochaic languages (e.g., Icelandic; Hayes 1995:83, 188ff), and lengthening of all or most stressed syllables is attested in some iambic languages (e.g., Hixkaryana; Hayes 1995:83, 205ff), but according to Hayes (1995), trochaic lengthening is not a gen-

eral phonological process (though cf. Revithiadou 2004). A system that could produce the derivation in (106) would predict that trochaic lengthening in all stressed syllables should be possible in languages with parasitic primary stress (i.e., languages whose primary stress moves from one foot to another during a derivation).

Regardless of the status of this generalization with respect to attested typology, the derivation in (106) cannot be the result of a high-ranked constraint favoring lengthening in the primary stress syllable in HS with the assumptions laid out here. An attempt to produce this derivation without a *general* constraint favoring lengthening in stressed syllables results in a ranking paradox after the first foot is built. If a constraint  $S_1\text{-TO-W}$  (which assigns a violation mark when the primary stress syllable is light) is ranked *below*  $\text{PARSE-}\sigma$ , then it will be more harmonic to continue footing than to stop after the first foot to lengthen. This can be seen in the second iteration of (107), which begins with a hypothetical six-syllable word with only light syllables. The choice between adding a foot and lengthening the initial foot at the second step will fall to the higher-ranked  $\text{PARSE-}\sigma$ , which favors (d) over (e), since  $S_1\text{-TO-W}$  is too low ranked to matter. Footing continues until all feet are built and then the head of the last foot, which now bears the primary stress, is lengthened to satisfy  $S_1\text{-TO-W}$ .

(107) Non-opaque lengthening when  $\text{PARSE-}\sigma \gg \text{S}_1\text{-TO-W}$ 

		$\text{PARSE-}\sigma$	$\text{ALLFTL}$	$\text{ALIGNHdR}$	$\text{S}_1\text{-TO-W}$	$\text{DEP-}\mu$
/patakamasana/ 1st iteration						
↙	a.	('pata)kamasana	4		5	1
	b.	patakama('sana)	4	$\text{W}_4$	$\text{L}_1$	1
→	2nd iteration					
	c.	('pata)kamasana	$\text{W}_4$	L	$\text{W}_5$	1
↙	d.	(.pata)('kama)sana	2	2	3	1
	e.	('pa:ta)kamasana	$\text{W}_4$	L	$\text{W}_5$	L
→	3rd iteration					
	f.	(.pata)('kama)sana	$\text{W}_2$	$\text{L}_2$	$\text{W}_3$	1
↙	g.	(.pata)(.kama)('sana)		6	1	1
→	4th iteration					
	h.	(.pata)(.kama)('sana)		6	1	$\text{W}_1$
↙	i.	(.pata)(.kama)('sa:na)		6	1	1
	(Convergence step not shown)					
→	<b>Output:</b> [(.pata)(.kama)('sa:na)]					

Ranking  $\text{S}_1\text{-TO-W}$  over  $\text{PARSE-}\sigma$  cannot produce the derivation in (106) either. When  $\text{S}_1\text{-TO-W}$  dominates  $\text{PARSE-}\sigma$  we do indeed predict that it will be possible to interrupt parsing in order to lengthen, as shown in the second iteration of the tableau in (108); candidate (d) defeats candidate (c) because the most important thing is to make sure the primary stress syllable is heavy. However, under this ranking  $\text{S}_1\text{-TO-W}$  will in fact prevent the primary stress from moving off of that syllable in subsequent parsing, counter to our intention in trying to produce the derivation in (106). The ranking for the left-to-right stress pattern with the rightmost foot receiving the primary stress is  $\text{PARSE-}\sigma \gg \text{ALLFTL} \gg \text{ALIGNHdR}$ . Since  $\text{S}_1\text{-TO-W}$  has to outrank  $\text{PARSE-}\sigma$  to interrupt footing, it must also outrank  $\text{ALIGNHdR}$  by transitivity. Once the primary stress syllable is lengthened and  $\text{S}_1\text{-TO-W}$  is satisfied, it is *less* harmonic to continue to move the primary stress rightward, as shown in the third iteration in (108), since doing so reintroduces a violation of

top-ranked  $S_1$ -TO-W. Candidate (f) defeats candidate (g) despite the latter's better satisfaction of ALIGNHDR.<sup>26</sup>

(108) Non-opaque lengthening when  $S_1$ -TO-W » PARSE- $\sigma$

	$S_1$ -TO-W	PARSE- $\sigma$	ALLFTL	ALIGNHDR	DEP- $\mu$
<b>/patakamasana/ 1st iteration</b>					
↖ a. ('pata)kamasana	1	4		5	
<b>2nd iteration</b>					
b. ('pata)kamasana	$W_1$	4		5	L
c. (,pata)(,kama)sana	$W_1$	$L_2$	$W_2$	$L_3$	L
↖ d. ('pa:ta)kamasana		4		5	1
<b>3rd iteration</b>					
e. ('pa:ta)kamasana		$W_4$	L	5	
↖ f. ('pa:ta)(,kama)sana		2	2	5	
g. (,pa:ta)(,kama)sana	$W_1$	2	2	$L_3$	
<b>4th iteration</b>					
h. ('pa:ta)(,kama)sana		$W_2$	$L_2$	5	
↖ i. ('pa:ta)(,kama)(,sana)			6	5	
(Convergence step not shown)					
↖ <b>Output:</b> [('pa:ta)(,kama)(,sana)]					

The two outcomes produced in this case ([('pata)(,kama)(,sa:na)] in (107) and [('pa:ta)(,kama)(,sana)] in (108)) both show lengthening in the primary stress syllable as a result of the ranking  $S_1$ -TO-W » DEP- $\mu$ . But neither ranking of PARSE- $\sigma$  and  $S_1$ -TO-W yields a derivation with opaque lengthening in all secondary stresses. Ranking in HS determines, among other things, the order in which processes will apply, but it is also able to block other processes at later iterations to ensure that a high ranked constraint once satisfied remains so.

As this example has shown, the fact that process ordering is determined by ranking in HS prevents certain derivations from occurring. It is not the case that HS cannot produce the derivation in (106) at all, since it could result from a high

<sup>26</sup>When  $S_1$ -TO-W is this highly ranked it will also be able to favor parsing non-contiguously, but since this input has no heavy syllables to start with this does not affect the outcome here.

ranked *general* constraint wanting stressed syllables to be heavy. But the output of the derivation in (106) cannot be the result of opaque *primary*-stress-driven lengthening.

As mentioned at the outset of this section, it is difficult to prove that negative typological predictions could never result from allowing primary stress to move, but this example has shown, at least, that an obvious example is not possible. When a constraint that favors a primary-stress-specific process is ranked highly enough to favor that process applying right away, it will also necessarily be high enough ranked to favor keeping the primary stress on this newly-perfected foot.

### 3.4.6 Summary

We have now seen that the most general theory of primary stress relabeling in GEN analyzes both autonomous and parasitic primary stress systems successfully. These two classes of primary stress, disparate though they seem, are both analyzed with the assumption that primary stress assignment in GEN is a free and maximally general operation.

## 3.5 Alternatives to top-down GEN

I have argued up to this point for a definition of GEN that is top-down with respect to the assignment of primary word stress, but there are other ways that primary stress could be conceptualized in HS. The most obvious alternative would be a bottom-up definition of GEN. In this section I will provide an explicit definition of a bottom-up GEN for comparison and illustrate why it might seem like a viable alternative. Ultimately though I will argue that the bottom-up GEN is not powerful enough to represent the full range of attested primary stress patterns, and that attempts to increase its power lead to augmentations of CON that make typologically undesirable predictions.

### 3.5.1 Defining bottom-up

In HS, a strictly bottom-up GEN would not allow the assignment of primary stress to happen freely at the same time that a foot is constructed. Instead, foot-building and primary stress assignment would have to occur in separate steps of the derivation. The operations in (109) define a bottom-up GEN with this assumption. The foot-building operations in (109a) are essentially the same as those from §3.2. The difference comes from the fact that the foot-building operations only build secondary stress feet because primary stress assignment is relegated to a distinct step, as defined by the non-freely-applying operation in (109b).

(109) Operations in a bottom-up GEN

a. Build a foot

$$\sigma \rightarrow (, \sigma)$$

$$\sigma\sigma \rightarrow (, \sigma\sigma)$$

$$\sigma\sigma \rightarrow (\sigma, \sigma)$$

b. Promote secondary stress to primary (abbrev.  $2^\circ \rightarrow 1^\circ$ )

$$\phi \rightarrow \phi_{Hd} \text{ (not free)}$$

Given these operations, at the first iteration of stress assignment the candidate set will include all the ways of building one (secondary stress) foot, as shown in (110). Again, because primary stress assignment is not free when GEN is strictly bottom-up, the candidate set at the first iteration does not include any candidates with primary stress.

(110) Candidates for first foot in a five-syllable word (bottom-up parsing)

<b>Operation</b>	<b>Candidates</b>
None (faithful)	$\sigma\sigma\sigma\sigma$
Mono- $\sigma$ foot added	$(,\sigma)\sigma\sigma\sigma$ $\sigma(,\sigma)\sigma\sigma$ $\sigma\sigma(,\sigma)\sigma$ $\sigma\sigma\sigma(,\sigma)$ $\sigma\sigma\sigma\sigma(,\sigma)$
Di- $\sigma$ trochee added	$(,\sigma\sigma)\sigma\sigma$ $\sigma(,\sigma\sigma)\sigma$ $\sigma\sigma(,\sigma\sigma)$ $\sigma\sigma\sigma(,\sigma\sigma)$
Di- $\sigma$ iamb added	$(\sigma,\sigma)\sigma\sigma$ $\sigma(\sigma,\sigma)\sigma$ $\sigma\sigma(\sigma,\sigma)$ $\sigma\sigma\sigma(\sigma,\sigma)$

If the candidate with the disyllabic, left-aligned trochee wins in the first iteration, the candidates for the second iteration of stress assignment with these assumptions will be those in (111). Since the local input has one secondary stress foot, the secondary-to-primary stress promotion operation (in (109b)) will produce one candidate, while additional candidates will come from the application of (109a), which builds an additional secondary stress foot rather than promoting the input foot to Hd(PWd).

(111) Candidates generated from local input  $(,\sigma\sigma)\sigma\sigma$  (bottom-up parsing)

<b>Operation</b>	<b>Candidates</b>
None (faithful candidate)	$(,\sigma\sigma)\sigma\sigma$
$2^\circ \rightarrow 1^\circ$ stress	$('\sigma\sigma)\sigma\sigma$
Mono- $\sigma$ foot added	$(,\sigma\sigma)(,\sigma)\sigma$ $(,\sigma\sigma)\sigma(,\sigma)$ $(,\sigma\sigma)\sigma\sigma(,\sigma)$
Di- $\sigma$ trochee added	$(,\sigma\sigma)(,\sigma\sigma)\sigma$ $(,\sigma\sigma)\sigma(,\sigma\sigma)$
Di- $\sigma$ iamb added	$(,\sigma\sigma)(\sigma,\sigma)\sigma$ $(,\sigma\sigma)\sigma(\sigma,\sigma)$

Given the candidates in (111), the constraint ranking will determine at the second iteration whether it is more harmonic to promote the input secondary stress foot to primary stress or to continue footing. In general, the ranking of PARSE- $\sigma$  and primary stress agonists like HEADEDNESS(PWD)<sup>27</sup> will determine the order of operations. If PARSE- $\sigma$  dominates all constraints that favor primary stress, then adding

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<sup>27</sup>And non-vacuous primary stress constraints, as discussed in chapter 4.



a foot will be preferred over promoting an existing foot to primary stress as long as there is material sufficient to build a licit foot. If instead a primary-stress-favoring constraint dominates  $\text{PARSE-}\sigma$ , it will be preferable to pause regular parsing in order to promote an existing foot to primary stress. In either case, the derivation will continue until the desired parsing is achieved and one of the feet is designated  $\text{Hd(PWd)}$ . The ability to interleave secondary stressing and primary stress assignment makes bottom-up derivations in HS potentially different from the way most other serial theories of stress are formulated (e.g., Halle and Vergnaud 1987, Hayes 1995), though it is not immediately obvious whether this difference could result in divergent predictions.

If we assume that the candidate  $(, \sigma \sigma)(, \sigma \sigma) \sigma$  wins among those in (111), then the candidates under consideration at the following step would be those in (112). Here the  $2^\circ \rightarrow 1^\circ$  operation generates two candidates because there are two secondary stress feet in the local input. There is only one additional stress candidate and it adds a monosyllabic secondary stress foot because there are not enough syllables to do otherwise. Which of these is chosen will depend principally on whether the ranking allows monosyllabic feet.

(112) Candidates generated from local input  $(, \sigma \sigma)(, \sigma \sigma) \sigma$  (bottom-up parsing)

<b>Operation</b>	<b>Candidates</b>
None (faithful candidate)	$(, \sigma \sigma)(, \sigma \sigma) \sigma$
$2^\circ \rightarrow 1^\circ$ stress	$(, \sigma \sigma)(, \sigma \sigma) \sigma$ $(, \sigma \sigma)(, \sigma \sigma) \sigma$
Mono- $\sigma$ foot added	$(, \sigma \sigma)(, \sigma \sigma)(, \sigma)$
Di- $\sigma$ trochee added	n/a
Di- $\sigma$ iamb added	n/a

This bottom-up definition of  $\text{GEN}$  is gradual in a way that the top-down definition in §3.2 is not, because it requires foot building and primary stress designation

to happen in separate steps. In this sense the bottom-up GEN is arguably more in line with the spirit of serialism.

Given this apparent aesthetic advantage to a bottom-up GEN for primary stress in a serial framework, we should address to what extent bottom-up analyses might be available for the autonomous primary stress languages used in §3.3 to exemplify the utility of top-down stressing. I address here a handful of extant or plausible bottom-up analyses of languages with autonomous primary stress. Although bottom-up analyses may be available for some languages that appear to have autonomous primary stress, the argument will be that there is no general bottom-up solution for the wide range of autonomous primary stress systems we would want to account for.

### 3.5.2 Constraints on word and foot edge coincidence

In §3.3.1 I argued that Finnish is an autonomous primary stress language because its primary stress foot obeys ALIGNHDL in violation of the otherwise-obeyed foot shape constraint \*('LH). Several previous analyses of Finnish in parallel OT use instead of ALIGNHDL a constraint that is not specific to primary stress and which only favors having *some* foot aligned to the left edge of the word (Hanson and Kiparsky 1996, Elenbaas and Kager 1999, Elenbaas 1999). This constraint is usually defined as a member of the generalized alignment family (McCarthy and Prince 1993a), as in (113). It was discussed by McCarthy and Prince (1993a) when the generalized alignment schema was first introduced and has been used in numerous subsequent analyses by many authors.

(113) **ALIGN(PWd,L,Ft,L) (ALIGNWdL)**

Assign one violation mark for every PWd whose left edge is not aligned with the left edge of some foot

If a constraint like ALIGNWDL exists and is the right way of analyzing Finnish, then Finnish would no longer present evidence in favor of top-down primary stress in HS. With ALIGNWDL, it is possible to consistently build a foot at the left edge of each word even before it is known that it will bear the primary stress. As the tableau in (114) shows, ranking ALIGNWDL where ALIGNHDL was in the hierarchy (principally, above \*('LH)) successfully accounts for the preference for a word-initial foot in Finnish. At the first iteration when parsing is bottom-up, the high rank of ALIGNWDL ensures that the first foot is left aligned, despite incurring a violation of \*('LH).

(114) Word-initial LH parsed as ('LH)

/ravintola/ 1st iteration	ALIGNWDL	*('LH)	PARSE-σ	ALLFTL
→ a. (,ravin)tola		1	2	
b. ra(,vinto)la	W <sub>1</sub>	L	2	W <sub>1</sub>

At a later iteration this initial foot will be assigned the primary stress if we assume that ALIGNHDL » ALIGNHDR, as in (115). Although ALIGNWDL takes the place of ALIGNHDL in terms of ranking (as shown in (114)), it does not replace it entirely; there still must be a constraint that favors promoting the leftmost foot to Hd(PWD) rather than the rightmost, so ALIGNHDL is still needed and it must dominate ALIGNHDR.

(115) Bottom-up derivation continued

(,ravin)tola 2nd iteration	PARSE-σ	ALIGNHDL	Hd(PWD)	ALLFTL
a. (,ravin)tola	W <sub>2</sub>		1	L
b. ('ravin)tola	W <sub>2</sub>		L	L
← c. (,ravin)(,tola)			1	2
→ <b>3rd iteration</b>				
d. (,ravin)(,tola)			W <sub>1</sub>	2
← e. ('ravin)(,tola)				2
f. (,ravin)(('tola)		W <sub>2</sub>		2

(Convergence step not shown)

→ **Output:** [(('ravin)(,tola)]

The bottom-up derivation requires ALIGN<sub>WDL</sub> because no other general constraint would favor a word-initial foot given the other rankings required for Finnish. Although ALL<sub>FTL</sub> is the dominant foot alignment constraint, it cannot be used to consistently favor a word-initial foot because \*('LH) must dominate it to account for the local ternarity in examples like [(‘puhe)li(,met)] ‘telephones (nom.)’. But it is clear from (114) and (115) that ALIGN<sub>WDL</sub> does indeed produce the correct result for Finnish even when primary stress assignment is not available right away.

Nonetheless, there are two problems with this approach that will be discussed in turn. The first is that ALIGN<sub>WD</sub> creates potentially problematic typological predictions because it makes the exceptional behavior of the foot at the edge unrelated to its status as the primary stress foot. Second, and perhaps more importantly, ALIGN<sub>WD</sub> is not a general solution and does not lead the way to bottom-up analyses of all autonomous primary stress systems.

The principal conceptual difference between the bottom-up analysis of Finnish presented in this section and the top-down analysis presented in §3.3.1 is that the bottom-up analysis treats the word-initial foot, and its violation of \*('LH), as a product of a high-ranked preference for *some* foot to be aligned with the left edge of the word. The primary stress is assigned to that foot later in the derivation because ALIGN<sub>HDL</sub> » ALIGN<sub>HDR</sub>, but this ranking is independent in the sense that high-ranking ALIGN<sub>WDL</sub> has no way of requiring that ALIGN<sub>HDL</sub> is also highly ranked. It follows that the factorial typology when ALIGN<sub>WD</sub> is permitted in CON includes languages with dissociations between exceptional foot behavior at one edge of a word and primary stress, which may be assigned at the opposite word edge. To assess whether this prediction is problematic we should look for a language that is like Finnish but with rightmost primary stress, and languages which

are bidirectional but do not assign the primary stress to the foot at the exceptional non-iterative edge.

A language like Finnish but with primary stress on the rightmost foot is potentially instantiated by German loanwords. Alber (1997) describes stress in German loanwords in the following way: primary stress is not entirely predictable, but appears on one of the last three syllables; secondary stresses occupy trochaic feet assigned left-to-right, but rhythmic alternation can be interrupted word-medially to avoid stressing a light syllable preceding a heavy syllable; a secondary stress nearly always appears on the initial syllable no matter its weight or that of the following syllable. In Alber's (parallel OT) analysis ALIGNWDL is responsible for favoring an initial foot despite the marked foot structure that sometimes results. In other work, Alber (1998, 2005) reanalyzes the same data and argues that interruptions of the basic left-to-right trochaic pattern are driven exclusively by stem stress preservation, making it somewhat less like Finnish overall, but ALIGNWDL is apparently still required.<sup>28</sup>

As for bidirectional stress systems, the presence of ALIGNWDL in a CON that contains other standard stress constraints (including ALLFTL and ALLFTR) predicts bidirectional systems in which the exceptional foot at the non-iterating edge is not the primary stress (see, e.g., Kager 2001, McCarthy 2003). Schematically, this could look like the stress pattern shown in (116) (assuming quantity-insensitive trochees for the purposes of illustration).

(116) Stress pattern predicted by ALIGNWDL in combination with standard parsing constraints

Even number of syllables: (<sub>1</sub>σσ)(<sub>1</sub>σσ)(<sup>1</sup>σσ)

Odd number of syllables: (<sub>1</sub>σσ)σ(<sub>1</sub>σσ)(<sup>1</sup>σσ)

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<sup>28</sup>This is made explicit in Alber 1998, but not 2005, though it is difficult to see how the full range of data could be analyzed without a constraint like ALIGNWDL.

ALIGNWDL makes this prediction in both bottom-up and top-down parsing in HS as well as in parallel OT. If such systems were found to be attested, it would not provide evidence against top-down parsing, but it would suggest that some apparently autonomous primary stress languages have other analyses available that would make them compatible with a bottom-up definition of primary stress in GEN. On the other hand, if such systems could be shown *not* to exist, this would constitute evidence against bottom-up parsing, because ALIGNWDL is crucial to the analysis of Finnish when parsing is bottom-up.

Whether such languages do indeed exist is not immediately obvious from surveying the previous literature on the topic. Kager (2001) argues that all bidirectional stress systems have primary stress on the ‘lone’ foot, claiming that systems like (116) do not exist. In Kager’s theoretical proposal this exclusion results from the fact that a sequence of two unstressed syllables (a stress lapse) may only appear word-medially if adjacent to a primary stress, which has the effect of allowing a language like  $(\sigma\sigma)\sigma(\sigma\sigma)(\sigma\sigma)$  (a pattern which most sources agree is realized by Garawa, Furby 1974, though cf. Alber 2005), but ruling out the pattern with primary stress at the other edge  $((\sigma\sigma)\sigma(\sigma\sigma)(\sigma\sigma))$ , as in (116)) which is predicted by ALIGNWDL in combination with other standard parsing constraints. Portions of Kager’s arguments are echoed by several others, including McCarthy (2003) and Alber (2005).<sup>29</sup> Nonetheless, reports of counterexamples are not difficult to find. Indonesian (Cohn 1989, 1993, Cohn and McCarthy 1994) and Spanish (Harris 1983, 1989, Roca 1986) are the most often cited counterexamples to the claim that such stress systems do not exist, but there are also extant rejoinders. In In-

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<sup>29</sup>Incidentally, McCarthy (2003) uses the absence of clear cases of languages like (116) to argue against the typical gradient formulations of ALLFTL/R, presupposing that constraints like ALIGNWDL are necessarily present in CON. What I am doing here is the opposite, presupposing ALLFTL/R and instead evaluating whether an ALIGNWD constraint is justified, without which languages like (116) are not predicted. See also Kager (2005).

donesian the controversy surrounds the fact that the relevant forms are Dutch loans and might therefore represent stress preservation rather than a productive pattern (though cf. Cohn 1993:374, fn. 1), while in Spanish Kager argues that morphological complexity may play a role in creating the pattern (though cf. Hyde 2008).

The balance of evidence makes it difficult to say for certain that a constraint like ALIGNWDL is not needed in CON. Nonetheless, top-down stress is motivated by languages other than Finnish. Piro, discussed in §3.3.4, was presented as an example of an autonomous primary stress system by virtue of its bidirectionality—the primary stress foot is right-aligned, the primary stress always falling on the penult, while secondary stresses iterate rightward from the initial syllable. To present a comparable analysis of Piro in a bottom-up grammar would require the mirror of ALIGNWDL, ALIGNWDR. Following the same logic as above, allowing ALIGNWDR in CON entails the prediction of bidirectional stress systems that are like Piro but which have initial primary stress, e.g., ( $\sigma\sigma$ )( $\sigma\sigma$ ) $\sigma$ ( $\sigma\sigma$ ). Although considerable discussion has surrounded stress systems of the Indonesian and Spanish type, to my knowledge, no mirror image cases have been reported (see also Hyde 2008).

For our purposes, what this means is that though ALIGNWDL might receive typological justification from German, Indonesian, and/or Spanish, no comparable typological support exists for ALIGNWDR because attraction of stress to the right edge of a word appears to always involve the primary stress.<sup>30</sup> Thus, Finnish may have a justified bottom-up analysis available with ALIGNWDL, but Piro and other autonomous primary stress systems that rely on ALIGHDR (as opposed to ALIGN-

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<sup>30</sup>However, a possible exception may be found in English words that exhibit (leftward) primary stress retraction, e.g., *désignâte*, where the primary stress seems to have drifted further to the left than strictly necessary to satisfy the requirements of NONFINALITY and FTBIN (which would be satisfied by \**de(sígn)ate*, for example). See Pater (2000:241f, fn. 5), who describes such cases as possible evidence, when couched within a general analysis of English primary stress, for a constraint demanding some foot head at the right edge of a word.

HdL) do not have a typologically justified bottom-up analysis. As such, the exceptional behavior (i.e., right-alignment) of primary stress in Piro and other languages still constitutes evidence in favor of top-down parsing.

Beyond these narrow issues of bidirectional stress typology, there are other languages with autonomous primary stress that simply cannot be handled by a general constraint like *ALIGNWD*. Latin is an example. Some of the reasons that a bottom-up analysis of Latin is problematic were discussed in §3.3.5; there the argument relied on a particular hypothesis about secondary stress feet and the fact that primary stress avoids the final syllable while secondary stress feet appear not to. Setting those issues aside, there is still an argument for top-down stress based on the fact that constraints specific to primary stress sometimes have different properties from general constraints and those properties are crucial to the analysis, as explained below.

*ALIGNWDR* cannot play a role in accounting for Latin primary stress for two reasons. The first is that the constraint that attracts primary stress to the right edge must evaluate gradiently since *NONFINALITY* will normally prevent it from being perfectly satisfied, but *ALIGNWDR* is a categorical constraint. Perfect right alignment of the primary stress or the primary stress foot is not achieved in words longer than one or two syllables because of the avoidance of the final syllable in Latin, and the grammar must be able to distinguish the winning candidate *L('LL)L* (e.g., [re('fike)re]) from a failed competitor like *\*('LL)LL*, which would both simply violate *ALIGNWDR* once. A misconception is that since *ALIGNWD* is defined from the generalized alignment constraint schema (McCarthy and Prince 1993a), it must allow gradient evaluation. McCarthy (2003:109f) largely dispels this misconception by noting that in practice *ALIGNWD* constraints are always evaluated categorically. Indeed, it is possible to take this conclusion somewhat further by noting that a gradient version of an *ALIGNWD* constraint makes no sense formally.



We would generally like ALIGN<sub>WD</sub> constraints to assign a violation mark when no foot is aligned to the relevant PWd edge, but this situation occurs when there is a foot somewhere else in the word and when there are no feet at all in the word. Coercing this constraint to gradient evaluation would mean that a candidate like ('σσ)σσσ would receive three violations of ALIGN<sub>WDR</sub>, but a candidate like σσσσ would receive only one. A candidate in which the foot closest to the right edge is more than one syllable away is worse than a candidate with no feet at all. This is clearly an unintended interpretation of ALIGN<sub>WDR</sub>. The incongruity of this violation profile demonstrates the difficulty of assigning violations gradiently when the larger prosodic constituent (here, the PWd) is the first argument in an alignment constraint (here, ALIGN(PWd, L/R, Ft, L/R)).<sup>31</sup>

The second reason ALIGN<sub>WDR</sub> is not appropriate for analyzing Latin is that it generally refers to a foot boundary, while the primary stress in Latin needs to be governed by a constraint that references the stressed syllable itself. This is evident when considering words of the shape LHσ, e.g., /ami:kus/. Words with a heavy penult and a light antepenult should be parsed L('H)L, but the candidate \*('LH)L is a dangerous competitor (to use a phrase from Alber 1998) because its foot is also just one syllable away from the right edge and it satisfies PARSE-σ better than the intended winner. Of course, it introduces a violation of a constraint against heavy syllables in the weak branch of a foot, but the shortening processes described in §3.3.5 assume that ('LH) feet are possible at intermediate stages of the derivation, so \*('LH)L cannot be dismissed out of hand. The constraint ALIGN<sub>HDR</sub> is responsible for favoring L('H)L over \*('LH)L because it gets the primary stress syllable closer to the right edge (Pater 2000). Since ALIGN<sub>WD</sub> constraints are not typically

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<sup>31</sup>Sometimes restrictions on representational assumptions are used to circumvent this issue. That is, the number of violations ALIGN<sub>WD</sub> assigns to a candidate like [σσσσσ]<sub>PWd</sub> is (perhaps) irrelevant when all PWds must contain at least one foot.

defined to reference the stressed syllable, this creates a problem.<sup>32</sup> A similar argument could be put forward with reference to the analyses of Tübatulabal and Huariapano in §3.3.2 and §3.3.3, which both relied on the fact that `ALIGNHDR` references the primary stress syllable rather than foot.

In this case we see that the unique characteristics of the primary stress alignment constraint—reference to the stressed syllable itself and gradient evaluation—are two important properties for the analysis of Latin primary stress, and `ALIGNWD` has neither of these under the typical definition. For this reason, `ALIGNWD` does not provide a general solution for analyzing autonomous primary stress systems bottom-up, despite its limited success in analyzing Finnish (and Piro, if the problematic typological predictions of `ALIGNWDR` could be aside).

Autonomous primary stress systems present a diverse range of ways that primary stress can behave differently and be subject to different constraints compared to secondary stresses. It seems unlikely that any augmentation to `CON` will provide a general solution that permits bottom-up analyses of all otherwise autonomous primary stress systems. Top-down parsing, in contrast, allows primary stress to behave autonomously in as many ways as there are constraints that are specific to primary stress, permitting straightforward analyses of the languages discussed in §3.3.

### 3.5.3 Bottom-up with moveable feet

Besides modifying `CON` with a constraint like `ALIGNWD`, an alternative way to try to ‘rescue’ bottom-up parsing would be to implement it with other changes in `GEN`. Although bottom-up parsing alone cannot reliably position a foot in the correct place for primary stress in all languages, as shown in §3.3 and §3.5.2, it

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<sup>32</sup>This is also why `ALLFTR` cannot be responsible for the rightward attraction of the stressed syllable in Latin. Although `ALLFTR` permits gradient evaluation, it is generally formulated to refer to foot boundaries rather than stressed syllables.

seems plausible that permitting foot structure to be revised *after* the primary stress is assigned would allow a bottom-up analysis of some autonomous primary stress languages.

Allowing feet to move at a later point in the derivation can permit a successful bottom-up analysis of a bidirectional stress system like Piro. A derivation of this kind would follow the path illustrated in (117). The derivation would build all secondary stress feet first and then assign primary stress the rightmost one (because ALIGNHDR dominates ALIGNHDL). Up to this point the derivation would look like that of a parasitic primary stress system. Until the primary stress is assigned there is no reason for feet to gravitate rightward; but once primary stress is assigned, violations of ALIGNHDR are introduced and better satisfaction of ALIGNHDR is sought. When GEN allows feet to move it presents an opportunity for that to happen, and in the next step a candidate with the primary stress foot shifted rightward by one syllable will win because it performs better on ALIGNHDR.

(117) Bottom-up derivation of Piro with foot movement

$$\begin{aligned} / \sigma \sigma \sigma \sigma \sigma \sigma / &\rightarrow (, \sigma \sigma) \sigma \sigma \sigma \sigma \rightarrow (, \sigma \sigma) (, \sigma \sigma) \sigma \sigma \rightarrow (, \sigma \sigma) (, \sigma \sigma) (, \sigma \sigma) \sigma \rightarrow \\ &(, \sigma \sigma) (, \sigma \sigma) ( ' \sigma \sigma) \sigma \rightarrow (, \sigma \sigma) (, \sigma \sigma) \sigma ( ' \sigma \sigma) \rightarrow [(, \sigma \sigma) (, \sigma \sigma) \sigma ( ' \sigma \sigma)] \end{aligned}$$

The problem with this solution is that although it looks like a minimal change to GEN, the foot moving operation needed in (117) is actually quite powerful. In one step it changes both a foot's constituency (i.e., what syllables are contained in the foot) and its headedness. But an analysis of Piro will not work if the foot moving operation is decomposed into two operations. If changing foot headedness and constituency were separate operations, the intent would be to inch the primary stress foot to the right by first making it an iamb, thereby getting the primary stress syllable closer to the right edge, and then shifting the foot boundaries so that the last foot is a perfectly right-aligned trochee. However, the ranking necessary to create the iamb as part of the rightward movement would also favor an iamb at the

last step, so the output would be \*[(,σσ)(,σσ)σ(σ'σ)] instead of [(,σσ)(,σσ)σ(σ'σ)], as shown in (118). An additional constraint (such as NONFINALITYHD) could be used to favor the desired outcome, but doing so makes a rather complicated analysis out of a relatively straightforward bidirectional stress system.

(118) Solution with non-holistic foot movement operations not available

a. Intended derivation

... → (,σσ)(,σσ)(σ'σ)σ → (,σσ)(,σσ)(σ'σ)σ → (,σσ)(,σσ)σ(σ'σ) →  
 [(,σσ)(,σσ)σ(σ'σ)]

b. Actual derivation

... → (,σσ)(,σσ)(σ'σ)σ → (,σσ)(,σσ)(σ'σ)σ → (,σσ)(,σσ)σ(σ'σ) →  
 \*(,σσ)(,σσ)σ(σ'σ) → \*[(,σσ)(,σσ)σ(σ'σ)]

The holistic foot movement operation used in (117) could also be used for Finnish, but there too it would require a complicated derivation. Setting aside the ALIGNWDL option, bottom-up parsing would have to subject all feet to the requirement against ('LH) trochees. For a word like /opiskelija/ 'student (nom.)', which begins with a light-heavy sequence, the initial bottom-up parse would be o(,piske)(,lija) because high-ranking \*('LH) prevents the desired first step (,opis)kelija. The primary stress is assigned at the following step to the leftmost foot, which then becomes subject to ALIGNHD. If a foot can move in one step, the derivation would proceed as in (119), shifting the primary stress foot leftward by one syllable, then shifting the secondary stress foot rightward to fill the gap (for better satisfaction of ALLFTL).

(119) Bottom-up derivation in Finnish with foot movement

... → o(,piske)(,lija) → o('piske)(,lija) → ('opis)ke(,lija) → ('opis)(,keli)ja →  
 [(('opis)(,keli)ja]

This strategy accounts for the stress patterns observed in Finnish, but it does so at the expense of parsimony. Each foot in the word must move after assignment of the primary stress in order to accurately model a stress pattern which straightforwardly arises from top-down parsing. The wholesale restructuring illustrated in (119) is only necessary when primary stress assignment is forced to happen later.

A potentially more promising way to analyze languages with autonomous primary stress using the general strategy outlined in this section might be to build a foot and assign primary stress to it at the very next step, before other parsing takes place. In principle this would allow the constraints on primary stress to move or otherwise alter the first foot in the desired ways, and, depending on the limits of foot-altering placed on GEN, might achieve more or less the same empirical coverage as top-down parsing. However, given the relatively liberal structure-changing operations this would require and the inevitable difficulty of formalizing such operations, it is not clear that it is a better alternative than simply accepting that autonomous primary stress systems provide evidence for limited parallelism in HS.

#### **3.5.4 Summary**

This section has presented a bottom-up definition of GEN and argued that it is not superior to the top-down model proposed in §3.2, principally because languages with autonomous primary stress are difficult to analyze bottom-up. Modifications to CON to account for some cases of primary stress autonomy are insufficiently general and/or typologically unrestrictive and therefore do not provide an adequate alternative. Similarly, although GEN can be augmented with foot restructuring provisions, they would need to be non-trivially powerful to deal with cases of autonomous primary stress discussed here, and the resulting derivations

will often be so complicated that considerations of parsimony, if not also empirical sufficiency, favor the top-down alternative.

### **3.6 Excursus: What does (and does not) count as evidence for top-down parsing**

In general, as we have seen throughout this chapter, evidence for top-down parsing comes from languages whose primary stress is autonomous, in that it is assigned without reference to secondary stresses according to a disjoint set of principles. In HS this means that the constraints responsible for the construction of iterative secondary stress feet would not consistently put a foot in the correct location for primary stress (if asked to do so) and that constraints specific to primary stress must be active right away in determining where to build the primary stress foot. This section demonstrates an important point that has only been implicit up to this point: that a language cannot be presented as evidence in favor of top-down parsing in any atheoretical sense. Whether a language provides evidence in favor of top-down stress depends very much on one's definition of top-down and the theory in which the top-down assumptions are embedded. The reason for addressing this point here is that analyses labeled as "top-down" have been proposed in other serial theories, and it is instructive to note that the arguments in favor of a top-down analysis in those cases do not necessarily carry over to HS.

Given a particular theoretical architecture, an argument for top-down parsing is found in languages that cannot be analyzed bottom-up at all, or not without jeopardizing the accuracy of typological predictions. This determination will depend on the range of bottom-up (or non-top-down) options available in the theory, how the particular framework/analysis makes typological predictions, and the consensus about attested typology itself, which is not always entirely clear. For example, as was implicit in the discussion in §3.5.2, Finnish presents evidence for

top-down stress only if it can be argued that a constraint like ALIGNWDL is not in CON, and arguing that ALIGNWDL is or is not in CON depends on whether the predicted typology is more accurate with or without it, other things being equal. In a sense, then, one's theoretical (and implied typological) assumptions are partly responsible for determining whether a language displays autonomous primary stress, and thus whether it presents an argument in favor of top-down parsing.

Arguments for top-down stress have also been made by van der Hulst (1984) and Hayes (1995). Van der Hulst (1984) argues that the high likelihood of the primary stress falling on the 'first' foot in a directional parse provides evidence for top-down parsing. This argument does not extend to the model I have proposed here because the primary stress reassignment provision entails no relationship between edge of footing origination and edge of primary stress alignment. Primary stress reassignment is proposed here in order to allow an analysis of parasitic primary stress systems, which are counterexamples to the connection between the edge of primary stress alignment and the general parsing directionality. Although primary stress will generally be assigned to the first foot with my assumptions, it need not remain there if high-ranked constraints favor it moving to a new foot as parsing continues. And since the present proposal does not require primary stress to remain on the first foot, the existence of the correlation cannot provide evidence in its favor.

Hayes (1995) analyzes a handful of languages as top-down, which for his theory means that the rule that assigns primary stress exceptionally applies before any other parsing rules. Some of the languages Hayes analyzes in this way would also require a top-down analysis in HS with the assumptions I have adopted thus far, but others would not. The reason that Hayes's theory requires primary-stress-first in many of these cases is due to his assumptions about degenerate, or sub-minimal feet (mainly ('L), but possibly also (' $\sigma$ ) in languages without quantity dis-

tinctions). His theory permits degenerate feet only in primary stress position. In some languages the primary stress occupies a degenerate foot that would never have been built by Hayes's regular parsing algorithm, principally because of the priority clause, given in (120).

(120) The Priority Clause (Hayes 1995:95)

If at any stage in foot parsing the portion of the string being scanned would yield a degenerate foot, the parse scans further along the string to construct a proper foot where possible.

Parsing must be top-down in languages whose primary stress occupies a degenerate foot that violates the priority clause.

The situation is potentially different in the theory adopted here because I do not assume an absolute ban on degenerate feet in non-primary-stress position. A crucial distinction is whether the primary stress behaves *differently* from secondary stresses in the range of foot types it can occupy. Since Hayes stipulates that primary and secondary stresses differ in whether they are allowed to be in a degenerate foot, top-down parsing is entailed virtually any time the primary stress is in a degenerate foot.<sup>33</sup> But since I do not assume this a priori difference, it matters whether degenerate feet also exist for secondary stresses in the language under consideration. If so, then top-down parsing cannot be argued because the regular parsing algorithm must already be able to build such feet; but if not, then top-down parsing is probably required.

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<sup>33</sup>An exception exists for cases in which the primary stress occupies a degenerate foot at the 'end' of a metrical parse (as in, e.g., Auca, Hayes 1995:182ff) where top-down parsing is not required. In Hayes's theory a 'weak ban' on degenerate feet (p87) means that end-of-parse degenerate feet are constructed where available and are erased if primary stress is not later assigned there. It is only in cases that a primary stress degenerate foot violates the Priority Clause (see (120)) that top-down parsing is needed to motivate its construction.



At least two of the languages that require top-down parsing in Hayes's analyses, Cahuilla (Seiler 1965, 1967, 1977) and Tümpisa Shoshone (Dayley 1989), show some evidence in favor of degenerate feet in non-primary-stress positions as well, thus obviating a need for a top-down analysis in HS. The cases that *would* present evidence for top-down parsing given my assumptions, are those in which the primary stress foot is *exceptionally* allowed to occupy a degenerate foot. That is, if there is no evidence that degenerate feet are otherwise permitted in the language, then it may be necessary for a primary-stress-specific constraint to favor them, in which case parsing would need to be top-down to motivate their construction (as in Tübatulabal, for example).

In sum, the nature of arguments in favor of one mode of parsing over another means that theoretical assumptions are actually rather crucial, as is the attested typology, though it too is frequently subject to theoretically-motivated reinterpretations. Although a simple demonstration of an atheoretically "top-down" language is not really possible, within a given framework it is possible to motivate a top-down theory of parsing with specific examples and explicit assumptions.

### **3.7 Chapter summary and conclusion**

I have argued that an adequate definition of GEN must treat primary stress assignment as a 'free' operation. Primary stress can be assigned to a foot at the same time that it is built, without requiring a separate step, and it is free to be reassigned at later iterations as well. These assumptions permit an account of a diverse range of patterns that include both parasitic and autonomous primary stress systems as illustrated in §§3.3-3.4, while alternative definitions of GEN fail to account for the full range of cases in a general and typologically restrictive way (§3.5).

## CHAPTER 4

### CONSTRAINTS ON PRIMARY STRESS

#### 4.1 Introduction

The previous chapter presented and justified a proposal for assigning primary stress in Harmonic Serialism. This chapter turns to a discussion of the proper formulation of constraints on primary stress. This chapter will not attempt a comprehensive discussion of all constraints to which primary stress may be subject, but instead two issues are addressed in detail. First, in §4.2, I discuss directly the issue of primary stress alignment, arguing that both foot-referencing and syllable-referencing primary stress alignment constraints are likely needed in CON. I also argue that primary stress alignment in Harmonic Serialism cannot be determined by constraints that only reference other feet, as these constraints cannot capture attested patterns of autonomous primary stress. In §4.3 I turn to a general discussion of the formulation of primary stress constraints and show that typical definitions, which allow vacuous satisfaction, make pathological typological predictions. Allowing primary stress constraints to be vacuously satisfied means that omitting primary stress should be a possible repair for well-formedness violations, but no attested stress patterns work this way. I propose a redefinition for constraints on primary stress that succeeds in preventing these pathologies. Finally, §4.4 concludes this chapter.

## 4.2 Primary stress alignment

### 4.2.1 ALIGN<sub>Hd</sub> and ALIGN<sub>HdFt</sub>

Although several factors may influence the placement of the primary stress, arguably the most important is that of edge alignment.<sup>1</sup> Primary stress typically gravitates to a word edge, either left or right depending on the language, as we have seen in many of the examples shown in chapter 3.

The analyses in chapter 3 assumed a version of the primary stress alignment constraint that assigns a violation mark for every syllable between the primary stress syllable (the head syllable of the head foot) and the word edge. Under the schema of generalized alignment (McCarthy and Prince 1993a, McCarthy 2003), the formal definitions are those in (121).<sup>2</sup>

(121) a. **ALIGN(Hd(Hd(PWd)),L,PWd,L,σ) (ALIGN<sub>HdL</sub>)**

For any Hd(Hd(PWd)), if there is some PWd, assign one violation mark for any σ that intervenes between the L edge of Hd(Hd(PWd)) and the nearest L edge of the PWd.

b. **ALIGN(Hd(Hd(PWd)),R,PWd,R,σ) (ALIGN<sub>HdR</sub>)**

For any Hd(Hd(PWd)), if there is some PWd, assign one violation mark for any σ that intervenes between the R edge of Hd(Hd(PWd)) and the nearest R edge of the PWd.

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<sup>1</sup>Here and elsewhere I use the term “alignment” to refer to constraints that cause the primary stress to gravitate toward the word edge. Whether such constraints are defined according to the generalized alignment schema proposed by McCarthy and Prince (1993a) is discussed where relevant but should not be assumed to apply to every use of the word “alignment” in this section.

<sup>2</sup>A constraint defined under the generalized alignment schema can only assign violations when its first argument (here, the primary stress) is present in the candidate being evaluated. In §4.3 I will present revised definitions for the ALIGN<sub>Hd</sub> constraints that deviate from the generalized alignment schema precisely on this point. The number of violation marks assigned to candidates *with* a primary stress remain the same, however, and thus the essential details of this discussion are not affected by the revisions proposed in §4.3.

The utility of a constraint that aligns the primary stress syllable, rather than just the primary stress foot, was evident in the analyses of Huariapano, Tübatulabal, and Latin in chapter 3. In all of these languages the primary stress foot takes on characteristics that set it apart from the secondary stress feet because the syllable with the primary stress wants to be closer to the word edge. In Huariapano, **ALIGNHDR** effectively causes primary stress quantity-sensitivity; in Tübatulabal, **ALIGNHDR** forces a monosyllabic foot at the right edge; and in Latin, **ALIGNHDR** (when combined with **NONFINALITYHD**) is responsible for favoring penult stress when antepenultimate stress might otherwise be optimal, as discussed in chapter 3 (§3.5.2). In general, the work of **ALIGNHD** is most obvious in a trochaic language when **ALIGNHDR** is high ranked (as in the languages just mentioned; see also Pater 2000:241ff), because a perfectly aligned canonical trochee would put place the head syllable one syllable away from the right edge.<sup>3</sup>

An alternative way to define the primary stress alignment constraint would be to refer to the head foot rather than to the syllable bearing the primary stress, with the formal definitions given in (122) (where **Hd(PWd)** refers only to the foot).

(122) a. **ALIGN(Hd(PWd),L,PWd,L,σ) (ALIGNHDFTL)**

For any **Hd(PWd)**, if there is some **PWd**, assign one violation mark for any  $\sigma$  that intervenes between the L edge of **Hd(PWd)** and the nearest L edge of the **PWd**.

b. **ALIGN(Hd(PWd),R,PWd,R,σ) (ALIGNHDFTR)**

For any **Hd(PWd)**, if there is some **PWd**, assign one violation mark for any  $\sigma$  that intervenes between the R edge of **Hd(PWd)** and the nearest R edge of the **PWd**.

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<sup>3</sup>The reverse is true for iambic languages and could analogously be used to describe the initial-if-heavy-else-peninitial pattern in iambic languages with left-edge attraction of the primary stress, particularly those with non-iterative stress (e.g., Hayes 1995:261).

There are many languages, e.g., Finnish and Piro from chapter 3, that display primary stress alignment preferences that do not obviously target the primary stress *syllable*. In a language like Finnish, which prefers left-headed feet and left-aligned primary stress, the trochaic foot head and the primary stress foot are coincident at the left word edge, so the alignment constraint need not refer specifically to the foot or its head; either one of the definitions in (121) or (122) would work. And in Piro, a trochaic foot aligns to the right edge of the word, but it does not sacrifice its left-headedness in the process. The question of interest, however, is whether there are examples that can *only* be analyzed with the foot-referring primary stress alignment constraints. An example would be a case that depends on having the primary stress foot extend toward a word edge even when no improvement on the syllable-referring ALIGN<sub>HD</sub> would be realized (and when a comparable effect is not seen in other feet, ruling out an explanation from a general parsing constraint).

There is at least one case that appears to fall into this category, namely Fijian (Schütz 1985, Dixon 1988), particularly as a result of its process of primary stress trochaic shortening, which was analyzed in chapter 2. Primary stress in Fijian falls on the final syllable if heavy, otherwise it falls on the penult, and a heavy penult is shortened when the final syllable is light. The analysis put forward in chapter 2 assumed that an ('HL) trochee is built word-finally and subsequently shortened to ('LL) to obey a constraint that favors trochees grouping elements of equal weight. The derivation follows the path shown in (123). Secondary stresses tolerate (at least optionally) stressed heavy syllables preceding stray (unfooted) light syllables (i.e., in the same configuration that motivates primary stress trochaic shortening), suggesting that they must be permitted to be parsed as ('H)L rather than as ('HL).

(123) Derivation of primary stress trochaic shortening in Fijian

/si:βi/ → ('si:βi) → ('siβi) → [( 'siβi)]

In chapter 2 and in Pruitt (2010) I analyzed this process with a derivation that builds an ('HL) foot at the right word edge to satisfy ALIGNWDR, but in chapter 3 I discussed various reasons to disfavor the constraint ALIGNWDR. Because it is only the primary stress foot that is affected by this process in Fijian, an alternative to ALIGNWDR would be to use ALIGNHDFTR.<sup>4</sup> The preference for an ('HL) foot word-finally could not be due to a constraint on primary stress *syllable* alignment because ('HL) and the alternative ('H)L tie on ALIGNHDR, both receiving one violation. And because we want to account for the fact that the process is obligatory in the word-final primary stress but optional in all other potential cases, a general constraint like PARSE- $\sigma$  or ALLFTR cannot be used to favor building the ('HL) foot over the alternative ('H)L.

Combined with the arguments for syllable-referring ALIGNHD mentioned above, it would seem that primary stress alignment must be able to make reference to both the syllable and the foot. It might seem somewhat unattractive to have two sets of primary stress alignment constraints, but analogous cases of syllable- and foot-referring constraints exist, for example, with NONFINALITY (Prince and Smolensky 1993/2004). Thus, it seems appropriate to allow both ALIGNHD and ALIGNHDFT in CON when the evidence supports both (see also Pater 2000, where ALIGNHD is taken to additively encompass both syllable reference and foot reference).

#### 4.2.2 ENDRULE

An alternative to the formulation of both ALIGNHD and ALIGNHDFT is discussed in the literature typically under the name ENDRULE (Prince 1983). In OT, ENDRULE constraints are different from the ALIGNHD constraints because other feet or

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<sup>4</sup>The optional variant in which all such sequences undergo shortening could still be analyzed as it is in chapter 2, footnote 20.

foot heads, instead of syllables, are counted to determine distance from the edge (e.g., McCarthy 2003:111). This is the only difference between the two sets of constraints, as the definitions in (124) indicate. **ENDRULE** constraints could also be defined under the generalized alignment schema by starting with the definition of either **ALIGNHD** (as in (121)) or **ALIGNHDFT** (as in (122)) and replacing the last argument,  $\sigma$ , with  $\acute{\sigma}$ .

(124) **ENDRULE** constraints as defined by McCarthy (2003:111)

a. **ENDRULE-L**

Assign a violation mark for each foot head intervening between the primary stress foot and the left edge of the PWD.

b. **ENDRULE-R**

Assign a violation mark for each foot head intervening between the primary stress foot and the right edge of the PWD.

However, **ENDRULE** constraints are not sufficient to control the location of primary stress in HS when parsing is top-down. **ENDRULE** can only prefer a particular position of primary stress relative to other feet; when parsing is top-down the first foot generally receives the primary stress, but since no other feet are yet present, **ENDRULE** fails to favor either right-alignment or left-alignment, meaning that the decision of where to build the first foot will always fall to other constraints, even if lower ranked. As a result, **ENDRULE** is essentially inert in top-down stress, compared to **ALIGNHD** or **ALIGNHDFT**, and therefore analyses of some autonomous primary stress systems are not possible. This is illustrated explicitly in (125) where it is shown that for input /ravintola/ in Finnish, **ENDRULE-L** cannot overcome the preference of \*('LH), despite our intent for the winner to be ('ravin)tola. In contrast, in chapter 3 (§3.3.1) it was shown that **ALIGNHD**L favors ('ravin)tola over \*ra('vinto)la straightforwardly.

## (125) Word-initial LH skipped over despite high-ranking ENDRULE-L

/ravintola/ 1st iteration	ENDRULE-L	*('LH)	PARSE- $\sigma$	ALLFTL
⊖ a. (,ravin)tola		1	2	
→ b. ra(,vinto)la			2	

The small difference in ‘what is counted’ by ENDRULE is enough to differentiate it from ALIGNHD and ALIGNHDFT in terms of its (lack of) success in motivating autonomous primary stress alignment.

ENDRULE has another characteristic that is not shared by ALIGNHD and ALIGNHDFT, which is the ability to disfavor subsequent footing after the primary stress has been assigned. Since ENDRULE counts foot heads, each additional foot contributes to the primary stress foot’s ‘misalignment’. A possible argument for this formulation is given by Elsmann (2010), who uses ENDRULE’s<sup>5</sup> ability to disfavor additional footing to account for the absence of secondary stresses to the right of the primary stress in Pichis Asheninca, which surfaces between two and five syllables from the right edge of the word as determined partly by sonority (Payne 1990). Without a constraint like ENDRULE-R it is difficult to account for the absence of a foot to the right of the primary stress even when there is room for one. An alternative analysis would likely have to assume that there *are* feet beyond the primary stress in the phonological representation of this stress system and leave it to the details of phonetic implementation to account for the fact that such stresses are apparently subject to a weaker, less audible realization. This approach is taken by Hayes (1995) and McGarrity (2003), for example (see also McGarrity 2003:195, fn. 18 for additional discussion).<sup>6</sup>

<sup>5</sup>Elsman (2010) gives this constraint a different name.

<sup>6</sup>Elsman’s (2010) analysis is also couched in HS and assumes similar operational assumptions as those presented in chapter 3, namely an essentially top-down stress grammar and the ability to reassign primary stress for ‘free’ during the derivation. The assumption of free reassignment of



Despite the fact that `ENDRULE` permits an analysis of Pichis Asheninca which is otherwise unavailable, its inability to account for autonomous primary stress alignment like that found in Finnish, Huariapano, Tübatulabal, and Latin, makes it ultimately less attractive as the basis for the general primary stress alignment constraint in HS. Thus, `ALIGNHD` and `ALIGNHDFT` are the constraints that I adopt here. Nonetheless, there is one aspect of the definitions of `ALIGNHD` and `ALIGNHDFT` that is typologically problematic; the next section addresses the ability of these constraints and other constraints on primary stress to be vacuously satisfied and offers a solution to the resulting problematic predictions.

### 4.3 Primary stress and vacuous satisfaction

#### 4.3.1 Background and proposal

A markedness constraint is vacuously satisfied when the structure whose well-formedness it evaluates is absent. Constraints on prosodic structure, for example, are often implicitly but sometimes explicitly conditional: “*if there is a foot in the representation, then it must be binary*” (Prince and Smolensky 1993/2004:57, emphasis in original). Thus, a constraint against sub-minimal feet (`FTBIN`) is satisfied when syllables are parsed into feet that meet the size minimum or are not parsed into feet at all.

Like most prosodic constraints, constraints on primary stress are generally defined to permit vacuous satisfaction, at least in theory.<sup>7</sup> This is, perhaps, most obviously the case for constraints defined under the schema of generalized alignment (McCarthy and Prince 1993a, McCarthy 2003), such as `ALIGNHD` and `ALIGN-`

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primary stress is crucial for the success of the `ENDRULE-R`-driven absence of post-tonic secondary stresses in her HS analysis of Pichis Asheninca stress.

<sup>7</sup>The sense in which “in theory” is relevant has to do with whether candidates without the structure in question are generated by `GEN`. A constraint can allow vacuous satisfaction “in theory” but not “in practice” if no candidates that would vacuously satisfy the constraint are ever considered.

HdFt, which were discussed in §4.2, but constraints governing other aspects of the markedness of the primary stress syllable or foot are also conditional under the most natural-sounding definitions. A primary-stress-specific STRESS-TO-WEIGHT constraint, for example, is defined by McGarrity (2003) as in (126).

(126) **STRESS<sub>1</sub>-TO-WEIGHT (S<sub>1</sub>-TO-W)**

“Primary stressed syllables must be heavy” (McGarrity 2003:30)

Although conditional definitions typically receive no special discussion, a non-conditional definition would sound comparatively odd without justification (e.g., ‘A prosodic word must have a head on a heavy syllable’).

The tendency to define prosodic structure markedness constraints conditionally is well-entrenched, but it is problematic in the case of primary stress. As I will demonstrate below, any primary stress markedness constraint that permits vacuous satisfaction will make pathological predictions via factorial typology. The problematic predicted stress systems generally have one thing in common: primary stress in some words but not others on the basis of arbitrary properties of inputs, a property I will refer to as non-uniform culminativity.<sup>8</sup> Non-uniform culminativity arises when a high-ranking primary stress markedness constraint can be satisfied *non*-vacuously for some inputs but must be satisfied vacuously for others (generally because other high-ranking constraints rule out candidates with non-vacuously perfect primary stress). Failing to build a degenerate foot is an attested way of satisfying a constraint like FtBin, but opting not to assign primary stress is not an attested ‘repair’ for violations of primary stress well-formedness constraints. This is why the resulting predictions are pathological, as will be illustrated in detail below. I will also note here that these pathologies and the proposed

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<sup>8</sup>This sense of the word non-uniformity follows Pater (2000), who cites Prince (1993) for the terminology. Prince and Smolensky (1993/2004) discuss non-uniformity phenomena as “except when” cases, particularly in their chapter 4.

solution will be demonstrated mainly within the context of HS, but parallel OT predicts the same things (Pruitt 2012); this will be addressed in §4.3.4.2.

I will argue that in order to prevent these pathological predictions, constraints on primary stress must be redefined according to non-vacuous constraint schemata. For any categorical constraint on primary stress markedness, like primary-stress-specific STRESS-TO-WEIGHT, the formula in (127) can be used to prevent the constraint from ever *disfavoring* primary stress. Any constraint defined using this schema cannot be vacuously satisfied, so it will never cause an input to map to a candidate without primary stress.<sup>9</sup>

(127) Non-vacuous primary stress constraint schema

Assign a violation mark for a PWd that does not have a Hd(PWd) with property  $\pi$ .

The non-vacuous version of  $S_1$ -TO-W, for example, reads as shown in (128).

(128)  $S_1$ -TO-W-NV

Assign a violation mark for a PWd that does not have a head on a syllable that is heavy

This constraint assigns one violation mark to a PWd without a head, one violation mark to a PWd with a head on a light syllable, and zero violation marks to a PWd with a head on a heavy syllable. Table 4.1 illustrates the contrast between this definition and that of the conditional, or vacuously satisfiable,  $S_1$ -TO-W constraint. The definition in (128) is non-vacuous because of the equivalent number of violation marks it assigns to the candidate without a head and the candidate with a light-syllable head.

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<sup>9</sup>This will be addressed in detail later, but technically, of course, this constraint is vacuously satisfied by non-PWd candidates. For now I will assume that all candidates are PWds.

Candidate	Violations assessed by:	
	S <sub>1</sub> -TO-W	S <sub>1</sub> -TO-W-NV
pa.ta.ka	0	1
'pa.ta.ka	1	1
'pa:ta.ka	0	0

**Table 4.1.** Comparison of violations assessed by regular and non-vacuous S<sub>1</sub>-TO-W

For constraints on primary stress alignment the solution is similar but it requires a bit more justification. Because the alignment constraints must be evaluated gradiently, as argued in chapter 3, the number of violations they assign for a maximally misaligned candidate is technically unbounded (in the sense that it depends on the number of syllables in a word, which is assumed to have no theoretical upper limit). In order to ensure that primary stress alignment constraints never *disfavor* primary stress assignment, these constraints must assign an equal or greater number of violation marks to a candidate without a primary stress as to a candidate with a maximally misaligned primary stress. For a given word that is  $n$  syllables in length, a misaligned primary stress can incur up to  $n - 1$  violation marks on the assumption that distance from the edge of alignment is counted in terms of syllables; thus, a word with  $n$  syllables must receive *at least*  $n - 1$  violations of each primary stress alignment constraint when it has no primary stress. This can be achieved with the definitions in (129) for non-vacuous ALIGN<sub>HDL</sub>, which give a candidate without any primary stress a number of violation marks equal to the number of syllables in the word (i.e.,  $n$ ).

(129) a. **ALIGN<sub>HDL</sub>-NV**

Assign a violation mark for every non-primary-stress syllable that does not have a primary stress syllable between itself and the left word edge

b. **ALIGNHDR-NV**

Assign a violation mark for every non-primary-stress syllable that does not have a primary stress syllable between itself and the right word edge

Table 4.2 illustrates the comparison between the violation marks assigned by regular **ALIGNHD** constraints and their non-vacuous counterparts. As with the  $S_1$ -**TO-W** example in Table 4.1, the only difference in violation assessment introduced by the non-vacuous version is the number of violations given to the candidate without a primary stress. Instead of zero, it is now  $n$ , where  $n$  is equal to the number of syllables in the word (here five).

<i>Candidate</i>	<i>Violations assessed by:</i>			
	<b>ALIGNHDL</b>	<b>ALIGNHDL-NV</b>	<b>ALIGNHDR</b>	<b>ALIGNHDR-NV</b>
σσσσσ	0	5	0	5
óσσσσ	0	0	4	4
σóσσσ	1	1	3	3
σσóσσ	2	2	2	2
σσσσó	3	3	1	1
σσσσó	4	4	0	0

**Table 4.2.** Comparison of violations assessed by regular and non-vacuous **ALIGNHD**

Non-vacuous versions of **ALIGNHDFt** can be constructed similarly. They would be defined as in (130). This definition again ensures that a candidate without a primary stress receives  $n$  violations, where  $n$  is equal to the number of syllables in the word.

(130) **ALIGNHDFt-NV**

Assign a violation mark for every syllable that is not a member of the primary stress foot and does not have a primary stress to its left/right

As before, the difference between  $\text{ALIGN}_{\text{HDFT-NV}}$  and  $\text{ALIGN}_{\text{HD-NV}}$  is that the foot-referring constraints do not penalize a syllable that is inside of the primary stress foot, even if that syllable stands between the primary stress and the word edge. For example, in a candidate  $(\sigma\sigma)\sigma\sigma$ ,  $\text{ALIGN}_{\text{HDR-NV}}$  is violated four times, once for each non-primary stress syllable that does not have a primary stress to its right. In contrast,  $\text{ALIGN}_{\text{HDFTR-NV}}$  is violated just three times, once for each syllable not affiliated with the primary stress foot that does not have a primary stress to its right. This mirrors the effect of the standard  $\text{ALIGN}_{\text{HDFTR}}$  constraint, which counts the number of syllables between the right edge of the primary stress foot and the right edge of the word.<sup>10</sup>

In the next section (§4.3.2) I illustrate the kinds of pathological predictions that emerge from vacuously satisfiable primary stress constraints and then in §4.3.3 show that the solution proposed in this section prevents those pathologies from arising. Section 4.3.4 discusses some alternatives to the non-vacuous constraint schemata and illustrates why they are insufficient. Section 4.3.5 concludes by arguing that the restricted  $\text{GEN}$  of HS is an important part of the proposed solution.

### 4.3.2 Pathologies of vacuous satisfaction

When constraints on primary stress are able to be vacuously satisfied, under some rankings it will be preferable not to assign primary stress at all. In chapter 3 I argued for a definition of  $\text{GEN}$  that in principle allows candidates with only sec-

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<sup>10</sup>In §4.2.1 I argued that both  $\text{ALIGN}_{\text{HD}}$  and  $\text{ALIGN}_{\text{HDFt}}$  constraints are needed to account for the diverse ways that primary stress alignment preferences are realized, and elsewhere I argued that the  $\text{ALIGN}_{\text{HD}}$  needs to be evaluated gradiently. However, there does not seem to be clear empirical evidence in favor of  $\text{ALIGN}_{\text{HDFt}}$  also being gradient. What would be needed is a case in which the primary stress foot behaves exceptionally by extending one syllable to the left/right but does not completely align to the edge, e.g.,  $\sigma\sigma(\sigma)\sigma\sigma \rightarrow \sigma\sigma(\sigma\sigma)\sigma$ . Without such evidence an alternative formulation of the non-vacuous  $\text{ALIGN}_{\text{HDFt}}$  constraint would be more or less equivalent to  $\text{ALIGN}(\text{Wd}, \text{Hd}(\text{PWd}))$ , which assigns a violation mark to any word that does not have a primary stress foot aligned to its left/right edge, but which never assigns more than one violation mark for any one  $\text{PWd}$ .

ondary stresses; the operation of primary stress assignment was defined to freely, but optionally, apply. Thus, when vacuously satisfiable primary stress constraints prevent the assignment of primary stress, but no constraints prevent footing in general, the result is a word with only secondary stresses. Problematic typological predictions subsequently arise not from the fact that words with only secondary stresses are predicted, but from the fact that within a single language (that is, under a single ranking) some words are predicted to surface with a primary stress and others are predicted not to. This is the property of non-uniform culminativity.

A simple case of non-uniform culminativity is found when two competing  $\text{ALIGN}_{\text{HD}}$  constraints are both ranked higher than the constraint that favors assigning a primary stress,  $\text{HEADEDNESS}(\text{PWD})$ . Since  $\text{ALIGN}_{\text{HDL}}$  and  $\text{ALIGN}_{\text{HDR}}$  cannot both be satisfied in words with two or more syllables, it will be preferable to build a secondary stress foot at the first iteration when an input is multisyllabic rather than build a primary stress; this is shown in (131).

(131) High-ranked  $\text{ALIGN}_{\text{HDL}}$  and  $\text{ALIGN}_{\text{HDR}}$  prevent primary stress assignment

$/\sigma\sigma\sigma\sigma/$ 1st iteration	$\text{ALIGN}_{\text{HDL}}$	$\text{ALIGN}_{\text{HDR}}$	$\text{PARSE-}\sigma$	$\text{HD}(\text{PWD})$
a. $\sigma\sigma\sigma\sigma$			$W_5$	1
→ b. $(\sigma\sigma)\sigma\sigma$			3	1
c. $(\sigma\sigma)\sigma\sigma$		$W_4$	3	L
d. $\sigma\sigma\sigma(\sigma'\sigma)$	$W_4$		3	L

Because any non-monosyllabic candidate with primary stress will always incur at least one violation of at least one of  $\text{ALIGN}_{\text{HDL}}$  or  $\text{ALIGN}_{\text{HDR}}$ , and because the only constraint favoring primary stress,  $\text{HD}(\text{PWD})$ , is ranked below  $\text{ALIGN}_{\text{HDL}}$  and  $\text{ALIGN}_{\text{HDR}}$ , under this ranking it will never be optimal, at any step in the derivation, to assign primary stress to multisyllabic inputs (assuming they remain multisyllabic throughout the derivation). For a monosyllabic input primary stress can be assigned without violation of either  $\text{ALIGN}_{\text{HDL}}$  or  $\text{ALIGN}_{\text{HDR}}$  so there is no bar-

rier to immediate satisfaction of  $\text{HD}(\text{PWD})$ . As a result, monosyllabic words under this ranking have a primary stress, while multisyllabic words do not.

This prediction is odd, but it might be possible to shrug it off if it were the only negative consequence of vacuously satisfiable primary stress constraints. (One could feasibly argue, for instance, that the existence of primary stress on only monosyllables might be difficult to hear or would possibly even be formally vacuous, since degrees of stress are relative and monosyllabic words would have no non-primary stressed syllables for comparison.) But the predictions of such constraints become even more obviously pathological under slightly different rankings. I will discuss four additional versions of this pathology. All have non-uniform culminativity, but they differ in how the non-uniformity is expressed, as will be evident in the illustrations below.

The simple example in (131) above shows a relatively obvious consequence of conflicting alignment preferences—perfect satisfaction of both  $\text{ALIGNHDL}$  and  $\text{ALIGNHDR}$  is not possible in multisyllabic words, and vacuous satisfaction is the optimal alternative. Less obvious examples involve only one of the primary stress alignment constraints. If general parsing constraints ( $\text{PARSE-}\sigma$ ,  $\text{FTBIN}$ ,  $\text{TROCHEE}$ ,  $\text{IAMB}$ , etc.) preclude building a foot whose head aligns perfectly to the dominant edge of primary stress alignment, but the  $\text{ALIGNHD}$  constraint still outranks  $\text{HD}(\text{PWD})$ , it will be preferable not to assign primary stress. This can result in uniform non-culminativity—when the high-ranked parsing constraints prevent a foot that would satisfy the  $\text{ALIGNHD}$  constraint for all words—but more often it will result in non-uniform (non-)culminativity—when the high-ranked parsing constraints prevent perfectly aligned feet in only a subset of inputs.

Uniform non-culminativity would arise, for example, under the ranking  $\text{TROCHEE}$ ,  $\text{FTBIN}$ ,  $\text{ALIGNHDR}$  »  $\text{HD}(\text{PWD})$ . Assuming a language without quantity-distinctions and a disyllabic word minimum,  $\text{FTBIN}$  requires a disyllabic foot, but



primary stress on a right-aligned disyllabic trochee introduces one violation of ALIGNHDR. Thus, the high-ranked foot-form constraints prevent a foot head from appearing adjacent to the right edge, and ALIGNHDR prevents any candidate with misaligned primary stress from winning. This is shown in (132), which assumes that parsing is otherwise right-to-left (i.e., ALLFTR » ALLFTL). Candidate (d) is preferred because it is the only one that satisfies all three high-ranked constraints (TROCHEE, FTBIN, and ALIGNHDR), though it does so by sacrificing a violation of HD(PWD).

(132) Assigning primary stress not optimal

/σσσσ/ 1st iteration	TROCHEE	FTBIN	ALIGNHDR	HD(PWD)
a. σσ('σσ)			W <sub>1</sub>	L
b. σσ(σ'σ)	W <sub>1</sub>			L
c. σσσ('σ)		W <sub>1</sub>		L
→ d. σσ(,σσ)				1

Like the first example, this ranking predicts a language with no primary word stress in word with two or more syllables. If other rankings ensure a disyllabic word minimum, all words will surface without primary stress, demonstrating uniform non-culminativity. But a minimal change in ranking demonstrates that nothing in the system guarantees the apparent uniformity exhibited by this language. If we again assume a language with right-to-left syllabic trochees, changing the dominant primary stress alignment constraint to ALIGNHDL instead of ALIGNHDR predicts a language with pathological non-uniform (non-)culminativity, because when disyllabic trochees are built from right to left, some words will end up with a foot head aligned to the left word edge, and some will not. If a word has an even number of syllables, a right-to-left trochaic parse places a foot head on the initial syllable (e.g., ('σσ)('σσ)), while a word with an odd number of syllables will not generally have a foot aligned to its left edge under this ranking (e.g., σ('σσ)('σσ)). It follows then that words with an even number of syllables will receive initial

primary stress because ALIGNHDL can be perfectly satisfied, while words with an odd number of syllables will have only secondary stresses because no other perfect solution is available for ALIGNHDL. This is illustrated in the tableaux in (133).

(133) a. Four syllable input receives primary stress

/σσσσ/ 1st iteration	ALIGNHDL	PARSE-σ	ALLFTR	Hd(PWD)
a. σσσσ		W <sub>4</sub>		1
b. σσ(,σσ)		2		1
c. σσ('σσ)	W <sub>2</sub>	2		L
d. ('σσ)σσ		2	W <sub>2</sub>	L
→ 2nd iteration				
e. σσ(,σσ)		W <sub>2</sub>	L	W <sub>1</sub>
f. (,σσ)(,σσ)			2	W <sub>1</sub>
g. ('σσ)(,σσ)			2	

(Convergence step not shown)  
→ **Output:** [( 'σσ)(,σσ)]

b. Five syllable input does not receive primary stress

/σσσσσ/ 1st iteration	ALIGNHDL	PARSE-σ	ALLFTR	Hd(PWD)
a. σσσσσ		W <sub>5</sub>		1
b. σσσ(,σσ)		3		1
c. σσσ('σσ)	W <sub>3</sub>	3		L
d. ('σσ)σσσ		3	W <sub>3</sub>	L
→ 2nd iteration				
e. σσσ(,σσ)		W <sub>3</sub>	L	1
f. σ(,σσ)(,σσ)		1	2	1
g. σ('σσ)(,σσ)	W <sub>1</sub>	1	2	L
h. ('σσ)σ(,σσ)		1	W <sub>3</sub>	L

(Convergence step not shown)  
→ **Output:** [σ(,σσ)(,σσ)]

Since the non-uniformity of primary stress in this example is based on the parity count of its syllables (i.e., whether odd or even), I will refer to this as the ‘parity pathology’. Several variations of the parity pathology are predicted under slightly different rankings, depending on whether the parsing direction is left-to-right or right-to-left, whether feet are iambic or trochaic, and whether monosyllabic feet are permitted or not. Clearly, all of these are undesirable predictions, as the like-

likelihood of having a primary stress is dependent on essentially arbitrary properties of each word.

Another version of the non-uniform culminativity pathology arises in a quantity-sensitive language with high-ranked *FTBIN*, *TROCHEE*, and *ALIGNHDR*, a ranking minimally different from the attested stress patterns of Huariapano and Tübatulabal discussed in chapter 3. In a quantity-sensitive language *FTBIN* places a bimoraic minimum on feet; ('H) is an acceptable bimoraic foot, but ('L) is not. Thus, when a word ends in a heavy syllable perfect satisfaction of *FTBIN*, *TROCHEE*, and *ALIGNHDR* is possible with a monosyllabic foot at the right edge. But when a word ends in a light syllable, there is no way to perfectly align a primary stress syllable without violating *FTBIN* or *TROCHEE* with ('L) or ('σL), respectively.

As shown in the tableaux in (134), under this ranking neither *ALIGNHDR* nor *FTBIN* (nor *TROCHEE*) can be violated, and the result is a language in which words with final heavies receive primary stress, (134a), while words with a final light syllable do not, (134b). This language will otherwise treat light and heavy syllables across inputs in a uniform way, depending on the ranking of the general parsing constraints. That is, no actual parsing differences will be observed for different inputs; it is only the likelihood of having a primary stress that is affected. Similarly, inputs like that in (134b) may have heavy syllables throughout the word, but if the final is not heavy primary stress is not assigned. The same tensions among these constraints arise in words with a final light syllable in Huariapano and in Tübatulabal, but Huariapano sacrifices minimal violation of *ALIGNHDR* in favor of a right-aligned ('LL) foot, and Tübatulabal permits violation of *FTBIN* to achieve perfect satisfaction of *ALIGNHDR* with ('L).

(134) a. Word with final heavy syllable receives primary stress

$/\sigma\sigma\sigma H/$ 1st iteration	ALIGNHDR	TROCHEE	FTBIN	HD(PWD)
→ a. $\sigma\sigma\sigma(H)$				
b. $\sigma\sigma\sigma(H)$				$W_1$

b. Input with final light syllable does not receive primary stress

$/\sigma\sigma\sigma L/$ 1st iteration	ALIGNHDR	TROCHEE	FTBIN	HD(PWD)
a. $\sigma\sigma\sigma(L)$			$W_1$	L
b. $\sigma\sigma(\sigma L)$	$W_1$			L
c. $\sigma\sigma(\sigma' L)$		$W_1$		L
→ d. $\sigma\sigma(\sigma L)$				1

Of course, a ‘solution’ to the problem illustrated in (134) would be to lengthen a final light syllable to make it heavy, but because lengthening and footing could not happen at the same step in HS this alternative is not available. More importantly, though, even if it GEN allowed simultaneous lengthening and footing (as it does in parallel OT, for example), the ranking of faithfulness constraints varies orthogonally to the parsing constraints, and there will always be a ranking in which such modifications are also blocked. Since we are interested in typological predictions, it is enough to observe that there is always *some* ranking in which the pathology in (134) arises with vacuously satisfiable ALIGNHDR because all alternatives are blocked by higher-ranking constraints.

A third example of non-uniform culminativity as a result of conditionally defined primary stress constraints can be seen with primary-stress-specific  $S_1$ -TO-W, which assigns a violation mark to a primary stress syllable that is not heavy. This pathology does not involve the ALIGNHD constraints, though it has characteristics similar to the ALIGNHD-based pathologies just discussed. When  $S_1$ -TO-W is defined in the normal way and assigns no violation mark to a word without a primary stress, it can only be non-vacuously satisfied in a word with at least one heavy syllable. Inputs with only light syllables prevent perfect non-vacuous satisfaction of  $S_1$ -TO-W because anywhere the primary stress is placed will introduce

a violation of  $S_1$ -TO-W. Since this violation is not shared by the candidate without primary stress under this definition, vacuous satisfaction presents itself as the optimal solution for a subset of inputs.

As illustrated in (135), an input with a heavy syllable anywhere in the word satisfies  $S_1$ -TO-W non-vacuously and does not incur a violation of  $H_D(PWD)$ ; but an input with no heavy syllables can only satisfy  $S_1$ -TO-W by omitting the primary stress altogether at the expense of a violation of  $H_D(PWD)$ . In this language only words with at least one heavy syllable receive primary stress.

(135) a. Input with a heavy syllable receives primary stress

/partakama/ 1st iteration	$S_1$ -TO-W	$H_D(PWD)$
→ a. ('pa:ta)kama		
b. (,pa:ta)kama		$W_1$

b. Input with only light syllables does not receive primary stress

/patakama/ 1st iteration	$S_1$ -TO-W	$H_D(PWD)$
a. ('pata)kama	$W_1$	L
→ b. (,pata)kama		1

As with the previously discussed examples, this is just one of several manifestations of this particular prediction; different rankings of the other constraints produce additional variations, as is typical with systemic pathologies.

A fourth and final example of non-uniform culminativity to be discussed here is found with a primary-stress-specific version of  $NONFINALITY$ . The only requirement that  $NONFINH_D$  constraints make is that the primary stress (syllable or foot) not be final in the prosodic word. Like other primary stress constraints  $NONFINH_D$  is satisfied vacuously in candidates without primary stress. Although  $NONFINH_D$  would seem to offer comparatively more ways of being *non*-vacuously satisfied relative to constraints like  $ALIGNH_D$  and  $S_1$ -TO-W, the availability of vacuous satisfaction is still a problem in more or less the same way. When candidates that

satisfy the constraint non-vacuously (i.e., by having a primary stress in a non-final position) are unavailable, vacuous satisfaction can be the preferred alternative.

A simple example of non-uniform culminativity caused by NONFINHD arises when it dominates HD(PWD), no matter the other rankings in the language. When this ranking holds, monosyllabic words are predicted not to have primary stress because there is no way for it to avoid the final (and only) syllable, but multisyllabic words are not prevented from having a primary stress because it may be possible to avoid the final syllable in those cases. This predicts the opposite effect from high-ranking ALIGNHDL and ALIGNHDL discussed at the outset of this section, which resulted in a language in which *only* monosyllables received primary stress.

Variations on this pattern also exist. If IAMB and FTBIN are highly ranked then even a disyllabic word cannot avoid violation of NONFINHD, so words of two syllables or fewer would have no primary stress, while words with three or more syllables would. Similarly, given various other constraints on the construction of feet, NONFINHD can prevent even three-syllable words from having primary stress if parsing the first two syllables into a foot is not an option. For example, given a three-syllable input with a heavy syllable followed by two light syllables, /HLL/, a disyllabic iamb that avoids violating NONFINHD would incur a violation of a constraint against having a dependent heavy syllable, e.g., WEIGH-TO-STRESS-FOOT (WSP-FT, Kager 1999:184). But if this constraint is highly ranked that candidate will be ruled out, and NONFINHD will favor the candidate without primary stress. This is shown in (136). In this language words with one or two syllables never have primary stress, while words with three or more syllables may or may not, depending on the syllable structure of the word. Thus, NONFINHD is just as likely to predict non-uniform culminativity as other constraints on primary stress when it can be satisfied by a word that has no primary stress at all.

(136) NONFINALITYHD prevents assignment of primary stress

/HLL/ 1st iteration	NONFINHD	WSP-F <sub>T</sub>	IAMB	HD(PWD)
a. (H'L)L		W <sub>1</sub>		L
b. H('LL)			W <sub>1</sub>	L
c. H(L'L)	W <sub>1</sub>			L
→ d. H(L,L)				1

The examples in this section have shown that non-uniform culminativity arises in many forms when constraints on primary stress can be vacuously satisfied. Languages with non-uniform culminativity are problematic because they treat the likelihood of an input being assigned a primary stress as a decision that can be made based on the relative well-formedness of that primary stress, which will necessarily be non-uniform across all inputs in any language. But, as stated at the outset, opting not to assign primary stress is not an attested ‘repair’ for constraints like ALIGNHD, S<sub>1</sub>-TO-W, and NONFINHD in any language. Constraints on primary stress well-formedness should govern *where* primary stress is assigned but not *whether* it is. These constraints should not permit vacuous satisfaction precisely because no language elects to satisfy them by not having a primary stress.

The next section returns to the solution proposed in §4.3.1 and illustrates how the non-vacuous constraint schemata eliminate all of these pathologies when adhered to strictly.

### 4.3.3 Non-vacuous solution

The pathologies of non-uniform culminativity are generated when a constraint on primary stress well-formedness can be satisfied by a candidate with no primary stress at all. To prevent these predictions across the board it is necessary to ensure that candidates without primary stress cannot perform better on primary stress constraints than candidates with a primary stress. The constraint schemata proposed in §4.3.1 provide a template for redefining primary stress constraints so

that vacuous satisfaction is not possible. In this section I first demonstrate that the pathologies based on  $\text{ALIGN}_{\text{HD}}$  do not arise with  $\text{ALIGN}_{\text{HD-NV}}$ , and then turn to the pathologies that arise as a result of  $\text{S}_1\text{-TO-W}$  and  $\text{NONFIN}_{\text{HD}}$ , which are similarly eliminated by following non-vacuous reformulations.

The first examples of non-uniform culminativity illustrated in the previous section were based on  $\text{ALIGN}_{\text{HD}}$  constraints, which assign one violation mark for each syllable between the primary stress syllable and the word edge but no violation marks when a word lacks a primary stress. The examples of  $\text{ALIGN}_{\text{HD}}$  constraints causing non-uniform culminativity were all cases in which a combination of conflicting constraints prevented perfect alignment of the primary stress, so vacuous satisfaction (that is, no primary stress at all) emerged as the ideal alternative. The non-vacuous  $\text{ALIGN}_{\text{HD-NV}}$  constraints, defined above in (129) and repeated below in (137), prevent all of these pathologies by assigning a greater number of violation marks to the formerly ‘perfect’ vacuous satisfaction candidates. This has the desired result of ensuring that candidates with only secondary stresses will not be judged as more harmonic than similar candidates with primary stress.

(137) a.  **$\text{ALIGN}_{\text{HD-L-NV}}$**

Assign a violation mark for every non-primary-stress syllable that does not have a primary stress syllable between itself and the left word edge

b.  **$\text{ALIGN}_{\text{HD-R-NV}}$**

Assign a violation mark for every non-primary-stress syllable that does not have a primary stress syllable between itself and the right word edge

In the first case discussed in §4.3.2, non-uniform culminativity resulted from the high ranking of both of the  $\text{ALIGN}_{\text{HD}}$  constraints, which place competing demands for edge alignment on the primary stress. Words with more than one syllable will incur at least one violation of one of the  $\text{ALIGN}_{\text{HD}}$  constraints when pri-



mary stress is added; when both ALIGN<sub>HD</sub> constraints are high-ranked, candidates without primary stress were favored because they are the only candidates that satisfy both ALIGN<sub>HD</sub> constraints. However, ALIGN<sub>HD</sub>-NV solves this problem by reversing the contextual primary stress antagonism of the head alignment constraints, assigning more violation marks to a candidate without a primary stress than to one with a primary stress, even a maximally misaligned one. Although non-primary-stress candidates could perfectly satisfy the original ALIGN<sub>HD</sub> constraints, there are no such candidates that perfectly satisfy both ALIGN<sub>HD</sub>L-NV and ALIGN<sub>HD</sub>R-NV. As shown in (138), this means that whichever one is higher-ranked will determine the outcome among the candidates *with* primary stress, but candidates with only secondary stresses cannot win under any ranking.

(138) High-ranked ALIGN<sub>HD</sub>L-NV and ALIGN<sub>HD</sub>R-NV do not prevent primary stress assignment

/σσσσσ/ 1st iteration	AL <sub>HD</sub> L-NV	AL <sub>HD</sub> R-NV	PARSE-σ	HD(PWD)
a. σσσσσ	W <sub>5</sub>	W <sub>5</sub>	W <sub>5</sub>	W <sub>1</sub>
b. (σσ)σσσ	W <sub>5</sub>	W <sub>5</sub>	3	W <sub>1</sub>
→ c. ('σσ)σσσ		4	3	
→ d. σσσ(σ'σ)	4		3	

The second case of non-uniform culminativity was the parity pathology, in which odd- and even-parity words are treated differently in the assignment of primary stress. The high rank of ALIGN<sub>HD</sub>L in that example meant that primary stress assignment was delayed until perfect satisfaction was possible, and this was illustrated by the tableaux in (133). This point is reached with the 'last' foot in the right-to-left trochaic parse of an even-parity word, but is never reached in the same parse of an odd-parity word, which surfaces with only secondary stresses. When ALIGN<sub>HD</sub>L-NV is substituted for ALIGN<sub>HD</sub>L in this ranking, the lack of perfect left alignment no longer prevents or delays the assignment of primary stress, so it is assigned at the first iteration for both even- and odd-parity inputs. Accord-

ing to ALIGNHDL-NV, any placement of primary stress is an improvement over no primary stress at all. If ALIGNHDL-NV dominates ALLFTR, the first foot will be left-aligned, as shown in (139).

(139) a. Four syllable input receives primary stress

/σσσσ/ 1st iteration	ALHDL-NV	PARSE-σ	ALLFTR
a. σσσσ	W <sub>4</sub>	W <sub>4</sub>	L
b. σσ(,σσ)	W <sub>4</sub>	2	L
c. σσ('σσ)	W <sub>2</sub>	2	L
→ d. ('σσ)σσ		2	2

b. Five syllable input also receives primary stress

/σσσσσ/ 1st iteration	ALHDL-NV	PARSE-σ	ALLFTR
a. σσσσσ	W <sub>5</sub>	W <sub>5</sub>	L
b. σσσ(,σσ)	W <sub>5</sub>	3	L
c. σσσ('σσ)	W <sub>3</sub>	3	L
→ d. ('σσ)σσσ		3	3

If instead ALLFTR dominates ALIGNHDL-NV, the derivation will build right-aligned feet and primary stress will be assigned at the first iteration for both four- and five-syllable inputs, as shown in (140). Even though ALLFTR prevents left alignment of the primary stress, not having primary stress at all is even worse. Because ALIGNHDL-NV is the dominant head alignment constraint, the primary stress will be reassigned leftwards during the derivation as allowed by the definition of GEN proposed in chapter 3. Even though perfect left-alignment of the primary stress is never achieved in five-syllable inputs, alternatives without primary stress fare no better on ALIGNHDL-NV so minimal deviation from perfect alignment is tolerated.

(140) a. Four syllable input receives primary stress

/σσσσ/ 1st iteration	PARSE-σ	ALLFtR	ALHdL-NV
a. σσσσ	W <sub>4</sub>		W <sub>4</sub>
b. σσ(,σσ)	2		W <sub>4</sub>
← c. σσ('σσ)	2		2
→ d. ('σσ)σσ	2	W <sub>2</sub>	L
<b>2nd iteration</b>			
e. σσ('σσ)	W <sub>2</sub>	L	W <sub>2</sub>
f. (,σσ)('σσ)		2	W <sub>2</sub>
← g. ('σσ)(,σσ)		2	

(Convergence step not shown)  
→ **Output:** [( 'σσ)(,σσ)]

b. Five syllable input also receives primary stress

/σσσσσ/ 1st iteration	PARSE-σ	ALLFtR	ALHdL-NV
a. σσσσσ	W <sub>5</sub>		W <sub>5</sub>
b. σσσ(,σσ)	3		W <sub>5</sub>
← c. σσσ('σσ)	3		3
→ d. ('σσ)σσσ	3	W <sub>3</sub>	L
<b>2nd iteration</b>			
e. σσσ('σσ)	W <sub>3</sub>	L	W <sub>3</sub>
f. σ(,σσ)('σσ)	1	2	W <sub>3</sub>
← g. σ('σσ)(,σσ)	1	2	1
→ h. ('σσ)σ(,σσ)	1	W <sub>3</sub>	L

(Convergence step not shown)  
→ **Output:** [σ('σσ)(,σσ)]

The preceding examples show that the parity pathology, in which odd and even parity words are treated differently in primary stress assignment, is prevented by using ALIGNHD-NV constraints. Because the primary-stress-less candidates already incur violations of the non-vacuous primary stress alignment constraints, there is no reason to delay assigning the primary stress, even if perfect alignment is not possible.

The third case of ALIGNHD-based non-uniform culminativity was one in which words with a final heavy syllable could be assigned primary stress, but words ending in a light syllable could not. This prediction emerged from high-ranked

TROCHEE, FTBIN, and ALIGNHDR, which could all be satisfied only by a candidate without primary stress when the final syllable was light. By using ALIGNHDR-NV instead, the assignment of primary stress to final heavy syllables is unaffected, as illustrated in (141a), but words with a final light syllable will now be assigned a primary stress according to the ranking of ALIGNHDR-NV, TROCHEE, and FTBIN. When the candidate without primary stress incurs violations of the head alignment constraint, no candidate for the input in (141b) will satisfy all three of the top-ranked constraints, but their ranking will determine which constraint is minimally violated in the optimal output. Candidate (d) in (141b), which was formerly optimal when ALIGNHDR was used, now is harmonically-bounded by candidate (b) and thus has no chance of winning.

(141) a. Word with final heavy syllable receives primary stress

$/\sigma\sigma\sigma H/$ 1st iteration	ALHDR-NV	TROCHEE	FTBIN	HD(PWD)
→ a. $\sigma\sigma\sigma(H)$				
b. $\sigma\sigma\sigma(H)$	$W_4$			$W_1$

b. Input with final light syllable also receives primary stress

$/\sigma\sigma\sigma L/$ 1st iteration	ALHDR-NV	TROCHEE	FTBIN	HD(PWD)
→ a. $\sigma\sigma\sigma(L)$			1	
→ b. $\sigma\sigma(\sigma L)$	1			
→ c. $\sigma\sigma(\sigma L)$		1		
d. $\sigma\sigma(\sigma L)$	$W_4$			$W_1$

The three preceding examples have shown that the non-vacuous reformulations of the head alignment constraints proposed in §4.3.1 prevent non-culminativity in examples which otherwise favor vacuous satisfaction, thereby eliminating the prediction of non-uniform (non-)culminativity in each of these examples.

The final two examples of non-uniform culminativity involve the categorical primary stress constraints  $S_1$ -TO-W and NONFINHD, which are both prevented from

pathological predictions when redefined according to the schema for categorical primary stress constraints proposed in §4.3.1, repeated here as (142).

(142) Non-vacuous primary stress constraint schema

Assign a violation mark for a PwD that does not have a Hd(PwD) with property  $\pi$ .

Defining primary stress constraints like  $S_1\text{-TO-W}$  and  $\text{NONFINHD}$  by this rule curtails the pathological predictions presented in the previous section because the constraints no longer favor candidates without primary stress

Recall that regular (that is, vacuously satisfiable)  $S_1\text{-TO-W}$  predicts languages in which words with at least one heavy syllable can receive primary stress while words with only light syllables cannot. When  $S_1\text{-TO-W-NV}$  is substituted, inputs with heavy syllables are treated the same as before, mapping to outputs that are assigned primary stress as shown in (143a), but the treatment of inputs with only light syllables is different. When an input has only light syllables, as shown in (143b),  $S_1\text{-TO-W-NV}$  assigns a violation mark to both  $[('pata)kama]$  and  $*[(,pata)kama]$ . Because these candidates tie on  $S_1\text{-TO-W-NV}$ , the decision in this case falls to  $\text{HD(PWD)}$ , which decides in favor of the candidate with a primary stress,  $[('pata)kama]$ .

(143) a. Input with a heavy syllable receives primary stress

/pa:takama/ 1st iteration	$S_1\text{-TO-W-NV}$	$\text{HD(PWD)}$
→ a. ('pa:ta)kama		
b. (,pa:ta)kama	$W_1$	$W_1$

b. Input with only light syllables also receives primary stress

/patakama/ 1st iteration	$S_1\text{-TO-W-NV}$	$\text{HD(PWD)}$
→ a. ('pata)kama	1	
b. (,pata)kama	1	$W_1$

In a similar way, a non-vacuous version of NONFINHD defined according to the schema in (127) would assign violations as expressed in (144).

(144) NONFINHD-NV

Assign a violation mark to a prosodic word that does not have a head that is non-final in the prosodic word

This definition eliminates the non-uniform culminativity illustrated at the end of the previous section by ensuring that candidates with final primary stress are not assigned more violation marks on NONFINHD-NV than candidates without primary stress. This is shown in (136). In this example the winner will be determined by the ranking of NONFINHD-NV, WSP-FT, and IAMB. But since the candidate with only secondary stress, \*[H(L,L)], is harmonically bounded by a candidate with primary stress, we are in no danger of predicting non-culminativity for this input under any of the rankings. Thus, the languages produced by re-ranking these constraints all have primary stress in every word, eliminating pathological non-uniform culminativity.

(145) NONFINALITYHD-NV does not prevent assignment of primary stress

/HLL/ 1st iteration	<small>NONFINHD-NV</small>	<small>WSP-FT</small>	<small>IAMB</small>	Hd(PWD)
→ a. (H'L)L		1		
→ b. H('LL)			1	
→ c. H(LL)	1			
d. H(L,L)	1			W <sub>1</sub>

These last two examples illustrate an important point. It is not enough that a subset of primary stress constraints be redefined according to this schema, because the tie on S<sub>1</sub>-TO-W-NV in (143b) and the tie on NONFINHD-NV in (145) each need to be broken in favor of the candidate *with* primary stress, otherwise the pathology is reintroduced. The categorical schema does no more than ensure that primary-stress-less candidates have *at least* as many violations on a given constraint as

equivalent candidates with only secondary stresses, so it is important that no other violations are introduced by the assignment of primary stress. Adhering strictly to the schemata proposed in §4.3.1 will ensure this outcome.<sup>11</sup>

This section has shown that the solution to problems of non-uniform culminativity, which are a pervasive consequence of vacuously satisfiable primary stress constraints, are eliminated with the redefined non-vacuous head alignment constraints and the categorical primary stress constraint schema. It is crucial that the non-vacuous redefinitions are applied to every primary stress constraint in order to completely eliminate the systemic pathology of non-uniform culminativity. In the next section I offer some alternative solutions and demonstrate their shortcomings relative to the solution presented here.

#### **4.3.4 Unsuccessful alternatives**

##### **4.3.4.1 Eliminating candidates with only secondary stress**

With the definition of GEN we have adopted, non-uniform culminativity manifests itself as the prediction of languages with primary stress in some words but only secondary stresses in others, as detailed in the preceding sections. One perhaps obvious way of preventing this particular pathology would be to adopt a definition of GEN that *requires* primary stress to be assigned at the first iteration of stress assignment, rather than simply *allowing* this to happen as the definition of GEN I adopted in chapter 3 does. This alternative definition of GEN would result in a kind of ‘forced’ top-down parsing, unlike the ‘emergent’ top-down parsing that I proposed and adopted. Requiring primary stress to be assigned at the first iteration, along with an assumption that it cannot be later removed, would prevent

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<sup>11</sup>This is related to the general point made in chapter 3 (§3.4.3) that bottom-up derivations are rendered impossible by assuming non-vacuous primary stress constraints.

candidates with only secondary stresses from arising, and thus would prevent the particular non-uniform culminativity pathologies just presented.

However, so ubiquitous is the problem with vacuous satisfaction that this change in GEN does not actually eliminate non-uniform culminativity; it only changes the details of its appearance. If GEN is redefined to only generate primary stress candidates at the first iteration of stress assignment, then primary stress constraints that cannot be perfectly satisfied can prevent footing altogether. The result is a kind of non-uniform culminativity in which some words receive no stress because no position of primary stress placement is optimal, while other words do receive stress, perhaps even iteratively, according to the ranking of stress constraints in the language.

An example of this problem can be seen with a ranking that also produced non-uniform culminativity under our original definition of GEN. When ALIGNHDR, TROCHEE, and FTBIN all dominate HD(PWD) then only words that end in a heavy syllable will be assigned primary stress, while words with end in a light syllable will not. In §4.3.2 this ranking was shown to favor candidates with only secondary stresses when a word ended in a light syllable. But when such candidates are eliminated, a candidate without any stress at all is favored instead. This is shown in (146). The input in (146a) is assigned primary stress, but the input in (146b) is assigned no stress. At subsequent iterations the input with the final heavy, / $\sigma\sigma\sigma H$ /, will continue to be footed according to the ranking of the general stress constraints. But because the input with a final light syllable, / $\sigma\sigma\sigma L$ /, could not perfectly satisfy ALIGNHDR, TROCHEE, and FTBIN, stress assignment never commences in this word; convergence happens right away.



(146) a. Word with final heavy syllable receives primary stress

$/\sigma\sigma\sigma H/$ 1st iteration	<i>ALIGNHbR</i>	<i>TROCHEE</i>	<i>FtBIN</i>	<i>Hb(PWD)</i>	<i>PARSE-σ</i>
a. $\sigma\sigma\sigma H$				$W_1$	$W_4$
→ b. $\sigma\sigma\sigma('H)$					3
c. $\sigma\sigma(\sigma H)$	$W_1$			L	$L_2$
d. $\sigma\sigma(\sigma'H)$		$W_1$		L	$L_2$

b. Input with final light syllable remains stressless

$/\sigma\sigma\sigma L/$ 1st iteration	<i>ALIGNHdR</i>	<i>TROCHEE</i>	<i>FtBIN</i>	<i>Hd(PWD)</i>	<i>PARSE-σ</i>
→ a. $\sigma\sigma\sigma L$				1	4
b. $\sigma\sigma\sigma(L)$			$W_1$	L	$L_3$
c. $\sigma\sigma(\sigma L)$	$W_1$			L	$L_2$
d. $\sigma\sigma(\sigma'L)$		$W_1$		L	$L_2$

This example illustrates that when candidates with only secondary stresses are omitted from the candidate set vacuous satisfaction favors completely stressless candidates. Thus, when a set of high-ranked constraints prevents primary stress assignment for some inputs but not others, the result is a language in which some words have regular (possibly even iterative) stress, while other words have no stress at all. We might refer to this version of non-uniform culminativity as the ‘gateway effect’. When primary stress assignment is permitted, it acts as a gateway to further footing (if the ranking of other stress constraints favors additional footing), but when primary stress assignment is not permitted, it puts up a barrier to footing altogether under this definition of GEN.

Many examples of gateway effects are possible under other rankings and with other primary stress constraints, analogous to the multiple instantiations of non-uniform culminativity discussed in the previous section. Gateway effects can be eliminated by adopting the non-vacuous constraint schemata discussed in §4.3.3.

By substituting ALIGNHDR-NV in the above example, for instance, we get the outcome shown in (147). An input with a final heavy syllable again selects a final monosyllabic foot because it satisfies ALIGNHDR-NV, TROCHEE, and FTBIN, as in (147a). But the input with a final light syllable will surface as either one of candidates (b), (c), or (d) in (147b) below, depending on the ranking of ALIGNHDR-NV, TROCHEE, and FTBIN. The non-vacuous constraints prevent inputs from being treated disparately depending on their ability to satisfy a primary stress constraint.

(147) a. Input with final heavy syllable receives primary stress

$/\sigma\sigma\sigma H/$ 1st iteration	ALIGNHDR-NV	TROCHEE	FTBIN	Hb(PWD)	PARSE- $\sigma$
a. $\sigma\sigma\sigma H$	W <sub>4</sub>			W <sub>1</sub>	W <sub>4</sub>
→ b. $\sigma\sigma\sigma('H)$					3
c. $\sigma\sigma('σH)$	W <sub>1</sub>			L	L <sub>2</sub>
d. $\sigma\sigma(σ'H)$		W <sub>1</sub>		L	L <sub>2</sub>

b. Input with final light syllable also receives primary stress

$/\sigma\sigma\sigma L/$ 1st iteration	ALIGNHDR-NV	TROCHEE	FTBIN	Hb(PWD)	PARSE- $\sigma$
a. $\sigma\sigma\sigma L$	W <sub>4</sub>			W <sub>1</sub>	W <sub>4</sub>
→ b. $\sigma\sigma\sigma('L)$			1		3
→ c. $\sigma\sigma('σL)$	1				2
→ d. $\sigma\sigma(σ'L)$		1			2

There are certainly other general parsing constraints that can favor a candidate without any stress. Violations of at least some of ALLFTL, ALLFTR, FTBIN, IAMB, and TROCHEE, will typically be incurred during parsing, and these violations could in principle prevent footing altogether if the constraints are given their typical vacuously satisfiable definitions and are high-ranked. However, these constraints *do not* predict gateway effects. Gateway effects are a unique consequence of vacuously satisfiable primary stress constraints under this definition of GEN because

only at the first iteration of stress assignment is the presence vs. absence of primary stress compared. Thus, only at the first iteration (of stress assignment) can primary stress block footing. In contrast, general constraints like ALLFTL, ALLFTR, FTBIN, IAMB, and TROCHEE, might disfavor footing but they will do so evenly at the first iteration of footing or the last.

#### 4.3.4.2 Adopting parallel OT

The discussion of the vacuous satisfaction property of primary stress constraints and its deleterious effects on the predicted typology has thus far been framed within Harmonic Serialism, and it has been shown that these problems arise under multiple definitions of GEN. But, as I will show in this section, non-uniform culminativity as a result of vacuously satisfiable primary stress constraints is also predicted in parallel OT (Pruitt 2012). The same predictions as those discussed in §4.3.2 and §4.3.4.1 arise in parallel OT when GEN is given comparable definitions (as elaborated below).

In §4.3.2 I showed examples of non-uniform culminativity that involved primary stress in some words and only secondary stress in other words. The ‘parity pathology’ was one form of this prediction. In the parity pathology example discussed in §4.3.2, words with an even number of syllables received primary stress when the stress pattern was right-to-left trochaic and ALIGNHDL was the dominant alignment constraint, but words with an odd number of syllables did not. An even number of syllables permits exhaustive binary parsing and ensures that the leftmost syllable will be in the head of a trochaic foot; this allows primary stress to be assigned without incurring any violations of ALIGNHDL (e.g., ( $\sigma\sigma$ )( $\sigma\sigma$ )). However, words with an odd number of syllables will have an unparsed syllable when parsing is strictly binary, and a right-to-left stress pattern means that it is the initial syllable that remains unparsed. Thus, in odd-parity words there is no way to

assign primary stress without incurring at least one violation of ALIGNHD<sub>L</sub>, so it is never assigned at all (e.g.,  $\sigma_{(}\sigma\sigma)(\sigma\sigma)$ ).

The same prediction is made in parallel OT when GEN is defined to permit candidates with only secondary stresses (that is, when the definition of parallel OT's GEN is representationally identical to that of the HS GEN assumed in the discussion in §4.3.2). This can be seen in (148) below. In (148a) a four-syllable input is shown to receive primary stress because the right-to-left trochaic parse permits a stress to be perfectly left-aligned, thereby providing a foot head to be assigned primary stress without violating ALIGNHD<sub>L</sub>. And in (148b) the five syllable input in contrast cannot be given a left-aligned foot because doing so causes fatal violation of ALLFtR, which is ranked so as to enforce the right-to-left stress pattern.<sup>12</sup>

(148) a. Four syllable input receives primary stress (parallel OT)

/σσσσ/	ALIGNHD <sub>L</sub>	PARSE-σ	ALLFtR	HD(PWD)
a. σσσσ		W <sub>4</sub>	L	W <sub>1</sub>
b. (σσ)(σσ)			2	W <sub>1</sub>
→ c. (σσ)(σσ)			2	
d. (σσ)(σσ)	W <sub>2</sub>		2	

b. Five syllable input does not receive primary stress (parallel OT)

/σσσσσ/	ALIGNHD <sub>L</sub>	PARSE-σ	ALLFtR	HD(PWD)
a. σσσσσ		W <sub>5</sub>	L	1
→ b. σ(σσ)(σσ)		1	2	1
c. σ(σσ)(σσ)	W <sub>1</sub>	1	2	L
d. (σσ)(σσ)σ		1	W <sub>4</sub>	L

The other examples of non-uniform culminativity discussed in §4.3.2 are also produced in parallel OT when candidates with only secondary stresses are permitted in the candidate set.

<sup>12</sup>As with the HS example in §4.3.2, the impression from the tableaux in (148) might be that ALIGNHD<sub>L</sub> dominates ALLFtR, but since vacuous satisfaction allows both ALIGNHD<sub>L</sub> and ALLFtR to be minimally violated there is no evidence for this specific ranking. ALIGNHD<sub>L</sub> is undominated because it is never violated, so it is listed at the top of the tableaux.

If parallel OT's GEN is instead defined to *not* produce candidates with only secondary stresses, the parity pathology and similar examples do not arise. However, changing this assumption does not prevent problems altogether. Instead, non-uniform culminativity identical to the gateway effects described in §4.3.4.1 is predicted, wherein a language may have regular iterative stress in some words but no stress at all in others, on the basis of arbitrary properties of inputs.

The gateway effect example discussed for HS in §4.3.4.1 was an unattested language in which only words with a final heavy syllable received any stress at all. A final heavy permits perfect satisfaction of ALIGNHDR while TROCHEE and FTBIN are also obeyed, but a word with a final light syllable requires that FTBIN or TROCHEE be violated, or else ALIGNHDR cannot be perfectly satisfied. When these three constraints are high ranked they will favor a candidate with no stress at all for inputs with a final light syllable, but they say nothing about words with a final heavy, which are free to be parsed as normal.

This prediction occurs in parallel OT in much the same manner that it does in HS, and this is shown in (149) and (150) below. In (149), a final light syllable cannot be parsed as a trochee, iamb, or monosyllabic foot without violating at least one of ALIGNHDR, TROCHEE, or FTBIN. Because this is parallel OT we also have the option of making the final light syllable heavy, which does permit perfect satisfaction of these three constraints, but it does so at the expense of violating a faithfulness constraint (here, DEP- $\mu$ ), as illustrated by candidate (e) in (149). When DEP- $\mu$  is also high ranked there are no better options available than simply leaving the word stressless. A candidate without stress vacuously satisfies ALIGNHDR (and the other stress constraints), so it is preferred.

(149) Input with final light syllable does not receive primary stress (parallel OT)

/σσσσL/	ALIGNH <sub>b</sub> R	TROCHEE	F <sub>T</sub> BIN	DEP-μ	H <sub>b</sub> (PW <sub>D</sub> )
→ a. σσσσL					1
b. σ(,σσ)('σL)	W <sub>1</sub>				L
c. σ(σ,σ)(σ'L)		W <sub>2</sub>			L
d. (,σσ)(,σσ)('L)			W <sub>1</sub>		L
e. (,σσ)(,σσ)('H)				W <sub>1</sub>	L

Meanwhile, this ranking does not prohibit an input with a final heavy syllable from mapping to an output with stress. The final heavy allows ALIGNH<sub>b</sub>R, TROCHEE, and F<sub>T</sub>BIN to be perfectly satisfied, so primary stress assignment is possible as shown in (150). And, crucially in this example, the ability to assign a *primary* stress translates into an ability to assign other stresses as well. When ALIGNH<sub>b</sub>R can be satisfied it acts as a ‘gateway’ for further footing under this definition of GEN, just as in the HS example shown in §4.3.4.1 above.

(150) Input with final heavy syllable receives primary stress (parallel OT)

/σσσσH/	ALIGNH <sub>b</sub> R	TROCHEE	F <sub>T</sub> BIN	DEP-μ	H <sub>b</sub> (PW <sub>D</sub> )
a. σσσσH					W <sub>1</sub>
b. σ(,σσ)('σH)	W <sub>1</sub>				
c. σ(σ,σ)(σ'H)		W <sub>2</sub>			
→ d. (,σσ)(,σσ)('H)					

Thus, under two different definitions of GEN, parallel OT predicts the same kinds of problematic non-uniform culminativity that is predicted in HS with comparable GENs. But, also like HS, non-vacuous constraints appear to rescue the ty-

polology and eliminate these predictions.<sup>13</sup> As shown in (151), substituting ALIGN-HdL-NV for ALIGNHdL eliminates the parity pathology by ensuring that the candidate with only secondary stress no longer escapes violation of the primary stress alignment constraint. Thus, vacuous satisfaction is not possible.

(151) a. Four syllable input receives a primary stress (parallel OT)

/σσσσ/	ALHdL-NV	PARSE-σ	ALLfTR
a. σσσσ	W <sub>4</sub>	W <sub>4</sub>	L
b. (,σσ)(,σσ)	W <sub>4</sub>		2
→ c. ('σσ)(,σσ)			2
d. (,σσ)('σσ)	W <sub>2</sub>		2

b. Five syllable input also receives a primary stress (parallel OT)

/σσσσσ/	ALHdL-NV	PARSE-σ	ALLfTR
a. σσσσσ	W <sub>5</sub>	W <sub>5</sub>	L
b. σ(,σσ)(,σσ)	W <sub>5</sub>	1	L <sub>2</sub>
c. σ('σσ)(,σσ)	W <sub>1</sub>	1	L <sub>2</sub>
→ d. ('σσ)σ(,σσ)		1	3

And similarly, non-vacuous constraints also eliminate the parallel OT version of the gateway effect. As the tableau in (152) shows, an input with a final light syllable will no longer map to an output without any stress at all because the stressless candidate no longer vacuously satisfies the primary stress alignment constraint. Which of the candidates in (b)-(e) wins will depend on the ranking of these constraints, but candidate (a) is no longer favored.

(152) Input with final light syllable receives primary stress (parallel OT)

/σσσσL/	ALHdR-NV	TROCHEE	FTBIN	DEP-μ
a. σσσσL	W <sub>5</sub>			
→ b. σ(,σσ)('σL)	1			
→ c. σ(σ,σ)(σ'L)		2		
→ d. (,σσ)(,σσ)('L)			1	
→ e. (,σσ)(,σσ)('H)				1

<sup>13</sup>This is not the whole story, as the relatively unconstrained candidate set of parallel OT will generally make it possible to find a candidate that permits vacuous satisfaction on some level (e.g., by not having a prosodic word at all). This point is addressed in §4.3.5.

It would seem that parallel OT and HS are more or less equivalent in their vulnerability to the pathological predictions of vacuously satisfiable primary stress constraints. We have seen that several definitions of HS's GEN and comparable definitions of parallel OT's GEN predict the same erroneous typologies with non-uniform culminativity, and that the non-vacuous redefinition of primary stress constraints is a general solution in all cases. This suggests more than any single example could that the typical vacuously satisfiable definitions of primary stress constraints are the locus of this problem.

#### 4.3.5 The role of candidate sets

A difficulty in preventing pathological predictions that derive from vacuous satisfaction is that, at some level, all markedness constraints may be vacuously satisfied. When a constraint demands the well-formedness of some structure, it follows that any candidate *without* that structure can incur no violations, and thus will satisfy the constraint vacuously. We have seen that constraints that place demands on the primary stress can favor outputs without primary stress when those demands cannot be met due to other high-ranking constraints. The solution put forward in this chapter relies in part on changing the locus of primary stress constraint definitions from the primary stress itself to the prosodic word in which the primary stress resides. While a regular primary stress constraint might demand that the primary stress have property  $\pi$ , the 'non-vacuous' constraints demand instead that every prosodic word have a primary stress with property  $\pi$ .

In the examples that were used to illustrate, this strategy was successful because every candidate was assumed to be a prosodic word. However, if candidates that are not prosodic words are available, then even the 'non-vacuous' constraints could be vacuously satisfied easily by any such candidate. What this means for the present discussion is that any solution to problems caused by vacuous satisfaction



cannot be built into CON alone, but must also rely on restrictions to GEN to prevent a regression to no structure at all as a recourse to otherwise imperfect structures.

The restricted GEN of HS has an advantage over the non-restricted GEN of parallel OT on this point. In parallel OT, a non-PWd candidate is assumed to be always available, meaning that vacuous satisfaction is technically *always* possible at some level. But in HS this is not necessarily the case. If we assume that inputs enter a derivation as non-PWds, and that they must become PWds in a step prior to the assignment of stress, then it is ensured that all candidates will be PWds by the time primary stress assignment is a licit operation. Because the assignment of PWd-hood happens in a separate iteration from the assignment of primary stress, the relative markedness of a primary stress is irrelevant to the decision to make an input a PWd, and this guarantees the success of the non-vacuous constraints for preventing non-uniform culminativity.<sup>14</sup>

#### 4.4 Chapter summary and conclusion

This chapter has addressed two issues that arise in the consideration of primary stress constraints in Harmonic Serialism. In §4.2 I showed evidence that we may need primary stress alignment constraints that refer to the primary stress syllable and to the primary stress foot, and I argued that an alternative formulation of primary stress alignment, ENDRULE, was not sufficient to account for primary stress location, particularly in languages with autonomous primary stress. In §4.3 I showed the problematic typological predictions that are made when primary stress constraints can be vacuously satisfied. Although many prosodic struc-

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<sup>14</sup>Since the non-vacuous constraints, particularly the categorical ones, generally reference the prosodic word, making an input a prosodic word will introduce violations of all of these constraints. If they are high-ranked then of course they may serve to block the creation of the prosodic word, but they will do so uniformly for all inputs or none, much like general constraints with this property (e.g., PARSE- $\sigma$ ), and thus are not in danger of predicting non-uniform culminativity.

ture (and other kinds of) markedness constraints can be vacuously satisfied, the reason primary stress constraints cause a particular problem is that permitting vacuous satisfaction simply does not correspond to how the constraints are known to enforce their preferences cross-linguistically—primary stress markedness constraints should determine *where* primary stress is assigned, but not *whether* it is. The proposed schemata for redefining primary stress constraints, combined with the properties of GEN in HS, successfully eliminates the prediction of non-uniform culminativity, consistent with attested typology.

## CHAPTER 5

### DIRECT AND INDIRECT REFERENCE TO RHYTHM

#### 5.1 Introduction

The notion that stress is the linguistic manifestation of rhythm lies at the heart of most work in metrical theory and was particularly prominent in early proposals for articulated metrical representations, which attempted to make this connection explicit (Lieberman 1975, Lieberman and Prince 1977, Prince 1983, Selkirk 1984, and others). Those metrical representations generally consisted either of trees, which model the relative prominence of syllables with nested asymmetric binary constituents (one branch strong, the other weak), and/or grids, which provide a direct representation of relative prominence with alternating strong and weak beats, possibly at multiple levels (“hierarchies of intersecting periodicities” Lieberman and Prince 1977:313, 333). A further development within tree theory introduced the notion of the metrical foot, which gave privileged status to the constituent grouping of syllables (Hayes 1980, Selkirk 1980), and eventually the foot was adopted in many grid theories as well (Hammond 1984, Halle and Vergnaud 1987, Hayes 1995).

Although most languages do not show invariant rhythmic alternation, many with iterative quantity-insensitive stress do—in Gordon’s (2002) survey of quantity-insensitive stress patterns, two-thirds of the languages with iterative stress display an alternating pattern in which every other syllable receives stress.<sup>1</sup>

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<sup>1</sup>Gordon’s survey—which uses “a combination of grammars and existing typologies of quantity-insensitive stress, including those in works by Hyman (1977), Hayes (1980, 1995), and Halle and

It is unsurprising then that strictly alternating stress patterns have been influential in the representations, rules, and constraints proposed in metrical theory. Pure grid theories motivate alternating, or rhythmic, stress more or less directly, by assuming that some configurations of stressed and unstressed syllables (or, peaks and troughs) are preferred over others (e.g., Prince's 1983 "perfect grid"). Foot-based theories, on the other hand, represent alternating rhythm indirectly, by assuming that the unmarked foot is a binary constituent consisting of a stressed syllable and an unstressed syllable (with their order determined by parameter setting) and that stress rules or constraints group syllables into such constituents contiguously in a directional sweep of the word. In theories that use both grids and feet, it is typically the foot that is responsible for rhythmic alternation, but grid marks are also made available to rules/constraints, which may reference rhythmic notions like clash (adjacent stresses).

In Optimality Theory, metrical proposals have generally been made with a similar range of representational assumptions. Some have proposed that constraints controlling the stress pattern of a word refer to constituents/feet (e.g., Prince and Smolensky 1993/2004, McCarthy and Prince 1993a,b). Others have proposed that stress can be controlled exclusively by constraints that reference configurations of stressed and unstressed syllables themselves (e.g., Gordon 2002). And still others assume that both kinds of constraints—those referring to constituents and those referring to stress peaks and troughs directly—are present and active in accounting for rhythmic stress patterns (e.g., Kager 2001, Alber 2005).<sup>2</sup>

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Vergnaud (1987)" (Gordon 2002:493)—includes 262 languages, and of these, 205 show one or two fixed stresses per word (Gordon 2002:495). Of the remaining 57 languages, 38 (that is, 66.7%) show a simple alternating stress pattern (Gordon 2002:522).

<sup>2</sup>The issue of metrical representations has received less direct discussion in OT as compared to rule-based metrical theory, but representational assumptions are just as fundamental to an OT theory of stress. In OT (both parallel and serial), we can think of representational assumptions as being distributed between GEN and CON. Representations are an important part of determining

Although this suggests that rule-based derivational theories and constraint-based parallel OT have similar options for the representation of alternating stress patterns, HS diverges from both in interesting ways. The purpose of this chapter is to investigate the formal relationships among metrical representations, constraints, and the architecture of the grammar, with the goal of characterizing how these different elements interact with each other. To do this, I will narrowly focus on purely alternating stress and consider the consequences of two different ways of deriving such patterns in HS—with feet and without feet. The constraints needed to account for simple alternating patterns under each set of representational assumptions make different predictions about what other stress patterns may look like, and these predictions can be used to favor one set of representational assumptions over another. A consideration of different representational assumptions also illuminates differences between serialism and parallelism on the one hand, and between rule-based and constraint-based theories of stress on the other. The primary conclusion of this chapter will be that foot-based metrical representations are the best way to model stress in HS, as grid-based representations and corresponding constraints predict a proliferation of unattested stress patterns.

The focus here will be on deriving purely rhythmic stress in HS; I will thus limit my attention to deriving the sub-class of iterative stress systems that illustrate quantity-insensitive binary alternation. I will also set aside the position of main stress (for which, see chapters 3 and 4). When main stress is not considered, there are four possible strictly-alternating stress patterns, which are illustrated in Table 5.1 along with an example of a language which instantiates each pattern (Prince 1983, Hayes 1995, Gordon 2002, and others). The goal, then, is to derive the patterns in Table 5.1 under different representational assumptions (with feet

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the candidate set, though beyond this function a particular representational assumption is made formally meaningful when some constraint refers to it.

Pattern	Description	Example language
$\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$	Odd-numbered syllables from left	Maranungku (Tryon 1970)
$\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$	Even-numbered syllables from left	Araucanian (Echeverría and Contreras 1965)
$\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$	Odd-numbered syllables from right	Urubu-Kaapor (Kakumasu 1986)
$\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$	Even-numbered syllables from right	Cavineja (Key 1968)

**Table 5.1.** Simple binary stress patterns

in §5.2 and without feet in §5.3) and to assess the consequences of each in terms of their typological predictions.

## 5.2 Quantity-insensitive metrical parsing with feet

This section is devoted to discussing some consequences of using foot-based representations and standard parsing constraints, which together constitute indirect reference to rhythm, to account for alternating stress in HS and in parallel OT. Controlling rhythm indirectly through constituent representations, with constraints that refer to the constituents themselves rather than to the rhythm that arises from them, leads to a certain amount of non-rhythmicity predicted in both HS and parallel OT, though it also reveals some interesting differences between the two frameworks. In §5.2.1 I discuss the derivation of alternating patterns with feet in HS and the typological predictions thereof; in §5.2.2 I compare these results to parallel OT, where alignment constraints behave somewhat differently in their treatment of monosyllabic feet in particular; §5.2.3 presents a brief defense

of using gradient alignment constraints in HS, despite their unsavory reputation (e.g., McCarthy 2003); and §5.2.4 concludes this section.

### 5.2.1 Deriving binary patterns

With foot-based representations, the four simple patterns in Table 5.1 correspond to the footings in (153). Stressing odd-numbered syllables counting from the left or even-numbered syllables counting from the right requires trochaic feet, ( $\acute{\sigma}\sigma$ ), while even-numbered syllables from the left or odd-numbered syllables from the right use iambs, ( $\sigma\acute{\sigma}$ ). The patterns that stress odd-numbered syllables from either the left or the right also require a monosyllabic foot, ( $\acute{\sigma}$ ), at the ‘end’ of the parse to maintain alternation (in a word with an odd number of syllables), while those that begin with even-numbered syllables from either edge do not.

(153) Alternating patterns represented with feet

a. Odd from left  $\approx$  L $\rightarrow$ R trochees (with ( $\acute{\sigma}$ ))

( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )    ( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )( $\acute{\sigma}$ )

b. Even from left  $\approx$  L $\rightarrow$ R iambs

( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )    ( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ ) $\sigma$

c. Odd from right  $\approx$  R $\rightarrow$ L iambs (with ( $\acute{\sigma}$ ))

( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )    ( $\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )( $\sigma\acute{\sigma}$ )

d. Even from right  $\approx$  R $\rightarrow$ L trochees

( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )     $\sigma$ ( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )( $\acute{\sigma}\sigma$ )

Deriving these patterns in HS is relatively straightforward with the standard constraints we have been using throughout, principally, *PARSE- $\sigma$* , *ALLFTL*, *ALLFT-R*, *TROCHEE*, *IAMB*, and *FTBIN* (Prince and Smolensky 1993/2004, McCarthy and Prince 1993a, Kager 1999). *PARSE- $\sigma$*  motivates parsing by assigning violation marks to syllables not parsed into feet; *ALLFTL* and *ALLFTR* favor left-aligning

or right-aligning feet, respectively; TROCHEE and IAMB dictate that disyllabic feet should be left-headed or right-headed, respectively; and FTBIN disfavors monosyllabic feet.<sup>3</sup>

The ranking  $\text{PARSE-}\sigma \gg \text{ALLFTL} \gg \text{ALLFTR}$  achieves an iterative left-to-right pattern, while an iterative right-to-left pattern uses the ranking  $\text{PARSE-}\sigma \gg \text{ALLFTR} \gg \text{ALLFTL}$ .  $\text{PARSE-}\sigma$  must dominate both foot alignment constraints for iterative patterns because multiple feet necessarily entail violations of foot alignment in multisyllabic words under the standard definitions (McCarthy and Prince 1993a). The relative ranking of TROCHEE and IAMB determines whether feet are left-headed or right-headed;  $\text{PARSE-}\sigma$  must also dominate the lower-ranked foot-headedness constraint since not parsing at all (or parsing into monosyllabic feet) would satisfy both IAMB and TROCHEE but perform comparatively worse on  $\text{PARSE-}\sigma$ . Finally, the relative ranking of  $\text{PARSE-}\sigma$  and FTBIN governs whether monosyllabic feet are permitted. The summary rankings required for each of the alternating patterns in HS are shown as Hasse diagrams in (154).<sup>4</sup>

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<sup>3</sup>FTBIN can be satisfied by a monosyllabic foot when the syllable is heavy, but since the issue of syllable weight is being set aside in this chapter all syllables can effectively be considered light for now.

<sup>4</sup>The rankings required for these same patterns in parallel OT are somewhat different; this is discussed in §5.2.2 below.



(154) Rankings required for alternating patterns with feet in HS

Pattern	Ranking
<p>a. Odd from left, L→R trochees + (ó)</p> <p>(óσ)(óσ)(óσ)    (óσ)(óσ)(óσ)(ó)</p>	<pre> graph TD     P[PARSE-σ] --&gt; FTBIN     P --&gt; TROCHEE     FTBIN --&gt; ALLFTL     ALLFTL --&gt; ALLFTR     TROCHEE --&gt; IAMB     </pre>
<p>b. Even from left, L→R iambs</p> <p>(σó)(σó)(σó)    (σó)(σó)(σó)σ</p>	<pre> graph TD     P[PARSE-σ] --&gt; FTBIN     P --&gt; TROCHEE     FTBIN --&gt; ALLFTL     ALLFTL --&gt; ALLFTR     TROCHEE --&gt; IAMB     </pre>
<p>c. Odd from right, R→L iambs + (ó)</p> <p>(σó)(σó)(σó)    (ó)(σó)(σó)(σó)</p>	<pre> graph TD     P[PARSE-σ] --&gt; FTBIN     P --&gt; IAMB     FTBIN --&gt; ALLFTR     ALLFTR --&gt; ALLFTL     IAMB --&gt; TROCHEE     </pre>
<p>d. Even from right, R→L trochees</p> <p>(óσ)(óσ)(óσ)    σ(óσ)(óσ)(óσ)</p>	<pre> graph TD     P[PARSE-σ] --&gt; FTBIN     P --&gt; TROCHEE     FTBIN --&gt; ALLFTR     ALLFTR --&gt; ALLFTL     TROCHEE --&gt; IAMB     </pre>

The tableau in (155) shows how a left-to-right trochaic stress pattern is derived in HS for a five-syllable word under the stated ranking in (154a). The mirror image right-to-left iambic pattern is derived similarly with the ranking in (154c). The patterns without (ó) differ in that convergence happens at the third iteration because adding an additional foot does not improve harmony.

(155) Derivation of L→R trochaic (odd from left) stress pattern

<i>/σσσσσ/ 1st iteration</i>	<i>TROCHEE</i>	<i>PARSE-σ</i>	<i>FTBIN</i>	<i>ALLFTL</i>	<i>LAMB</i>	<i>ALLFTR</i>
a. σσσσσ		W <sub>5</sub>			L	L
← b. (óσ)σσσ		3			1	3
c. (σó)σσσ	W <sub>1</sub>	3			L	3
d. (ó)σσσσ		W <sub>4</sub>	W <sub>1</sub>		L	W <sub>4</sub>
e. σσσ(óσ)		3		W <sub>3</sub>	1	L
→ 2nd iteration						
f. (óσ)σσσ		W <sub>3</sub>		L	L <sub>1</sub>	L <sub>3</sub>
← g. (óσ)(óσ)σ		1		2	2	4
h. (óσ)(σó)σ	W <sub>1</sub>	1		2	L <sub>1</sub>	4
i. (óσ)(ó)σσ		W <sub>2</sub>	W <sub>1</sub>	2	L <sub>1</sub>	W <sub>5</sub>
j. (óσ)σ(óσ)		1		W <sub>3</sub>	2	L <sub>3</sub>
→ 3rd iteration						
k. (óσ)(óσ)σ		W <sub>1</sub>	L	L <sub>2</sub>	2	4
← l. (óσ)(óσ)(ó)			1	6	2	4
(Convergence step not shown)						
→ <b>Output:</b> [(óσ)(óσ)(ó)]						

The sense in which constituent representations are an ‘indirect’ representation of rhythm can be seen particularly in the treatment of monosyllabic feet with these constraints. *PARSE-σ* favors parsing syllables into feet, and when only one syllable is left over at the end of a metrical parse, it will be parsed into a monosyllabic foot if *PARSE-σ* dominates *FTBIN*; if the reverse ranking holds then the syllable will be left unparsed. However, this ranking is independent of the other rankings, and the presence vs. absence of monosyllabic feet is not predicted to be correlated with any other descriptive parameter (i.e., foot headedness or directionality). From the independence of these constraints and their rankings in the hierarchies above, we can already see that nothing guarantees that monosyllabic feet will be chosen just when doing so maintains alternating rhythm. Although some rankings produce this effect, other rankings do not.

This point is confirmed when we look at the factorial typology of this constraint set in HS. The typological predictions of this constraint set were calculated using the computational tools discussed in chapter 1 (§1.4.2), primarily OT-Help 2.0 (OTH2; Staubs, *et al.* 2010). Just two inputs were used—a word with six syllables and a word with seven syllables—as limiting the focus in this way allows us to concentrate on the different iterative/alternating patterns possible with these constraints. I assume an operation that builds feet of the form ( $\acute{\sigma}\sigma$ ), ( $\sigma\acute{\sigma}$ ), or ( $\acute{\sigma}$ ).

The predicted typology in HS with these constraints includes 16 unique languages (out of 17 total).<sup>5</sup> Of these, seven are non-iterative and therefore non-rhythmic.<sup>6</sup> The remaining nine languages show iterative patterns, which are listed in (156). The first four are the same alternating patterns from Table 5.1 from above, while the last five are variations on these patterns that do not maintain strict alternation of stress.

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<sup>5</sup>In this context uniqueness is determined relative to the output *metrical structure* and it collapses languages that achieve the same outputs with different derivational paths. This means that the typology calculation produced 17 distinct sets of derivations, but one of these was found to have the same set of (final) outputs as another language in the typology. Unless otherwise noted, uniqueness in this context does not collapse languages that simply share the same *stress pattern* unless they are also completely identical with respect to their foot structure (this dissociation occurs precisely because using feet to represent stress patterns is an *indirect* way of describing them).

<sup>6</sup>The non-iterative patterns include one language with no stress, two languages with initial stress (left-aligned ( $\acute{\sigma}$ ) or ( $\acute{\sigma}\sigma$ )), one with peninitial (left-aligned ( $\sigma\acute{\sigma}$ )), two with final (right-aligned ( $\acute{\sigma}$ ) or ( $\sigma\acute{\sigma}$ )), and one with penultimate (right-aligned ( $\acute{\sigma}\sigma$ )). The language with no stress is predicted because any metrical structure violates some stress markedness constraint(s), and PARSE- $\sigma$ —the only stress-favoring constraint among those used in this typology—can be ranked low. In general, this prediction holds in any theory as long as a stressless candidate is considered and as long as metrical structure markedness constraints are vacuously satisfied when no metrical structure is present.

## (156) Iterative stress patterns predicted by standard constraints in HS

6σ (even) 7σ (odd)	Description
<i>Alternating patterns</i>	
1 (óσ)(óσ)(óσ) (óσ)(óσ)(óσ)(ó)	Odd from left, L→R trochees + (ó)
2 (σó)(σó)(σó) (σó)(σó)(σó)σ	Even from left, L→R iambs
3 (σó)(σó)(σó) (ó)(σó)(σó)(σó)	Odd from right, R→L iambs + (ó)
4 (óσ)(óσ)(óσ) σ(óσ)(óσ)(óσ)	Even from right, R→L trochees
<i>Non-strictly-alternating patterns</i>	
5 (óσ)(óσ)(óσ) (óσ)(óσ)(óσ)σ	Odd from left no final, L→R trochees
6 (σó)(σó)(σó) (σó)(σó)(σó)(ó)	Even from left + final, L→R iambs + (ó)
7 (σó)(σó)(σó) σ(σó)(σó)(σó)	Odd from right no initial, R→L iambs
8 (óσ)(óσ)(óσ) (ó)(óσ)(óσ)(óσ)	Even from right + initial, R→L trochees + (ó)
9 <sup>7</sup> (ó)(ó)(ó)(ó)(ó)(ó) (ó)(ó)(ó)(ó)(ó)(ó)(ó)	Every syllable stressed, R→L or L→R (ó)

Languages 5-8 display the primary consequence of treating the allowance of a monosyllabic foot as orthogonal to parsing direction and foot-headedness, as allowed by the indirect reference to rhythm assumed here. For each alternating pattern that requires (ó), there also exists in the predicted typology a pattern without (ó) because FTBIN dominates PARSE-σ. And conversely, for each alternating pattern that does not use (ó), there exists in the typology a counterpart that favors an (ó) because PARSE-σ dominates FTBIN.

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<sup>7</sup>Two different derivations produce this set of outputs.

The effective parameterization of monosyllabic feet, independent of other aspects of the stress pattern, receives partial support from attested stress systems. Language 5 is a common stress pattern, and is instantiated for example in Pintupi (Hansen and Hansen 1969, 1978), which was analyzed in chapter 1. Language 6 is not attested as a quantity-insensitive stress pattern, but according to Gordon (2002) this pattern exists phrase-medially in quantity-sensitive Central Alaskan Yupik.<sup>8</sup> Language 8 is attested (also according to Gordon 2002) in Biangai (Dubert and Dubert 1973). On the other hand, language 7, a right-to-left iambic language with no monosyllabic feet, is generally regarded as unattested. This suggests, as many have previously noted, a lack of symmetry in quantity-insensitive stress typology, which is unaccounted for by treating monosyllabic feet as an independent choice (see, among others, Hyde 2001, Gordon 2002, Kager 2001, McCarthy 2003, for further discussion of this gap).

Finally, language 9 in (156) arises when both *IAMB* and *TROCHEE* are high-ranked, because a monosyllabic foot is the only foot that satisfies both foot-headedness constraints under the current definitions. No language has been described with this kind of stress pattern. Other definitions of *TROCHEE* and *IAMB* are certainly possible and could be used to get rid of this prediction. These are not pursued further here, however, because fine-tuning the definitions of *TROCHEE* and *IAMB* will need to be carried out with quantity-sensitive languages in mind, something I have set aside for this chapter.<sup>9</sup>

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<sup>8</sup>However, other secondary sources on Central Alaskan Yupik (Hayes 1995, Goedemans and van der Hulst 2011) give the stress pattern as left-to-right iambic with no final stress.

<sup>9</sup>It might be possible to argue that the pattern in language 9 is formally equivalent to a language with no stress (or, no secondary stress), since the realization of the category ‘stressed’ must be defined relative to ‘unstressed’, yet no unstressed syllables exist in the language for comparison. Nonetheless, with a broader constraint set this same behavior of *IAMB* and *TROCHEE* will arise with less uniform consequences (e.g., the addition of *NONFINALITY* predicts a language with this pattern: (acute)(acute)(acute)(acute)(acute)σ), suggesting that alternative definitions of the foot-headedness constraints may ultimately be preferable.

The constraints used in this section are obviously an incomplete theory. Although they account for alternating patterns, some predicted languages are not attested and some attested iterative quantity-insensitive languages are not predicted (e.g., those with bidirectional stress patterns). However, the goal here is primarily to compare frameworks, with representational assumptions held constant. This comparison can be accomplished by varying this theory slightly, and thus, grappling with the multiple ways in which the standard constraints are typologically insufficient (in both HS and in parallel OT) is left to another occasion.

The next section compares these results to those of parallel OT and highlights a difference between the two frameworks in terms of their treatment of monosyllabic feet.

### 5.2.2 Monosyllabic feet in rhythm and typology

The 16 languages (7 non-iterative + 9 iterative) predicted in HS with the standard parsing constraints and representations are also predicted in parallel OT with the same assumptions, although the rankings that produce each pattern are not necessarily the same in the two frameworks. This difference arises because the *location* of a monosyllabic foot within an otherwise-binary quantity-insensitive stress pattern is determined differently in parallel OT and HS. With this small constraint set this difference has no consequences for the predicted typology, but it is nonetheless valuable to understand the difference, as its effects can be seen more readily when other assumptions are varied.

With the exception of cases like language 9 in (156) above where constraints conspire to explicitly prefer monosyllabic feet, in HS a monosyllabic foot can generally only arise at the ‘end’ of a metrical parse (and typically only in words with an odd number of syllables). Before the end of the parse has been reached a disyllabic foot is generally available, and this will be chosen over a monosyllabic

foot for its better satisfaction of  $\text{PARSE-}\sigma$ , other things being equal. In parallel OT, however, there is no derivation and therefore no concept of the ‘end’ of a metrical parse. Instead, foot alignment constraints in parallel OT are primarily responsible for determining the location of all feet, monosyllabic included (again, other things being equal). Although this does not affect the typological predictions just presented, this difference *can* have typological consequences when other assumptions are varied, as this section will show. The locus of the difference lies in part in the different behavior of alignment constraints when evaluation is serial vs. parallel, so I begin by reviewing the role of these constraints in determining directionality in parallel OT and HS.

Thus far I have employed gradient foot alignment constraints to govern directionality (McCarthy and Prince 1993a). They determine violation marks for candidates by adding the number syllables separating each foot from the left or right edge of the word. The definition of these constraints is repeated in (157). These constraints were proposed by McCarthy and Prince (1993a) as part of a family of constraints that govern the alignment of prosodic and morphological elements with one another (“generalized alignment”).

(157) a. **ALLFtL**

For each foot in a word assign one violation mark for every syllable separating it from the left edge of the word

b. **ALLFtR**

For each foot in a word assign one violation mark for every syllable separating it from the right edge of the word

In parallel OT these constraints simulate parsing directionality even though feet are not actually built in an iterative, directional fashion. These constraints prefer feet to gravitate toward one edge of the word or the other. Thus, directionality is an emergent property of stress systems, rather than a description of how

those patterns are constructed. These constraints achieve this by stating that *all* feet in a word should be aligned to the left/right edge of the word in order to escape violation. Obviously, this requirement cannot be perfectly met in a word with more than one foot, but the constraints evaluate gradiently, meaning that fewer violation marks are assessed the closer a foot is to the specified word edge, and the marks for each foot are added together. This, combined with minimal violation (McCarthy 2002:134ff), means that foot alignment constraints are generally successful in favoring candidates that look as though they were built by directional iteration of foot-building, as schematized in (158).

- (158) a. Iterative parsing when ALLFTL » ALLFTR:  $(\sigma\sigma)(\sigma\sigma)(\sigma\sigma)\sigma$   
 b. Iterative parsing when ALLFTR » ALLFTL:  $\sigma(\sigma\sigma)(\sigma\sigma)(\sigma\sigma)$

The story is similar in HS, in that directionality is again not parametrically specified, but arises from constraints and ranking. As in parallel OT, alignment constraints in HS assign a number of violation marks to each foot based on how far away from the word edge it is, and the violation marks for the feet are added up to determine the number of violation marks that are assigned to a candidate. A conceptual difference is that in HS, each candidate differs from the input by the addition of at most one foot. Thus, mark cancellation will generally mean that the only relevant violations are those of a new foot, all else being equal.<sup>10</sup> An interesting consequence of this difference arises when monosyllabic feet are allowed, as this creates non-intuitive behavior for alignment constraints in parallel OT, though not in HS.

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<sup>10</sup>“All else being equal” is, of course, an important caveat here. If segment deletion and/or epenthesis can happen in one step and can lead to immediate resyllabification, for example, then it is possible for candidates derived from either of these processes to show a different number of violations on alignment constraints, and “all else” would not be “equal” for mark cancellation. Thus, it is intuitively useful to think of only newly-added feet incurring relevant violation marks on alignment constraints, but it is not a formal statement of how the constraints work in HS.



In HS, under the ranking ALLFTL » ALLFTR, left-to-right footing emerges, and vice versa for ALLFTR » ALLFTL, regardless of whether monosyllabic feet are allowed. The derivation in (159) shows that ALLFTL » ALLFTR produces (σσ)(σσ)σ, which has left-to-right parsing, when monosyllabic feet are prohibited, while the derivation in (160) shows that the same ranking of the alignment constraints produces (σσ)(σσ)(σ), also with left-to-right parsing, when monosyllabic feet are allowed. The effect of left-to-right foot parsing emerges in HS with the ranking ALLFTL » ALLFTR regardless of whether monosyllabic feet are allowed (and vice versa for ALLFTR » ALLFTL). This is the expected behavior of these constraints.

(159) ALLFTL » ALLFTR, monosyllabic feet prohibited

	/σσσσσ/ 1st iteration	FTBIN	PARSE-σ	ALLFTL	ALLFTR
a.	σσσσσ		W <sub>5</sub>		L
← b.	(σσ)σσσ		3		3
c.	σ(σσ)σσ		3	W <sub>1</sub>	L <sub>2</sub>
→	<b>2nd iteration</b>				
d.	(σσ)σσσ		W <sub>3</sub>	L	L <sub>3</sub>
← e.	(σσ)(σσ)σ		1	2	4
f.	(σσ)σ(σσ)		1	W <sub>3</sub>	L <sub>3</sub>
→	<b>3rd iteration</b>				
← g.	(σσ)(σσ)σ		1	2	4
h.	(σσ)(σσ)(σ)	W <sub>1</sub>	L	W <sub>6</sub>	4
→	<b>Output: [(σσ)(σσ)σ]</b>				

(160) ALLFtL » ALLFtR, monosyllabic feet allowed

	/σσσσσ/ 1st iteration	PARSE-σ	FTBIN	ALLFtL	ALLFtR
	a. σσσσσ	W <sub>5</sub>			L
←	b. (σσ)σσσ	3			3
	c. σ(σσ)σσ	3		W <sub>1</sub>	L <sub>2</sub>
→	<b>2nd iteration</b>				
	d. (σσ)σσσ	W <sub>3</sub>		L	L <sub>3</sub>
←	e. (σσ)(σσ)σ	1		2	4
	f. (σσ)σ(σσ)	1		W <sub>3</sub>	L <sub>3</sub>
→	<b>3rd iteration</b>				
	g. (σσ)(σσ)σ	W <sub>1</sub>	L	L <sub>2</sub>	4
←	h. (σσ)(σσ)(σ)		1	6	4
	(Convergence step not shown)				
→	<b>Output:</b> [(σσ)(σσ)(σ)]				

This makes sense because monosyllabic feet in quantity-insensitive stress patterns can be seen as a kind of last resort. Such feet are never the only kind of foot allowed in a language, but instead arise under duress—generally at the end of a parse in an odd-parity word when the choice is either to create a monosyllabic foot or not parse the syllable. Languages that allow monosyllabic feet in such contexts nonetheless prefer to build canonical disyllabic feet when possible, presumably in order to maintain rhythmic alternation.

The situation is different in parallel OT. Crowhurst and Hewitt (1995a) observe that in parallel OT the apparent parsing directionality that emerges in a language when monosyllabic feet are allowed requires a ranking of ALLFtL and ALLFtR opposite from what we would expect based on (158). The violation mark assessment leading to this consequence is illustrated in Table 5.2; when ALLFtL outranks ALLFtR for example, the candidate with (what looks like) left-to-right parsing is favored if monosyllabic feet are prohibited (candidate (a) in Table 5.2), but the candidate with (what looks like) right-to-left parsing is favored if monosyllabic feet are allowed (candidate (d) in Table 5.2). Similarly, the apparent left-to-right parse in (a), with no monosyllabic foot, requires the ranking ALLFtL » ALLFtR, while

		Apparent direction	ALLFTL marks		ALLFTR marks
Monosyllabic feet prohibited	a. $(\sigma\sigma)(\sigma\sigma)\sigma$	L→R	$0 + 2 = \boxed{2}$	<	$1 + 3 = \boxed{4}$
	b. $\sigma(\sigma\sigma)(\sigma\sigma)$	R→L	$1 + 3 = \boxed{4}$	>	$0 + 2 = \boxed{2}$
Monosyllabic feet allowed	c. $(\sigma\sigma)(\sigma\sigma)(\sigma)$	L→R	$0 + 2 + 4 = \boxed{6}$	>	$0 + 1 + 3 = \boxed{4}$
	d. $(\sigma)(\sigma\sigma)(\sigma\sigma)$	R→L	$0 + 1 + 3 = \boxed{4}$	<	$0 + 2 + 4 = \boxed{6}$

**Table 5.2.** Foot alignment and monosyllabic feet

the apparent left-to-right parse in (c), with a monosyllabic foot, would require the opposite ranking.

This reversal is unexpected from the point of view of directional parsing, which treats  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma\sigma)(\sigma\sigma)(\sigma)$  as a class, as both are the result of starting with foot-building at the left and iterating rightward. The gradient foot alignment constraints in parallel OT instead treat  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma)(\sigma\sigma)(\sigma\sigma)$  as a class, because both are derived from the same ranking of the alignment constraints, ALLFTL » ALLFTR.

In other words, in parallel OT the ranking of ALLFTL and ALLFTR interacts with the ranking of PARSE- $\sigma$  and FTBIN and obscures simple generalizations about sub-rankings. Unlike in HS, the directionality ranking in parallel OT is not orthogonal to the monosyllabic foot ranking, at least if we would like to continue referring to a parse like  $(\sigma\sigma)(\sigma\sigma)(\sigma)$  as “left-to-right” and  $(\sigma)(\sigma\sigma)(\sigma\sigma)$  as “right-to-left”.

Despite the fact that parallel OT patterns differently from HS (and from rule-based directional parsing) in what languages it groups together by parsing ‘direction’, it may not be immediately clear whether this property of alignment in parallel OT has unwanted consequences. If the status of monosyllabic feet is constant

in a language (i.e., monosyllables are always or never licit feet) and the apparent directionality is constant, then the alignment constraints correctly describe stress patterns with monosyllabic feet, albeit with a different ranking than we might have initially thought. In addition, the same set of languages is predicted by this set of constraints in both HS and in parallel OT, so at least under very simple assumptions, this difference has no consequences for the predicted typology at all.

However, there are other reasons to think that this consequence of foot alignment in parallel OT is indeed undesirable. In a language that does not uniformly allow monosyllables to be licit feet, we would predict that directionality could vary among words. For example, in generalized trochee languages like Wergaia and Estonian (chapter 2), parsing is largely quantity-insensitive, but rhythmic alternation may be maintained by building a monosyllabic foot on a *final* syllable if and only if that syllable is heavy. Thus, some words in Wergaia have monosyllabic feet (e.g., (búna)(dùg) ‘broad-leaved mallee’) while others do not (e.g., (délgu)na ‘to cure’). Because alignment constraints prefer to attract monosyllabic feet *toward* the dominant edge of alignment (due to the violation-mark relationship seen in Table 5.2), the ranking for left-to-right parsing (ALLFTL » ALLFTR) would yield a monosyllabic foot as close to the *left* edge as possible, modulo the quantity requirements of such feet. In other words, the ranking ALLFTL » ALLFTR cannot be used to explain why monosyllabic feet are only permitted at the end of the metrical parse in generalized trochee languages in parallel OT. Indeed, in chapter 2 (§2.2.1.2) it was shown that an additional constraint, \*CLASH, is needed in order to force the monosyllabic foot to appear only at the end of the word if at all. In a sense, then, the fact that parsing in words with light syllables appears to be left-to-right in

Wergaia has nothing to do with the fact that a monosyllabic foot can appear only at the end of a word; in parallel OT this is merely a coincidence.<sup>11</sup>

Another problem posed by this property of alignment in parallel OT can be seen in languages with optional monosyllabic feet. Gordon (2002) lists 18 languages as having an odd-from-left alternating stress pattern, and three of these are indicated to have optional final stress avoidance in odd-parity words.<sup>12</sup> The odd-from-left pattern is derived with left-to-right trochees under the current representational assumptions, and the optional final stress suggests that an odd-parity word may have a monosyllabic foot,  $(\acute{\sigma}\sigma)(\acute{\sigma}\sigma)(\acute{\sigma})$ , or may not,  $(\acute{\sigma}\sigma)(\acute{\sigma}\sigma)\sigma$ . Optionality has been formalized in OT with constraints in variable or stochastic rankings (Anttila 1997, 2002, Boersma 1997). In a language with output variation between  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma\sigma)(\sigma\sigma)(\sigma)$ , the ranking of  $\text{PARSE-}\sigma$  and  $\text{FTBIN}$  must be in

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<sup>11</sup>I should note that although this monosyllabic-foot-attraction property of alignment constraints does play a role in the non-locality of the unattested languages discussed in chapter 2 (§2.2), it is not the primary cause of it—that is, the monosyllabic-foot-attraction property of alignment and the non-locality prediction are distinct. The non-locality prediction discussed in detail in that chapter centers around the fact that  $\text{FTBIN}$  permits an (H) foot, and  $\text{PARSE-}\sigma$  favors building such a foot wherever possible in order to minimize the total number of unparsed syllables in the word. Thus, an input /LLLLH/ will be parsed [(‘LL)(‘LL)(‘H)], while /LLHLL/ will be parsed [(‘LL)(‘H)(‘LL)], and /HLLLL/ will be parsed [(‘H)(‘LL)(‘LL)]. The ranking of the alignment constraints is irrelevant here, yet the prediction is non-local because there is no consistent left-to-right or right-to-left description which can be given that would favor parsing heavy syllables into monosyllabic feet just in these cases (and not, for example, when the total number of syllables in the word is even or when the heavy syllable itself appears in an even-numbered rather than odd-numbered syllable counting from the edge of footing origination; see example (33) in chapter 2).

In the non-local language described in chapter 2 (§2.2.2) the alignment constraints—and their monosyllabic-foot-attraction—become relevant just when more than one heavy syllable appears in a position that would maximize parsing, e.g., /HLHLH/. In this case, a ranking of  $\text{ALLFTL} \gg \text{ALLFTR}$  would favor [(‘H)(‘LH)(‘LH)], while the opposite ranking would favor [(‘HL)(‘HL)(‘H)]. That is, the dominant alignment constraint will choose the closest heavy syllable that will maximize parsing to be parsed into a monosyllabic foot. This is an example of the Crowhurst and Hewitt (1995a) problem under discussion, but it should be clear that the non-local properties exhibited by the alignment constraints and the non-local properties of  $\text{PARSE-}\sigma$  in combination with  $\text{FTBIN}$ —though they both are active in the non-local language from chapter 2 (§2.2.2)—are technically distinct.

Nonetheless, the fact that HS solves both the non-locality arising from  $\text{PARSE-}\sigma/\text{FTBIN}$  and the monosyllabic-foot-attraction properties of foot alignment constraints is no coincidence. They both involve a global violation-mark trade-off which is not possible when metrical parses are built and compared serially rather than in parallel.

<sup>12</sup>The three languages are Burum, Selepet, and Northern Sámi (Gordon 2002 cites Olkkonen 1985, McElhanon 1970, and Nielsen 1926, respectively).

variation so that sometimes a syllable goes unparsed if it would lead to a monosyllabic foot, and sometimes monosyllabic feet are tolerated in order to maximally parse syllables into feet. However, to get this pattern in parallel OT given the behavior of alignment described above, the ranking of ALLFTL and ALLFTR must also be in variation and must *co-vary* with the ranking of PARSE- $\sigma$  and FTBIN. That is, for  $(\sigma\sigma)(\sigma\sigma)\sigma$  to emerge, FTBIN must outrank PARSE- $\sigma$  and ALLFTL must outrank ALLFTR. But when  $(\sigma\sigma)(\sigma\sigma)(\sigma)$  wins, *both* rankings are reversed, such that PARSE- $\sigma$  outranks FTBIN and ALLFTR outranks ALLFTL.

To my knowledge, no theory of variation in OT has a mechanism to force pairs of constraints into co-varying rankings. Instead, standard theories of variation in OT predict that if both pairs of constraints are variably ranked, then the ranking chosen for one pair of constraints would vary orthogonally with the ranking chosen for the other pair. Thus, the variable ranking between PARSE- $\sigma$  and FTBIN on the one hand and ALLFTL and ALLFTR on the other predicts four-way variation between  $(\sigma\sigma)(\sigma\sigma)\sigma$ ,  $(\sigma\sigma)(\sigma\sigma)(\sigma)$ ,  $\sigma(\sigma\sigma)(\sigma\sigma)$ , and  $(\sigma)(\sigma\sigma)(\sigma\sigma)$  within a single language, rather than the intended two-way variation between  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma\sigma)(\sigma\sigma)(\sigma)$ . The tableau in (161) and the summary in (162) show this result.

(161) Rankings in variation

/ $\sigma\sigma\sigma\sigma$ /	PARSE- $\sigma$	FTBIN	ALLFTL	ALLFTR
a. $(\sigma\sigma)(\sigma\sigma)\sigma$	1		2	4
b. $(\sigma\sigma)(\sigma\sigma)(\sigma)$		1	6	4
c. $\sigma(\sigma\sigma)(\sigma\sigma)$	1		4	2
d. $(\sigma)(\sigma\sigma)(\sigma\sigma)$		1	4	6

(162) Possible outcomes of variation

- a.  $(\sigma)(\sigma\sigma)(\sigma\sigma)$  PARSE- $\sigma$  » FTBIN and ALLFTL » ALLFTR
- b.  $(\sigma\sigma)(\sigma\sigma)(\sigma)$  PARSE- $\sigma$  » FTBIN and ALLFTR » ALLFTL
- c.  $(\sigma\sigma)(\sigma\sigma)\sigma$  FTBIN » PARSE- $\sigma$  and ALLFTL » ALLFTR
- d.  $\sigma(\sigma\sigma)(\sigma\sigma)$  FTBIN » PARSE- $\sigma$  and ALLFTR » ALLFTL

Crowhurst and Hewitt (1995a) make a similar point—namely,  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma)(\sigma\sigma)(\sigma\sigma)$  are predicted in parallel OT to be “minimally contrastive” because only one re-ranking distinguishes them, while  $(\sigma\sigma)(\sigma\sigma)\sigma$  and  $(\sigma\sigma)(\sigma\sigma)(\sigma)$  are not minimally contrastive because two re-rankings distinguish them. They give examples from Cahuilla (Seiler 1965, 1967, 1970, 1977, Hayes 1995) to suggest that the kind of contrast predicted by parallel OT to be minimal is visible in a comparison of the stem+suffix stress domain as compared to the prefix stress domain (stem+suffix stress: left-to-right, degenerate feet allowed; prefix stress: right-to-left, degenerate feet not allowed). However, this example seems less compelling as empirical evidence of “minimal contrast” compared to the attested cases of optional final stress avoidance just described, primarily because there would seem to be no a priori reasons to favor a view of stress domain differences that privileges one re-ranking over two. Crowhurst and Hewitt also suggest that a theory’s definition of minimal contrast should make predictions about changes that are more or less likely to occur diachronically, but they acknowledge that those predictions are not really falsifiable because of the large number of other factors likely to affect such shifts.

The existence of of generalized trochee languages and languages with optional monosyllabic feet suggest that the behavior of alignment constraints in parallel OT discussed by Crowhurst and Hewitt (1995a) is indeed something we should be glad to be rid of in HS. The serial model does not reproduce this prediction, despite adopting the same constraints and definitions. Instead the emergent directionality from the ranking of ALLFTL and ALLFTR is constant.

In general, then, the behavior of alignment with respect to monosyllabic feet appears to be superior in HS. However, the quality of HS that leads to this difference—its insistence that monosyllabic feet be at the end of a metrical parse—has been criticized for leading to typological overgeneration of a different nature

(Hyde 2009). Namely, when constraints are introduced that favor bidirectional parsing—placing a foot at one edge and iterating feet from the opposite edge—the ‘end’ of the metrical parse is technically in the middle of the word, as the derivation in (163) shows. The constraint ranking favoring bidirectionality is independent of the ranking of *PARSE-σ* and *FTBIN*, just as with the alternating patterns discussed above. At the end of the metrical parse the decision about whether to build a monosyllabic foot on a remaining unparsed syllable is made solely on the basis of the ranking of *PARSE-σ* and *FTBIN* and has no relation to other constraints or ranking, nor to the fact that the stress system is bidirectional; derivations like the one in (163) are a predicted consequence.

(163) Bidirectional parse with monosyllabic foot predicted in HS

$$\sigma\sigma\sigma\sigma\sigma\sigma \rightarrow (\sigma\sigma)\sigma\sigma\sigma\sigma \rightarrow (\sigma\sigma)\sigma\sigma(\sigma\sigma) \rightarrow (\sigma\sigma)\sigma(\sigma\sigma)(\sigma\sigma) \rightarrow (\sigma\sigma)(\underline{\sigma})(\sigma\sigma)(\sigma\sigma)$$

Furthermore, when quantity-sensitivity is considered, HS also predicts bidirectional languages in which the relevant word-medial syllable is parsed into a monosyllabic foot if and only if it is heavy; this would be like the generalized trochee pattern discussed in chapter 2 but with the added feature of bidirectionality, making the ‘extra’ syllable word-medial rather than word-final. As Hyde (2009) illustrates, these predictions are not made in parallel OT—when the ranking favors having a monosyllabic foot, the dominant alignment constraint attracts it to the word edge.

Hyde (2009) argues that HS should be dispreferred as a model of stress on the basis of this prediction, as no attested bidirectional systems seem to involve a word-medial monosyllabic foot. However, the stress pattern of English provides a plausible counterexample to this typological claim. In English, primary stress tends to be aligned with the right edge of the word, modulo *FOOTBINARITY*, *NON-FINALITY*, and lexical variation, while secondary stresses are generally left-aligned



in words with a sufficient number of pretonic syllables (Pater 2000). The differential edge-attraction of primary and secondary stresses creates the environment for a bidirectional generalized trochee pattern, where a stray syllable between the primary stress and secondary stresses is parsed into a monosyllabic foot and stressed if and only if it is heavy. And in general, this is what we find. A word-medial (and immediately pretonic) stray light syllable is not stressed, e.g., *Tàtamagóuchi*, while a heavy syllable in the same position often is, e.g., *Hàlicàrnássus*.

This aspect of the stress pattern of English in fact presents a problem for an analysis in parallel OT with the standard constraints and representational assumptions. As Pater (2000:269f) discusses, the standard constraints in parallel OT have difficulty keeping the monosyllabic foot in word-medial position. In a word like *argumentation* the desired parse is  $(\grave{a}rgu)(m\grave{e}n)(t\acute{a}tion)$ , but the initial syllable would also satisfy FTBIN if parsed as a monosyllabic foot, e.g.,  $^*(\grave{a}r)(g\grave{u}men)(t\acute{a}tion)$ , and this is in fact what the dominant foot alignment constraint, ALLFTL, prefers. In contrast, because of HS's ability to place monosyllabic feet at the end of a metrical parse, it is possible to derive this aspect of English stress without further augmentation to our representations or constraints.

If English is a genuine case of a bidirectional generalized trochee language, as these facts suggest, then the prediction of such by HS would not be a liability. As for entirely quantity-insensitive bidirectional languages with monosyllabic feet, these do seem to be unattested despite being predicted by HS with current assumptions. If the absence of such systems represents an accurate typological generalization, it may be possible to vary our representational assumptions in order to prevent this prediction. For example, it is possible to stipulate that monomoraic feet are banned and that apparent word-initial and word-final exceptions involve catalexis (Kiparsky 1991, Kager 1995) to meet an inviolable bimoraic size minimum. In that case, a word-medial monomoraic foot would simply be disallowed

representationally.<sup>13</sup> This is clearly an issue which demands more attention, but addressing it further is left to another occasion. Suffice it to say that monosyllabic feet present an opportunity to observe differences between parallelism and serialism even when the same representational assumptions are adopted.<sup>14</sup>

I will now turn to a different issue surrounding standard constraints and representations in HS. The next section presents a brief defense of retaining gradient alignment constraints in HS, despite their generally negative reputation (e.g., McCarthy 2003). Categorical alternatives to gradient alignment are discussed and shown to be insufficient to properly control the location of feet.

### 5.2.3 Problems with categorical alignment

Although the previous section showed that alignment in HS does not suffer from the monosyllabic-foot-attraction problem that arises in parallel OT, it is nonetheless reasonable to ask whether moving to serial evaluation of restricted candidate sets would allow some alternative to alignment which crucially does not rely on gradience, since this property has been much-maligned, particularly on formal grounds (McCarthy 2003, Eisner 1999, Potts and Pullum 2002, among others). In this section I discuss two potential alternatives mentioned by McCarthy (2003) and show that they cannot in fact guarantee an appropriate parse in HS,

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<sup>13</sup>FTBIN would then be replaced in the hierarchy by a constraint that is violated by a catalectic foot; its ranking with respect to PARSE- $\sigma$  would primarily determine whether such feet arise, analogous to the behavior of FTBIN and PARSE- $\sigma$  with the current assumptions.

<sup>14</sup>Hyde (2009) presents an additional criticism of stress in HS—under the standard constraints and representational assumptions, deleting a syllable is predicted to be a way of improving satisfaction on PARSE- $\sigma$  (and, possibly, alignment), though this is not supported by language typology. However, gradualness in HS places considerable limits on what can be accomplished in one step, and it is likely that deletion of an entire syllable is beyond that which we would entertain as a single operation. If deletion of sufficient material to realize the loss of a syllable is not possible in one step, then we do not in fact predict that deletion is a possible repair for PARSE- $\sigma$  violations. An alternative tactic would be to reformulate PARSE- $\sigma$  as a positive constraint—a strategy which HS affords but parallel OT does not (e.g., Kimper to appear). A positive definition of PARSE- $\sigma$  (e.g., ‘assign +1 for every syllable parsed into a foot’) would see no benefit in the deletion of unparsed syllables, so this prediction would again not arise in HS.

particularly for bidirectional stress systems, while gradient alignment can. This section concludes that gradient alignment constraints are better than categorical alternatives for determining foot placement in HS.

### 5.2.3.1 ‘Categorical’ alignment I

McCarthy (2003:79) offers in passing two alternatives to gradient alignment which fall under the categorical constraint schema he defines. The first are the constraints defined in (164), which can be considered categorical equivalents of ALLFTL and ALLFTR, respectively. In the standard definition of alignment, a syllable can incur more than one alignment violation, subject to the number of feet in the word. In this proposed alternative formulation, a syllable can incur at most one violation on the constraint, and it does so when it appears between some foot and the relevant word edge.<sup>15</sup>

(164) a. \*σ... (F<sub>T</sub>

Assign one violation mark for every syllable appearing to the left of some foot

b. \*F<sub>T</sub>)... σ

Assign one violation mark for every syllable appearing to the right of some foot

Table 5.3 shows the violation marks assessed by ALLFTL and \*σ... (F<sub>T</sub> to candidates with one, two, and three left-aligned feet. In (a) and (b) the constraints match in their assessments, but in (c), gradient ALLFTL assigns more violation marks than \*σ... (F<sub>T</sub>; the former assigns marks for every syllable to the left of *each* foot, meaning some syllables incur more than one violation mark, while the latter assigns only one mark per syllable occurring to the left of *some* foot. In effect, \*σ... (F<sub>T</sub>

---

<sup>15</sup>McCarthy (2003) gives these constraints slightly different labels: \*σ/...F<sub>T</sub> and \*σ/F<sub>T</sub>... , instead of \*σ... (F<sub>T</sub> and \*F<sub>T</sub>)... σ, respectively.

assigns the number of violation marks corresponding to the distance, in syllables, of the foot furthest from the relevant word edge; here, the last foot in (c) is four syllables away from the word edge, hence four violation marks are incurred.

<i>Candidate</i>	<i>Violations assessed by:</i>	
	ALLFTL	*σ... (FT
a. (σσ)σσσσσ	0	0
b. (σσ)(σσ)σσσ	2	2
c. (σσ)(σσ)(σσ)σ	6	4

**Table 5.3.** Comparison of violations assessed by ALLFTL and \*σ... (FT

Similarly, Table 5.4 shows the same candidates and the violation marks they receive from ALLFTR and the categorical equivalent in (164). Each candidate shown receives five violation marks from \*FT)...σ, because in each case there are five syllables that appear to the right of a foot. Thus, the number of violation marks does not change with additional feet placed to the right of the foot in (a).

<i>Candidate</i>	<i>Violations assessed by:</i>	
	ALLFTR	*FT)...σ
a. (σσ)σσσσσ	5	5
b. (σσ)(σσ)σσσ	8	5
c. (σσ)(σσ)(σσ)σ	9	5

**Table 5.4.** Comparison of violations assessed by ALLFTR and \*FT)...σ

This alternative works for contiguous foot building of the type shown in most of the examples in this paper. A representative derivation for a language with left-to-right disyllabic feet is shown in (165).

(165) Derivation with categorical foot placement constraints

	/σσσσσ/ 1st iteration	PARSE-σ	*σ... (FT)	*FT)... σ
	a. σσσσσ	W <sub>5</sub>		L
←	b. (σσ)σσσ	3		3
	c. σ(σσ)σσ	3	W <sub>1</sub>	L <sub>2</sub>
→	<b>2nd iteration</b>			
	d. (σσ)σσσ	W <sub>3</sub>	L	3
←	e. (σσ)(σσ)σ	1	2	3
	f. (σσ)σ(σσ)	1	W <sub>3</sub>	3

(Convergence step not shown)

→ **Output:** [(σσ)(σσ)σ]

However, to see why these constraints cannot be what dictates foot placement in HS, we need to look at bidirectional stress systems. Examples include the languages Piro (Matteson 1965; see also chapter 3), Lenakel (verbs and adjectives only; Lynch 1974, 1977, 1978), and Garawa (Furby 1974). In both Piro and Lenakel a single trochaic foot is placed at the right edge of the word and other feet iterate from the left, as shown in (166) with data from Lenakel; Garawa shows the opposite pattern.

(166) Bidirectional stress in Lenakel

Even parity: n̩mamàrolkáykey ‘you (pl.) were liking it’

Odd parity: t̩nakàmarolkáykey ‘you (pl.) will be liking it’

In order to derive a pattern like this in HS with the standard parsing constraints, the derivation must proceed by first building the static right-edge foot and then iterating feet from the left. I will illustrate how this works and then explain why it must be this way. To simplify the discussion I will assume ALIGNWDR is the constraint that favors having a foot at the right edge.<sup>16</sup>

<sup>16</sup>The primary stress in Lenakel is on the final foot, and thus ALIGHDR would be a better choice than ALIGNWDR, which I argued in chapter 3 should be avoided. But since I have set main stress aside in this chapter I will use ALIGNWDR here instead anyway; the analysis is the same when ALIGHDR is substituted.

ALIGNWDR should be ranked above the standard foot alignment constraint ALLFtL so that the foot indeed is placed at the right. ALLFtL must in turn dominate ALLFtR to account for why the non-rightmost stresses align to the left. And PARSE-σ must dominate ALLFtL to get multiple feet iterating from the left. The derivation of a seven-syllable word in HS with gradient alignment is shown in (167). The rankings just asserted can be verified by examining the tableau.

(167) Derivation of 7-syllable word in Lenakel with gradient alignment

	PARSE-σ	ALIGNWDR	ALLFtL	ALLFtR
/tinakamarolkeykey/ 1st iteration				
a. tinakamarolkeykey	W <sub>7</sub>	W <sub>1</sub>	L	
b. (tina)kamarolkeykey	5	W <sub>1</sub>	L	W <sub>5</sub>
c. tinakamarol('keykey)	5		5	
→ 2nd iteration				
d. tinakamarol('keykey)	W <sub>5</sub>		5	L
e. tinaka(,marol)('keykey)	3		W <sub>8</sub>	L <sub>2</sub>
f. (tina)kamarol('keykey)	3		5	5
→ 3rd iteration				
g. (tina)kamarol('keykey)	W <sub>3</sub>		L <sub>5</sub>	L <sub>5</sub>
h. (tina)ka(,marol)('keykey)	1		W <sub>8</sub>	L <sub>7</sub>
i. (tina)(,kama)rol('keykey)	1		7	8
(Convergence step not shown)				
→ Output: [(tina)(,maka)rol('keykey)]				

This is the only way that the bidirectional derivation can be ordered. It is not possible to account for this stress system by building feet from the left edge and then ‘skipping’ the penultimate syllable in odd-parity words to achieve the appearance of a bidirectional system. This is because of the fact that higher-ranked constraints effectively have their preferences satisfied first in HS, and this is what determines ordering. If ALLFtL were to outrank ALIGNWDR, then it will be optimal to add contiguous feet from the left edge, and when faced with the choice of (tina)(,kama)(,rolkey)key or (tina)(,kama)rol('keykey) at the third iteration, the former will win. In order to have the latter option win, ALIGNWDR must outrank

ALLFTL, but under this ranking, the candidate with a foot on the right edge, tinakamarol('keykey), will win over ('tina)kamarolkeykey at the first iteration because the candidate with the right-aligned foot better satisfies the higher ranked constraint. Thus, bidirectional derivations must begin by satisfying the top-ranked ALIGNWD (or ALIGNHD) constraint, then iterate feet from the opposite edge.

When we replace ALLFTL and ALLFTR with the categorical alternatives in (164), we do not achieve the desired result. The violation marks assigned by these constraints do not identify the correct winner at the second iteration. The following partial derivation illustrates. The first iteration looks the same as the first iteration from the derivation with gradient alignment in (167), but in the second iteration, candidates (e) and (f) tie on PARSE- $\sigma$  and  $^*\sigma \dots (F_T)$ , while  $^*F_T) \dots \sigma$  prefers candidate (e), tinaka(,marol)('keykey), because it incurs fewer additional violations of this constraint.

(168) Wrong winner with categorical alignment

<i>/tinakamarolkeykey/</i> 1st iteration	<i>PARSE-<math>\sigma</math></i>	<i>ALWDR</i>	<i><math>^*\sigma \dots (F_T)</math></i>	<i><math>^*F_T) \dots \sigma</math></i>
a. tinakamarolkeykey	W <sub>7</sub>	W <sub>1</sub>	L	
b. ('tina)kamarolkeykey	5	W <sub>1</sub>	L	W <sub>5</sub>
c. tinakamarol('keykey)	5		5	
2nd iteration				
d. tinakamarol('keykey)	W <sub>5</sub>		5	L
→ e. tinaka(,marol)('keykey)	3		5	2
⊙ f. ('tina)kamarol('keykey)	3		5	W <sub>5</sub>

It is possible to rescue the second iteration by employing ALIGNWDL, which assigns a violation mark for a word that does not have a foot at its left edge, and ranking it above  $^*F_T) \dots \sigma$  to force (f) to win in (168). However, even if this strategy were employed to rescue the second iteration, an even bigger problem would arise in the third iteration. As the partial derivation in (169) shows, the categorical alignment constraints do not distinguish the candidates in (b) and (c) in (169)

precisely because they both already have a foot at the left and right edge, meaning additional feet do not add additional violations. In fact, the categorical alignment constraints are not even able to be ranked relative to each other on the basis of this derivation. Indeterminacy of this sort is not easily fixed in a principled way.

(169) Indeterminacy in third iteration with categorical alignment

(,tina)kmarol('keykey) 3rd iteration	PARSE- $\sigma$	* $\sigma$ ... (FT	*FT)... $\sigma$
a. (,tina)kamarol('keykey)	W <sub>5</sub>	5	5
→ b. (,tina)ka(,marol)('keykey)	1	5	5
→ c. (,tina)(,kama)rol('keykey)	1	5	5

Thus, for bidirectional systems, the categorical foot placement constraints defined in (164) will not suffice to determine the placement of non-peripheral feet. McCarthy (2003:79) observes the these constraints behave this way, but he argues this to be a virtue.<sup>17</sup> Here we see that the indeterminacy leads to failure of HS to analyze Lenakel. Because peripheral feet are built first in a bidirectional parse, we must face the choice between (169b) and (169c) at this point in the derivation, but these non-gradient alternatives to alignment cannot decide between them.

### 5.2.3.2 'Categorical' alignment II

The other possible replacement for gradient alignment constraints that is mentioned by McCarthy (2003) is to formulate local constraints that directly prefer contiguous footing by penalizing feet with an adjacent unfooted syllable, as in (170).

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<sup>17</sup>In the alternative proposed by McCarthy (2003), which builds on the proposal by Kager (2001), the position of the main stress foot is crucial to being able to distinguish candidates (b) and (c) in (169), so the indeterminacy would not persist in his analysis. However, the main-stress-sensitive constraint that McCarthy's and Kager's analysis uses is a context-sensitive version of \*LAPSE. I will argue in §5.3 that \*LAPSE is a problematic constraint; that illustration will assume no feet, but the problematic predictions of \*LAPSE persist even when feet are used, so using a \*LAPSE constraint would not be a tenable solution in HS.



(170) a.  $*\sigma(\mathbf{FT})$

Assign one violation mark for every foot with an adjacent unfooted syllable to the left

b.  $*\mathbf{FT})\sigma$

Assign one violation mark for every foot with an adjacent unfooted syllable to the right

However, this proposal also fails to determine an optimal parse in bidirectional stress systems, for very similar reasons. The tableau in (171) illustrates an attempt at the same seven-syllable derivation with these constraints. The constraint ALIGN-WdL is again needed to get the correct winner in the second iteration, and the third iteration again fails to return an optimal candidate.

(171) Alternative categorical alignment constraints also insufficient

<i>/tinakamarolkeykey/</i> <b>1st iteration</b>	<i>PARSE-σ</i>	<i>ALIGNWR</i>	$*\sigma(\mathbf{FT})$	<i>ALIGNWL</i>	$*\mathbf{FT})\sigma$
a. tinakamarolkeykey	W <sub>7</sub>	W <sub>1</sub>	L	1	
b. (ˈtina)kamarolkeykey	5	W <sub>1</sub>	L	L	W <sub>1</sub>
c. tinakamarol(ˈkeykey)	5		1	1	
<b>2nd iteration</b>					
d. tinakamarol(ˈkeykey)	W <sub>5</sub>		1	W <sub>1</sub>	L
e. tinaka(,marol)(ˈkeykey)	3		1	W <sub>1</sub>	L
f. (,tina)kamarol(ˈkeykey)	3		1		1
<b>3rd iteration</b>					
g. (,tina)kamarol(ˈkeykey)	W <sub>3</sub>		1		1
→ h. (,tina)ka(,marol)(ˈkeykey)	1		1		1
→ o. (,tina)(,kama)rol(ˈkeykey)	1		1		1

It would seem then that these non-gradient alternatives to generalized alignment constraints encounter problems because they are not sufficiently deterministic. Both of these categorical alternatives to alignment are subject to the same problem and we are thus in the position of preferring a gradient alignment analysis on the grounds that it allows us to derive bidirectional stress systems. Standard

alignment constraints can handle bidirectional systems because the constraints that prefer regular iteration from one edge are gradiently defined and thus ensure feet will be as far to the dominant edge as they can be, modulo the satisfaction of other high-ranked constraints on metrical structure and location of other feet; this is something the proposed alternatives cannot do.

#### 5.2.4 Summary

In this section I have discussed some consequences of adopting standard stress constraints and foot-based representations to account for quantity-insensitive rhythmic stress in HS. The primary focus was on the role of monosyllabic feet in accounting for alternating stress patterns and on how parallel OT and HS differ in their treatment of such feet. While in both cases the decision about whether to build a monosyllabic foot is largely orthogonal to other descriptive parameters of a stress pattern, HS restricts the location of monosyllabic feet in such stress patterns to the end of the metrical parse; in parallel OT monosyllabic feet are instead invariably attracted to a word edge by the dominant alignment constraint. The need for monosyllabic feet is the clearest consequence of indirect reference to rhythm in HS and parallel OT, and the comparison between the two theories suggests that constituent representations function more closely to what is intended when built serially rather than in parallel.

The other topic addressed in this section was the role of gradience in alignment constraints in accounting for attested stress patterns. The gradient property of foot alignment constraints—that is, their ability to assign violations for every syllable intervening between each foot and the relevant word edge—was shown to be necessary to account for bidirectional stress patterns, where categorical alternatives fail to ensure a deterministic parse.

The next section shifts gears from constituent representations of alternating stress patterns to non-constituent representations and again compares the predictions of HS and parallel OT when representations and constraints are held constant.

### **5.3 The failure of direct reference to rhythm**

I have assumed foot-based representations throughout this dissertation, and in this chapter I have discussed some HS/parallel OT differences that emerge when parsing even the simplest alternating stress patterns with foot-based representations and constraints. But, as noted in the introduction to this chapter, indirect reference to rhythm is not the only way to represent stress. Another option is to represent stress peaks and troughs (or stressed and unstressed syllables) directly, without assuming constituent groupings thereof. Doing so, in fact, highlights considerable differences between HS and parallel OT. More so than with foot-based representations, the constraints needed to account for simple alternating patterns without feet behave differently and have considerably divergent typological predictions in HS as compared to parallel OT. The primary difference is that HS over-generates with these assumptions, predicting improbable *non*-rhythmic stress patterns that parallel OT does not. This section will illustrate this in detail and will discuss the reasons for this asymmetry and what it means for metrical typology in OT frameworks.

#### **5.3.1 The metrical grid**

Metrical grids were proposed by Liberman and Prince (1977) to supplement tree-based representations which originally represented metrical constituent structure in terms of binary branching (see also Liberman 1975). A grid is a two-dimensional object with terminals/stress-bearing units (e.g., syllables) ordered

temporally from left-to-right, and the prominence of each of the terminals represented by a column extending upward; the height of each column is interpreted relative to the heights of the other columns in a word (or phrase) to determine the relative prominence of each terminal element. For example, the stress pattern of the English word *Apalachicola* is given as a grid representation in (172) below, assuming two levels of stress.

(172) Grid representation of *Àpalàchicóla* in English

```

      ×
     × ×
    × × × × × ×
Apalachicola

```

The principal utility of a grid is that it allows direct and efficient reference to rhythmic concepts like alternating stress (“adjacent elements are metrically alternating if, in the next lower level, the elements corresponding to them (if any) are not adjacent”, Liberman and Prince 1977:314) and stress clash (“adjacent elements are metrically clashing if their counterparts one level down are adjacent”, *ibid.*). Although Liberman and Prince (1977) assume that metrical grids work together with tree-based representations to define stress patterns, Prince (1983) argues instead that the trees can be done away with altogether if grid theory is suitably enriched; he presents a theory of stress which derives a number of attested stress patterns using only grid-based rules and principles.

For Prince, deriving the four basic patterns of alternating stress involves appealing to the notion of the PERFECT GRID. Abstractly, the perfect grid is a platonic ideal of alternating rhythm, a sequence of stressed and unstressed syllables (or possibly morae), as illustrated in (173). According to Prince (1983:48), “[t]he main burden of lexical stress theory is to map words onto the perfect grid”.

(173) The Perfect Grid (Prince 1983:48, example (61))

```

      ×  ×  ×  ×  ×  ×
     × × × × × × × × × × ×
... σ σ σ σ σ σ σ σ σ σ σ σ ...

```

Prince implements stress assignment for the simple rhythmic patterns by applying the perfect grid to a word, starting either from the left or right word edge with either a stressed syllable (peak) or an unstressed syllable (trough). From this basic parametric system the four strictly alternating stress patterns emerge, as illustrated in (174).

(174) Alignments of the perfect grid (Prince 1983:48, example (62))

- |                             |                   |                                                                                                              |
|-----------------------------|-------------------|--------------------------------------------------------------------------------------------------------------|
|                             |                   | $\begin{array}{c} \times \quad \times \quad \times \\ \times \times \times \times \times \times \end{array}$ |
| a. Odd-numbered from left   | L→R, peak-first   | # σ σ σ σ σ σ...                                                                                             |
|                             |                   | $\begin{array}{c} \times \quad \times \quad \times \\ \times \times \times \times \times \times \end{array}$ |
| b. Even-numbered from left  | L→R, trough-first | # σ σ σ σ σ σ...                                                                                             |
|                             |                   | $\begin{array}{c} \times \quad \times \quad \times \\ \times \times \times \times \times \times \end{array}$ |
| c. Odd-numbered from right  | R→L, peak-first   | ... σ σ σ σ σ σ #                                                                                            |
|                             |                   | $\begin{array}{c} \times \quad \times \quad \times \\ \times \times \times \times \times \times \end{array}$ |
| d. Even-numbered from right | R→L, trough-first | ... σ σ σ σ σ σ #                                                                                            |

Although much work on stress in OT has assumed some kind of constituent representation, there are a handful of proposals that use exclusively grid-based representations and constraints, with Gordon (2002) being a prominent example. Gordon (2002) proposes a grid-based constraint set to account for a wide range (argued to be exhaustive) of quantity-insensitive stress patterns. Here I will use a subset of Gordon's proposed constraints, since the focus here is mainly on the strictly alternating patterns.

In §5.3.2 I will discuss the constraints that are needed to motivate the perfect grid and its various alignments in parallel OT and show how the same constraints can derive these patterns in HS. In §5.3.3 I illustrate the problematic typological predictions that are made by these constraints in HS though not in parallel OT.

### 5.3.2 Deriving grids with violable constraints

#### 5.3.2.1 In parallel OT

For the simple alternating patterns without feet, we will first need a constraint or constraints that favor strict alternation of stresses. Following Gordon (2002) and others, I assume the constraints \*LAPSE and \*CLASH, defined below in (175) and (176). In OT a constraint like \*CLASH is ubiquitous and has been more or less uncontroversial, regardless of the choice of representations (Hung 1994, Elenbaas 1999, Elenbaas and Kager 1999, Alber 1997, 1998, 2005, Hyde 2001, Gordon 2002, among others). \*LAPSE is also frequently found in parallel OT analyses, though there is less consensus about its precise definition (Elenbaas and Kager 1999, Elenbaas 1999, Kager 1994, 2001, 2005, Gordon 2002, McCarthy 2003, Alber 2005). The definition in (175) reflects the ‘simplest’ grid-based definition, found in Gordon (2002), Kager (2001), and others. A parametric version of \*CLASH was also an integral part of Prince’s (1983) proposal, while Selkirk (1984) includes discussion of rhythmic alternation arising from the two principles of lapse-avoidance and clash-avoidance.

(175) \*LAPSE

Assign a violation mark for every pair of adjacent unstressed syllables

(176) \*CLASH

Assign a violation mark for every pair of adjacent stressed syllables

The constraint \*LAPSE disfavors sequences of unstressed syllables, while \*CLASH militates against adjacent syllables both being stressed. When high-ranked, these constraints conspire to favor a perfect grid as in (173), as this is the only configuration which incurs no violations of either constraint. However, these constraints do not distinguish between the examples in (174), which align the grid in different ways and may begin with a stressed or unstressed syllable. Thus, ad-

ditional constraints are needed to favor aligning the grid in the four possible ways illustrated in (174).

In order to account for the peak-first patterns I will use the constraints **PEAK-L** and **PEAK-R**, defined in (177). The **PEAK** constraints favor aligning a stressed syllable to the left or right word edge, thereby favoring L→R peak-first or R→L peak-first patterns, respectively, when combined with the preferences of \***LAPSE** and \***CLASH**. Gordon (2002) assumes a similar constraint, which he calls **ALIGN EDGES** and which acts like a disjunction of **PEAK-L** and **PEAK-R** as I have defined them here, but I have chosen to use the more transparent **PEAK** constraints.<sup>18</sup> The **PEAK** constraints act somewhat similarly to the **ALIGNWD** constraints discussed in various places elsewhere in this dissertation, but I have named them differently because the **ALIGNWD** constraints typically refer to feet, while the **PEAK** constraints refer to a stress/grid mark itself.

(177) **PEAK-L/R**

Assign a violation mark for a word whose initial/final syllable is not stressed

Another constraint is needed in order to account for trough-first patterns. As illustrated in (178), although different rankings of **PEAK-L** and **PEAK-R** would account for both possible grid alignments in words with an even number of syllables

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<sup>18</sup>Gordon's justification for using the disjunctive **ALIGN EDGES** rather than atomistic single-edge constraints is typological—using the two individual constraints results in three more unattested stress patterns being predicted as compared to **ALIGN EDGES** alone. However, in parallel OT this divergence only occurs when a larger range of word-lengths is considered; compared to **ALIGN EDGES**, the **PEAK-L/R** constraints predict additional languages that differ only in the stress patterns of shorter (2-3 syllable) words (see Gordon 2002:534f for discussion). This issue does not arise in this chapter because I assume just six- and seven-syllable inputs for the purposes of the typology calculations throughout. In HS **ALIGN EDGES** and **PEAK** constraints do predict different typologies even with only six- and seven-syllable inputs, but **PEAK** constraints are needed to account for all of the simple alternating patterns.

$\begin{array}{cc} \times & \times & \times & & \times & \times & \times \\ \times & \times & \times & \times & \times & \times & \times \end{array}$   
 (σσσσσσ or σσσσσσ), in odd-parity words only one alignment could be optimal  
 $\begin{array}{cc} & \times & \times & \times & \times & & \times & \times & \times \\ & \times & \times & \times & \times & \times & \times & \times & \times \end{array}$   
 with just these constraints (namely, σσσσσσσ, but not σσσσσσσσ).

(178) a. Violations of PEAK constraints in six-syllable words

	$\begin{array}{c} \times \times \times \times \times \times \\ / \sigma \sigma \sigma \sigma \sigma \sigma / \end{array}$	PEAK-L	PEAK-R
→ i.	$\begin{array}{c} \times & \times & \times \\ \times & \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$		1
→ ii.	$\begin{array}{c} & \times & \times & \times \\ & \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$	1	

b. Violations of PEAK constraints in seven-syllable words

	$\begin{array}{c} \times \times \times \times \times \times \times \\ / \sigma \sigma \sigma \sigma \sigma \sigma \sigma / \end{array}$	PEAK-L	PEAK-R
→ iii.	$\begin{array}{c} \times & \times & \times & \times \\ \times & \times & \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$		
⊕ iv.	$\begin{array}{c} & \times & \times & \times \\ & \times & \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$	1	1

In order to make trough-first patterns possible I will adopt the constraints defined in (179), again following Gordon (2002). These constraints evaluate gradiently the distance of each stressed syllable (or level-1 grid mark) to the relevant word edge. They are therefore grid-based analogs of ALLFTL/R, which calculate each foot's distance to the word edge.

(179) **ALIGN-×-L/R**

For each stressed syllable in a word, assign one violation mark for every syllable intervening between it and the left/right edge of the word

The utility of these constraints in favoring trough-first patterns lies in the fact that in parallel OT they favor fewer grid marks in general, in the same way that ALLFTL and ALLFTR effectively favor fewer feet. A perfect grid in a word with an odd number of syllables will have fewer stresses when aligned trough-first as compared



to peak-first, thereby incurring fewer violations of both ALIGN- $\times$  constraints (e.g.,  
 $\begin{array}{cc} \times & \times & \times & & \times & \times & \times & \times \\ \times & \times & \times & \times & \times & \times & \times & \times \end{array}$   
 $\sigma\sigma\sigma\sigma\sigma\sigma$  vs.  $\sigma\sigma\sigma\sigma\sigma\sigma$ ).

As shown in (180), for even-parity words ALIGN- $\times$ -L and ALIGN- $\times$ -R have the same favoring relations as PEAK-L and PEAK-R, respectively; but for an odd-parity word, the ALIGN- $\times$  constraints both favor the candidate with fewer stresses, undoing the harmonic bounding that was otherwise ensured by the PEAK constraints' uniform preference for peak-first patterns.

(180) Violations of PEAK and ALIGN- $\times$  in six- and seven-syllable words

	$\begin{array}{c} \times \times \times \times \times \\ / \sigma \sigma \sigma \sigma \sigma / \end{array}$	PEAK-L	PEAK-R	ALIGN- $\times$ -L	ALIGN- $\times$ -R
→ a.	$\begin{array}{c} \times & \times & \times \\ \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$		1	6	9
→ b.	$\begin{array}{c} \times & \times & \times \\ \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$	1		9	6
	$\begin{array}{c} \times \times \times \times \times \times \\ / \sigma \sigma \sigma \sigma \sigma \sigma / \end{array}$	PEAK-L	PEAK-R	ALIGN- $\times$ -L	ALIGN- $\times$ -R
→ c.	$\begin{array}{c} \times & \times & \times & \times \\ \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$			12	12
→ d.	$\begin{array}{c} \times & \times & \times \\ \times & \times & \times & \times & \times \\ \sigma & \sigma & \sigma & \sigma & \sigma \end{array}$	1	1	9	9

For a left-to-right peak-first pattern, candidates (a) and (c) in (180) must be optimal; for this to happen, PEAK-L should dominate PEAK-R (for (a)) and both ALIGN- $\times$  constraints (for (c)). A right-to-left peak-first pattern (with optima (b) and (c)) is similar, except that PEAK-R is the dominant constraint, ranked over PEAK-L and both ALIGN- $\times$  constraints. For a left-to-right trough-first pattern, candidates (b) and (d) should be optimal; in order to ensure this, one of the ALIGN- $\times$  constraints must dominate both PEAK constraints (for (d)), and to make (b) optimal it must be ALIGN- $\times$ -R rather than ALIGN- $\times$ -L. That is, somewhat paradoxically, a left-to-right trough-first pattern in even-parity words is derived from a right-to-left peak-first

ranking of the ALIGN- $\times$  constraints. And similarly, for a right-to-left trough-first pattern (with optima (a) and (d)), the same ranking holds but with ALIGN- $\times$ -L as the dominant alignment constraint.<sup>19</sup>

With this set of constraints—\*LAPSE, \*CLASH, PEAK-L/R, and ALIGN- $\times$ -L/R—each of the four alternating patterns is optimal under some ranking; these are summarized in (181). For the perfect grid \*LAPSE and \*CLASH are undominated. For all the patterns it must also be the case that \*LAPSE dominates both ALIGN- $\times$  constraints; because multiple stresses incur multiple violations of the ALIGN- $\times$  constraints, they must be dominated by a constraint that favors stress, and here that constraint is \*LAPSE. (This is analogous to the PARSE- $\sigma$  » ALLFTL/R ranking needed for iterative stress when feet are used.)

(181) Rankings for alternating patterns with grids in parallel OT

Pattern	Description	Ranking
a. $\begin{array}{cc} \times \times \times & \times \times \times \times \\ \times \times \times \times \times & \times \times \times \times \times \times \\ \sigma \sigma \sigma \sigma \sigma & \sigma \sigma \sigma \sigma \sigma \sigma \end{array}$	Odd from left L→R peak-first	*LPS, *CLSH, PK-L » PK-R, AL- $\times$ -L, AL- $\times$ -R
b. $\begin{array}{cc} \times \times \times & \times \times \times \\ \times \times \times \times \times & \times \times \times \times \times \times \\ \sigma \sigma \sigma \sigma \sigma & \sigma \sigma \sigma \sigma \sigma \sigma \end{array}$	Even from left L→R trough-first	*LPS, *CLSH » AL- $\times$ -R » PK-L, PK-R, AL- $\times$ -L
c. $\begin{array}{cc} \times \times \times & \times \times \times \times \\ \times \times \times \times \times & \times \times \times \times \times \times \\ \sigma \sigma \sigma \sigma \sigma & \sigma \sigma \sigma \sigma \sigma \sigma \end{array}$	Odd from right R→L peak-first	*LPS, *CLSH, PK-R » PK-L, AL- $\times$ -L, AL- $\times$ -R
d. $\begin{array}{cc} \times \times \times & \times \times \times \\ \times \times \times \times \times & \times \times \times \times \times \times \\ \sigma \sigma \sigma \sigma \sigma & \sigma \sigma \sigma \sigma \sigma \sigma \end{array}$	Even from right R→L trough-first	*LPS, *CLSH » AL- $\times$ -L » PK-L, PK-R, AL- $\times$ -R

The alignment constraints used here are able to derive the correct typology under the right rankings and are able to favor trough-first grid alignments, although their behavior is not entirely intuitive in doing so. It might seem that an easier alternative for favoring trough-first patterns is available, namely, defining con-

<sup>19</sup>This paradoxical switching of the alignment constraints for trough-first patterns (ALIGN- $\times$ -R » ALIGN- $\times$ -L for a left-to-right pattern, ALIGN- $\times$ -L » ALIGN- $\times$ -R for a right-to-left pattern), is formally similar to the behavior of ALLFTL/R with monosyllabic feet, which was discussed at length earlier in this chapter (see §5.2.2).

straints like TROUGH-L and TROUGH-R that do the opposite of the PEAK constraints by preferring that words should begin/end with an *unstressed* syllable. Although this would correctly allow each of the four perfect grid patterns to be described, it would not be sufficient for making typological predictions, as under many rankings of these constraints (\*LAPSE, \*CLASH, PEAK-L/R, TROUGH-L/R), two or more candidates would tie for the optimal output. The ALIGN- $\times$  constraints avoid this problem by ensuring that any non-harmonically-bounded violation profile (i.e., a violation profile that could win under some ranking) corresponds to at most one candidate. The complete typological predictions of these constraints will be discussed in §5.3.3. But first, the next section (§5.3.2.2) will discuss how these same constraints can be used in HS to derive the perfect grid patterns.

### 5.3.2.2 In HS

The same constraints from the previous section can be used to derive the four alternating patterns without feet in HS, although the behavior of the constraints is somewhat different, as are the rankings that produce each pattern. I assume that with these representations, one step in an HS derivation involves the addition of at most one level-1 grid mark. Thus, deriving these patterns will require the derivations shown below in (182). (Only the derivation of an even-parity word is shown for each pattern in (182); an odd-parity word would be derived in the same way, with the derivation continuing as far as necessary to make sure that every other syllable is stressed.)

(182) Derivations for the perfect grid

- a. L→R, peak-first (even:  $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ , odd:  $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ )

$\begin{array}{cccc} & \times & & \\ \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times \\ \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma \end{array}$

- b. L→R, trough-first (even:  $\sigma\sigma\sigma\sigma\acute{\sigma}$ , odd:  $\sigma\sigma\sigma\sigma\sigma\acute{\sigma}$ )

$\begin{array}{cccc} & \times & & \\ \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times \\ \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma \end{array}$

- c. R→L, peak-first (even:  $\sigma\sigma\sigma\sigma\acute{\sigma}$ , odd:  $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ )

$\begin{array}{cccc} & \times & & \\ \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times \\ \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma \end{array}$

- d. R→L, trough-first (even:  $\acute{\sigma}\acute{\sigma}\acute{\sigma}\acute{\sigma}$ , odd:  $\sigma\sigma\sigma\sigma\sigma\acute{\sigma}$ )

$\begin{array}{cccc} & \times & & \\ \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times & \times\times\times\times\times \\ \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma & \rightarrow \sigma\sigma\sigma\sigma\sigma \end{array}$

The constraints \*LAPSE and \*CLASH will again be assumed to be primarily responsible for rhythmic alternation. \*LAPSE takes the place of PARSE- $\sigma$  as the constraint which favors assigning stresses, just as in parallel OT; this can be seen by comparing candidate (a) with the other candidates in tableau (183). This tableau shows the exhaustive list of candidates under consideration at the first iteration of stress assignment in a six-syllable word and their violations of \*LAPSE and \*CLASH. Because derivations are gradual, no candidates at the first iteration will perfectly satisfy \*LAPSE (for inputs longer than two syllables), and no candidates at the first iteration will violate \*CLASH. As is evident from this tableau, \*LAPSE in HS has the somewhat peculiar characteristic of favoring non-peripheral stress, that is, candidates (c)-(f) over (a), (b), and (g); this is discussed further below.

(183) \*LAPSE favors stress on non-peripheral syllables

xxxxxx /σσσσσσ/ 1st iteration	*LAPSE	*CLASH
a.       xxxxxx σσσσσσ	5	
b.       x xxxxxx σσσσσσ	4	
→ c.     x xxxxxx σσσσσσ	3	
→ d.     x xxxxxx σσσσσσ	3	
→ e.     x xxxxxx σσσσσσ	3	
→ f.     x xxxxxx σσσσσσ	3	
g.       x xxxxxx σσσσσσ	4	

To achieve the derivations in (182), it will need to be the case that candidates (b), (c), (f), and (g) in (183) are able to win at the first iteration under some ranking (for L→R peak-first, L→R trough-first, R→L trough-first, and R→L peak-first patterns, respectively). As shown by candidates (b) and (g), adding a stress on the initial or final syllable gets rid of one violation of \*LAPSE, compared to a candidate with no stresses, (a), but placing stress elsewhere in the word gets rid of two violations. Thus, \*LAPSE itself favors initiating stress assignment trough-first.<sup>20</sup> High-ranking \*LAPSE is not yet enough for trough-first patterns, however. When only one stress can be added at a time, the intended first step in the derivation of a L→R trough-first derivation, candidate (c), ties with the intended first step of a R→L trough-first derivation, candidate (f), and they both tie with two candidates

<sup>20</sup>Kager (2005:13) makes an equivalent observation about the behavior of \*LAPSE in single-stress systems.

that should never begin a derivation, (d) and (e), which have a stress in the middle of the word. The ALIGN- $\times$  constraints from the previous section are able to solve the indeterminacy that otherwise prevents trough-first derivations from selecting the intended (unique) winner at the first iteration. This is illustrated in (184) (with candidate indices copied from (183)); candidates (c) and (f) are able to win under some ranking, but candidates (d) and (e) are collectively harmonically bounded as a result.

(184) ALIGN- $\times$  constraints break tie

	xxxxx /σσσσσ/ 1st iteration	*LAPSE	ALIGN- $\times$ -L	ALIGN- $\times$ -R
✓ c.	x xxxxxx σσσσσσ	3	1	4
d.	x xxxxxx σσσσσσ	3	2	3
e.	x xxxxxx σσσσσσ	3	3	2
✓ f.	x xxxxxx σσσσσσ	3	4	1

Although ALIGN- $\times$  constraints would prefer to stack all stresses as close as possible to their indicated word edge, other constraints prevent this from happening. \*CLASH disfavors adjacent stresses, of course, but \*LAPSE is also a factor. Since \*LAPSE is the constraint that motivates stress assignment, grid marks are only added in ways that minimize lapses, and this will generally entail alternating stress for the same reason that \*LAPSE favors non-peripheral stress in (183); a grid mark adjacent to another grid mark is peripheral in the same way that a grid mark adjacent to a word edge is peripheral, which means that maintaining alternation will usually get rid of more \*LAPSE violations than building adjacent stresses. In HS, as in parallel OT, \*LAPSE must dominate both ALIGN- $\times$  constraints to motivate

iterative parsing, and this entails that iterative stress will maintain alternation insofar as doing so continues to improve performance on \*LAPSE.

However, the ranking needed for iterative stress, \*LAPSE » ALIGN-×-L/R, also highlights the fact that the four constraints included thus far will not yet deliver an alternating peak-first pattern. This can be appreciated by considering the tableau in (185). In order for candidate (b) to win, for example, \*LAPSE must be dominated by ALIGN-×-L, otherwise a trough-first pattern is favored. But the ranking ALIGN-×-L » \*LAPSE also means that at the second iteration adding additional stresses does not improve harmony, since any additional stresses violate ALIGN-×-L.

(185) Non-iterative stress when ALIGN-×-L » \*LAPSE

xxxxxx /σσσσσσ/ 1st iteration	*CLASH	ALIGN-×-L	*LAPSE	ALIGN-×-R
a. xxxxxx σσσσσσ			W <sub>5</sub>	L
b. x xxxxxx σσσσσσ			4	5
c. x xxxxxx σσσσσσ		W <sub>1</sub>	L <sub>3</sub>	L <sub>4</sub>
<b>2nd iteration</b>				
d. x xxxxxx σσσσσσ			4	5
e. xx xxxxxx σσσσσσ	W <sub>1</sub>	W <sub>1</sub>	L <sub>3</sub>	W <sub>9</sub>
f. x x xxxxxx σσσσσσ		W <sub>2</sub>	L <sub>2</sub>	W <sub>8</sub>
x xxxxxx <b>Output: [σσσσσσ]</b>				

To motivate peak-first patterns at the first iteration in a way that does not impede iterative stress at later iterations, we will again need the PEAK constraints from the previous section. To favor peak-first patterns, PEAK-L or PEAK-R will need to dominate \*LAPSE, which is then free to dominate both ALIGN-× constraints as

needed for iterative stress. The tableau in (186) repeats the tableau in (183) but adds the two PEAK constraints to illustrate their violation marks. To achieve a left-to-right peak-first pattern, PEAK-L will dominate PEAK-R and \*LAPSE (favoring candidate (b)), while a right-to-left peak-first pattern will commence correctly with the ranking PEAK-R » PEAK-L, \*LAPSE (favoring (g) at this first iteration).

(186) \*LAPSE, \*CLASH, and PEAK constraints at the first iteration

xxxxxx /σσσσσσ/ <b>1st iteration</b>	PEAK-L	PEAK-R	*LAPSE	*CLASH
a. xxxxxx σσσσσσ	1	1	5	
b. x xxxxxx σσσσσσ		1	4	
c. x xxxxxx σσσσσσ	1	1	3	
d. x xxxxxx σσσσσσ	1	1	3	
e. x xxxxxx σσσσσσ	1	1	3	
f. x xxxxxx σσσσσσ	1	1	3	
g. x xxxxxx σσσσσσ	1		4	

With these constraints (\*LAPSE, \*CLASH, PEAK-L/R, and ALIGN-x-L/R) the derivations required for each of the four alternating patterns are achieved with the rankings given in (187).





## (188) Left-to-right trough-first derivation

	/oooooo/ 1st iteration	*L <sub>Fs</sub>	*C <sub>LsH</sub>	P <sub>K-L</sub>	P <sub>K-R</sub>	A <sub>L-x-L</sub>	A <sub>L-x-R</sub>
	a. oooooo	W <sub>5</sub>		1	1	L	L
	b. Xooooo	W <sub>4</sub>		L	1	L	W <sub>5</sub>
←	c. oXoooo	3		1	1	1	4
	d. ooXooo	3		1	1	W <sub>2</sub>	L <sub>3</sub>
	e. oooXoo	3		1	1	W <sub>3</sub>	L <sub>2</sub>
	f. ooooXo	3		1	1	W <sub>4</sub>	L <sub>1</sub>
	g. oooooX	W <sub>4</sub>		1	L	W <sub>5</sub>	L
→	<b>2nd iteration</b>						
	h. oXoooo	W <sub>3</sub>		1	1	L <sub>1</sub>	L <sub>4</sub>
	i. XXoooo	W <sub>3</sub>	W <sub>1</sub>	L	1	L <sub>1</sub>	W <sub>9</sub>
	j. oXXooo	W <sub>2</sub>	W <sub>1</sub>	1	1	L <sub>3</sub>	W <sub>7</sub>
←	k. oXoXoo	1		1	1	4	6
	l. oXooXo	1		1	1	W <sub>5</sub>	L <sub>5</sub>
	m. oXoooX	W <sub>2</sub>		1	L	W <sub>6</sub>	L <sub>4</sub>
→	<b>3rd iteration</b>						
	n. oXoXoo	W <sub>1</sub>		1	1	L <sub>4</sub>	6
	o. XXoXoo	W <sub>1</sub>	W <sub>1</sub>	L	L	L <sub>4</sub>	W <sub>11</sub>
	p. oXXXoo	W <sub>1</sub>	W <sub>2</sub>	1	1	L <sub>6</sub>	W <sub>9</sub>
	q. oXoXXo		W <sub>1</sub>	1	1	L <sub>8</sub>	W <sub>7</sub>
←	r. oXoXoX			1	1	9	6

(Convergence step not shown)

→ **Output:** [oXoXoX]

A peak-first derivation starting at the left will proceed as shown in (189) below, showing just the most relevant constraints and candidates. P<sub>PEAK-L</sub> dominates \*L<sub>LAPSE</sub>, which in turn dominates A<sub>LIGN-x-L</sub>. A right-to-left peak-first derivation would instead be optimal if P<sub>PEAK-L</sub> and A<sub>LIGN-x-L</sub> exchange places in the ranking with P<sub>PEAK-R</sub> and A<sub>LIGN-x-R</sub>, respectively.

## (189) Left-to-right peak-first derivation

	/oooooo/ 1st iteration	<i>*CLASH</i>	<i>P<sub>K-L</sub></i>	<i>*LPS</i>	<i>AL-x-L</i>
a.	oooooo		W <sub>1</sub>	W <sub>5</sub>	
b.	Xooooo			4	
c.	oXoooo		W <sub>1</sub>	L <sub>3</sub>	W <sub>1</sub>
2nd iteration					
d.	Xooooo			W <sub>4</sub>	L
e.	XXoooo	W <sub>1</sub>		W <sub>3</sub>	L <sub>1</sub>
f.	XoXooo			2	2
3rd iteration					
g.	XoXooo			W <sub>2</sub>	L <sub>2</sub>
h.	XoXXoo	W <sub>1</sub>		W <sub>1</sub>	L <sub>5</sub>
i.	XoXoXo				6

(Convergence step not shown)  
 → **Output:** [XoXoXo]

An interesting note from the tableaux in (188) and (189) is that *\*CLASH* does most of its ‘work’ toward the end of the derivation. At the second iteration in (189), for example, candidate (e) has a clash, while the locally optimal (f) does not, but even if *\*CLASH* were not high-ranked, (f) would still win because of its better performance on *\*LAPSE*, for reasons discussed above regarding *\*LAPSE*’s preference for non-peripheral stresses. The utility of *\*CLASH* can be seen, however, in step 3 of the derivation in (188)—when only one lapse remains, stressing either of the adjacent unstressed syllables gets rid of that one violation, so the choice between them is made by other constraints. In (188), high-ranked *\*CLASH* decides in favor of candidate (r) to maintain the alternation of stress. To ensure this outcome, *\*CLASH* must dominate *ALIGN-x-L* to rule out candidate (q). I will return to this point below, as it factors in to the prediction of unattested stress patterns with these constraints in HS.

To summarize what we have seen in this section, the four basic patterns of perfect grid alignment and binary alternating stress are derivable in HS, as they are in parallel OT, using the rhythm constraints *\*LAPSE* and *\*CLASH* along with the

edge alignment PEAK constraints and the gradient ALIGN- $\times$  constraints. The rankings needed for HS, (187), are somewhat different from those required in parallel OT, (181), but all four patterns are able to be derived under some ranking in both frameworks.

However, we when consider the factorial typology that arises from this constraint set, the two frameworks behave quite differently. As I will show in the next section, HS predicts roughly twice as many languages with these constraints compared to parallel OT and compared to either framework when feet are used, and most of these additional patterns are unattested.

### 5.3.3 (Non-)Rhythmic predictions of grid constraints

The typological predictions of the six constraints discussed in the previous sections were calculated for six- and seven-syllable inputs in HS and in parallel OT using the tools discussed in chapter 1.

With these assumptions, parallel OT predicts 14 languages, and HS predicts the same 14 languages plus an additional 17, for 31 unique languages total. (When unique languages are not collapsed, HS generates 39 sets of optimal derivations.) Among the 14 languages predicted in both frameworks, four have non-iterative stress.<sup>21</sup> The remaining 10 shared languages have iterative stress; these are listed in (190). The now-familiar alternating patterns are listed in 1-4 in (190). The remaining patterns in 5-10, which do not show strict alternation, are discussed below.

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<sup>21</sup>The non-iterative stress patterns include: one with no stress, one with initial stress, one with final stress, and one with both initial and final stress (which is produced by two different derivations in HS).

## (190) Iterative stress patterns predicted by grid constraints (HS and parallel OT)

	6σ (even)	7σ (odd)	Description
<i>Alternating patterns</i>			
1	XoXoXo	XoXoXoX	Odd from left, L→R peak-first
2	oXoXoX	oXoXoXo	Even from left, L→R trough-first
3	oXoXoX	XoXoXoX	Odd from right, R→L peak-first
4	XoXoXo	oXoXoXo	Even from right, R→L trough-first
<i>Non-strictly-alternating patterns</i>			
5	XoXoXX	XoXoXoX	Odd from left + final L→R peak-first + X#, with clash
6 <sup>22</sup>	XoXooX	XoXoXoX	Odd from left + final, no penult L→R peak-first + X#, with lapse
7	oXoXoX	oXoXoXX	Even from left + final, L→R trough-first + X#, with clash
8	XXoXoX	XoXoXoX	Odd from right + initial R→L peak-first + #X, with clash
9 <sup>23</sup>	XooXoX	XoXoXoX	Odd from right + initial, no peninitial R→L peak-first + #X, with lapse
10	XoXoXo	XXoXoXo	Even from right + initial R→L trough-first + #X, with clash

The patterns in 5-10 show an interruption of strict alternation by allowing a stress clash or lapse in either odd or even parity words. Languages 5 and 6 are mirror images of each other, as are 7 & 8 and 9 & 10. The following are the attestations of each pattern, according to Gordon (2002); Language 5: attested in Gosiute Shoshone (Miller 1996); 6: not attested; 7: not attested in a quantity-insensitive

<sup>22</sup>In HS, two different derivations produce this set of outputs.

<sup>23</sup>In HS, two different derivations produce this set of outputs.

language, but Central Alaskan Yupik shows this pattern in strings of light syllables<sup>24</sup>; 8: attested in Tauya (MacDonald 1990); 9: not attested; and 10: attested in Biangai (Dubert and Dubert 1973).

Much like the simple foot-based typology around which parallel OT and HS were compared in §5.2, it is clear that this is not a complete theory of quantity-insensitive stress; some relatively common patterns are not included (e.g., the stress pattern of Pintupi: odd from left, no final), and two of the predicted patterns are not attested at all. However, the primary concern here is again to compare parallel OT and HS. More constraints could be added to achieve better coverage, but no more constraints are needed to show that the behavior of grid constraints in HS diverges from the same in parallel OT. Since additional constraints can only expand a typology, not make it smaller (with the standard caveat about ties; see the brief discussion in chapter 1), whatever predictions HS makes with this constraint set it will also make with a superset of these constraints. We thus turn now to the additional 17 languages predicted by HS with the same constraints.

The 17 patterns that are predicted exclusively by HS with these constraints are all iterative; these languages are listed in (191) (with the language numbering continued from (190)). Of the 17 languages, 16 are paired with a mirror image pattern; the table below shows descriptions only for the left-to-right patterns, with the corresponding right-to-left patterns shown in the rightmost column. (Descriptions for the mirror image patterns can be gotten by changing left-to-right to right-to-left, initial to final, final to initial, etc., but leaving peak, trough, odd, and even as they are.) The symmetry is a result of the fact that the constraints utilized in calculating the typology are entirely balanced—both *PEAK-L* and *PEAK-R* are included, as are *ALIGN-X-L* and *ALIGN-X-R*. The same symmetry exists for the 14 languages

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<sup>24</sup>But see fn. 8

that parallel OT and HS both predict with these constraints (including the languages in (190)). Language 17 in (191) produces a palindromic pattern in six and seven syllable words, so its mirror image is not among the ‘unique’ stress patterns predicted with these constraints. The stress patterns in (191) are all unattested with the following exceptions: language 19 is attested in Garawa (Furby 1974) and language 22 is attested in Southern Paiute (Sapir 1930, Prince and Smolensky 1993/2004).

(191) Non-rhythmic predictions of grid constraints in HS

Pattern		Description	Mirror image	
11	XXoXoX	Odd from left + initial	12	XoXoXX
	XXoXoXo	L→R trough-first + #X, w/ clash		oXoXoXX
13 <sup>25</sup>	XXoXoX	Odd from left + initial & final	14 <sup>26</sup>	XoXoXX
	XXoXoXX	L→R trough-first + #X & X#, w/ clashes		XXoXoXX
15	XoXoXo	Odd from left + penult, no final	16	oXoXoX
	XoXoXXo	L→R peak-first + Xo#, w/ clash		oXXoXoX
17 <sup>27</sup>	XoXXoX	Odd from left + final & antepenult		
	XoXoXoX	L→R peak-first + XoX#, w/ clash		
18	oXoXoX	Even from left + final, no penult	19	XoXoXo
	oXoXooX	L→R trough-first + oX#, w/ lapse		XooXoXo
20	oXoXoX	Even from left + final & antepenult	21	XoXoXo
	oXoXXoX	L→R trough-first + XoX#, w/ clash		XoXXoXo
22	oXoXXo	Even from left + penult, no final	23	oXXoXo
	oXoXoXo	L→R trough-first + Xo#, w/ clash		oXoXoXo
24	XXoXXo	Even from left + initial & penult, no final	25	oXXoXX
	XXoXoXo	L→R trough-first + #X & Xo#, w/ clashes		oXoXoXX
26	XXoXoX	Even from left + initial, final, & antepenult	27	XoXoXX
	XXoXXoX	L→R trough-first + #X & XoX#, w/ clashes		XoXXoXX

<sup>25</sup>Two sets of derivations produce this pattern.

<sup>25</sup>Two sets of derivations produce this pattern.

<sup>25</sup>Four sets of derivations produce this pattern.

Although the languages in (191) are somewhat diverse, some general tendencies can be identified which will help to explain why these languages arise from grid constraints in HS but not parallel OT. Nearly all of these languages contain stress clashes in at least one output, and sometimes both of them. (The exceptions are language 18 and its mirror image 19, which have a stress lapse in odd-parity words but no clashes.) As will be illustrated below, most of the derivations begin in a rhythmic manner, but then stresses are added in the latter steps of the derivations that make the patterns non-rhythmic and introduce stress clashes.

There are three main reasons that clashing stresses are added to otherwise-rhythmic-looking patterns in later steps of the derivations. These reasons are first enumerated briefly and then discussed individually in detail below. First, one or both of the PEAK constraints can be high-enough ranked that the derivation prefers to satisfy them at the expense of \*CLASH violations, but still low-enough ranked that they are not satisfied right away (i.e., by a peak-first derivation). This is the case for languages 11-14 and 24-27. Second, if the dominant ALIGN- $\times$  constraint dominates \*CLASH, then grid marks will prefer to gravitate toward the dominant edge of alignment rather than maintain alternation; for reasons addressed above in the discussion of the \*LAPSE constraint, this occurs just when \*LAPSE violations are not at issue, generally at the end of the parse. Languages 15-16 and 22-25 show this effect. And finally, bidirectional derivations lead to a third cause of non-rhythmicity; these typically arise when the dominant PEAK constraint and the dominant ALIGN- $\times$  constraint have opposite orientations (e.g., PEAK-L and ALIGN- $\times$ -R, or vice versa), and clashes are created in bidirectional systems when \*LAPSE is highly ranked. Bidirectional derivations are responsible for languages 17-21 and 26-27.<sup>26</sup>

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<sup>26</sup>Languages 24-27 each have two sources of non-rhythmicity, so they appear in two places in the lists above.



The first source of non-rhythmic predictions of grid constraints in HS is found in the behavior of the PEAK constraints when they are ranked between \*LAPSE and \*CLASH. When \*LAPSE outranks both PEAK constraints a trough-first derivation is favored (because \*LAPSE prefers to place stress on non-peripheral syllables), but when one or both PEAK constraints are ranked over \*CLASH, there is nothing to prevent a later step in the derivation from adding a stress on an initial and/or final syllable originally skipped over in the placement of stress.

Language 11 shows a clear example of this. As shown in (192), language 11 begins with a L→R trough-first derivation, but the final step adds an extra grid mark on the initial syllable. The trough-first derivation is motivated by high-ranked \*LAPSE, but when PEAK-L is also highly-ranked (below \*LAPSE but above \*CLASH), the derivation will continue once all violations of \*LAPSE are eliminated by adding an additional stress to satisfy PEAK-L. The ranking responsible for this is \*LAPSE » PEAK-L » \*CLASH » PEAK-R (with the additional ranking of \*LAPSE » ALIGN-×-L » ALIGN-×-R to favor an iterative left-to-right derivation).

(192) Derivation of language 11 (Odd from left + initial)

6σ oXo0000 → oXoX00 → oXoXoX → XXoXoX

7σ oXo00000 → oXoX000 → oXoXoXo → XXoXoXo

A similar thing happens in the derivation of language 13, shown in (193), where this time both PEAK-L and PEAK-R are high-enough ranked to compel stress clashes, but are themselves ranked below \*LAPSE so that a trough-first derivation is again initially favored (i.e., \*LAPSE » PEAK-L » PEAK-R » \*CLASH).

(193) Derivation of language 13 (Odd from left + initial and final)<sup>27</sup>

6σ oXo0000 → oXoX00 → oXoXoX → XXoXoX

7σ oXo00000 → oXoX000 → oXoXoXo → XXoXoXo → XXoXoXX

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<sup>27</sup>This is one of two sets derivations that result in these outputs. The other is:

The derivation of the stress pattern for an odd-parity word in language 11 or 13 begins like the strictly alternating trough-first derivation analyzed above in the tableau in (188). Once the derivation reaches oXoXoXo all lapse violations have been taken care of, but the derivation has not yet converged because PEAK-L has not yet been satisfied. The derivation continues at step four by getting rid of the PEAK-L violation; this introduces a violation \*CLASH, but it is too low-ranked to protest, as illustrated in (194).

(194) Clash tolerated for satisfaction of PEAK-L

	oXoXoXo 4th iteration	PEAK-L	*CLASH
a.	oXoXoXo	W <sub>1</sub>	L
→ b.	XXoXoXo		1

If \*CLASH outranks PEAK-R, then the derivation terminates at the following step, resulting in language 11. But if PEAK-R dominates \*CLASH, the next step will find the addition of final stress to be harmonically-improving, as shown in (195), resulting in language 13.

(195) Clash tolerated for satisfaction of PEAK-R

	XXoXoXo 5th iteration	PEAK-R	*CLASH
a.	XXoXoXo	W <sub>1</sub>	L
→ b.	XXoXoXX		1

In addition to languages 11 and 13, the ranking \*LAPSE » PEAK » \*CLASH is responsible for adding initial and/or final stresses to trough-first patterns in 12 and 14 (mirror images of 11 and 13, respectively) and languages 24-27.

These constraints behave more or less as expected in parallel OT, as evident from the smaller typology in (190), which did not include languages like 11 and 13.

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oXoooo → oXoXoo → oXoXoX → XXoXoX  
 oXooooo → oXoXooo → oXoXoXo → oXoXoXX → XXoXoXX

The ranking responsible for this alternative derivation is \*LAPSE » PEAK-R » PEAK-L » \*CLASH.

But these constraints are having unintended consequences in HS. What accounts for this difference? In parallel OT, high ranking *\*LAPSE*, *PEAK-L*, and *PEAK-R* do not necessarily compete in the same way that they do in HS—in an odd-parity word they can be simultaneously satisfied by, e.g., a candidate with initial and final stress and perfect rhythmic alternation: *XoXoXoX*. But in HS, this candidate is not available right away, and these constraints cannot be simultaneously satisfied. The ranking *\*LAPSE* » *PEAK-L* means that a reduction in *\*LAPSE* violations will be prioritized over initial stress, leading to a first step of *oXoooo* (4 violations of *\*LAPSE*) rather than *Xooooo* (5 violations of *\*LAPSE*). Once this first step is made it does not preclude later satisfaction of *PEAK-L* and/or *PEAK-R* if *\*CLASH* is low-ranked. This would appear to be an example of problematic myopia in HS. There is a globally better alternative (namely, *XoXoXoX*), but it is not under consideration at the beginning of the derivation, and it cannot cause the initial steps to have a different outcome.

The second source of the non-rhythmic predictions in (191) also involves low-ranking *\*CLASH*, but here what is relevant is its ranking with respect to the dominant *ALIGN- $\times$*  constraint, as I will illustrate with language 22. The derivations in this language, shown in (196), begin in much the same way as the derivations of 11 and 13 shown above. However, at the third iteration of stress in the six-syllable word, after two stresses have already been added, the ranking for language 22 selects the non-rhythmic candidate *oXoXXo* over the perfectly rhythmic *oXoXoX* because the former has fewer violations of *ALIGN- $\times$ -L*, which dominates *\*CLASH*.

(196) Derivation of language 22 (Even from left + penult, no final)

6 $\sigma$  *oXoooo* → *oXoXoo* → *oXoXXo*

7 $\sigma$  *oXooooo* → *oXoXooo* → *oXoXoXo*

The full derivation of an even-parity word in this language is shown in (197). The interesting thing here is that, as noted in the discussion of the *\*LAPSE* con-

straint above, alternating rhythm is primarily enforced by \*LAPSE, with little assistance from \*CLASH. It is only at the third iteration that ALIGN- $\times$ -L can cause a \*CLASH violation, because at this point in the derivation the clashing candidate and the non-clashing candidate perform equally well on \*LAPSE, so the decision is handed to the next-highest ranking constraint. In this case that constraint is ALIGN- $\times$ -L, not \*CLASH, so non-rhythmic stress is favored over rhythmic stress in this case.

(197) ALIGN- $\times$ -L favors clashing stress

/oooooo/ 1st iteration	*LAPSE	ALIGN- $\times$ -L	*CLASH
a. oooooo	W <sub>5</sub>	L	
b. Xooooo	W <sub>4</sub>	L	
c. oXoooo	3		
2nd iteration			
d. oXoooo	W <sub>3</sub>	L <sub>1</sub>	
e. oXXooo	W <sub>2</sub>	L <sub>3</sub>	W <sub>1</sub>
f. oXoXoo	1	4	
3rd iteration			
g. oXoXoo	W <sub>1</sub>	L <sub>4</sub>	L
h. oXoXXo		8	1
i. oXoXoX		W <sub>9</sub>	L

(Convergence step not shown)

→ Output: [oXoXXo]

It was noted above that language 22 is in fact an attested stress pattern. This pattern, which would be described with feet as having left-to-right iambs with rhythmic reversal of the final foot, is attested in Southern Paiute (Sapir 1930), Axininca Campa (Payne, Payne, and Santos 1982, McCarthy and Prince 1993b), and a few other languages (see, e.g., the discussion in chapter 2, where a foot-based analysis of Axininca is provided). However, it is generally argued to be the constraint NONFINALITY that is responsible for final stress avoidance in these cases (e.g., Prince and Smolensky 1993/2004:65). Evidence for this characterization comes from the fact that no languages with the mirror image pattern, oXXoXo

(language 23 in (191)), have been reported—this asymmetry is unexpected if (197) illustrates the correct analysis of this pattern. Similarly, the other languages in (191) produced by this behavior—languages 15, 16, 23-25—are all unattested. The behavior of ALIGN- $\times$ -L and \*CLASH exhibited in (197) (that is, the ability of ALIGN- $\times$ -L to pull grid marks toward the dominant edge when \*LAPSE is not at issue) is thus not something that has positive consequences, even though it happens to produce an attested language in the isolated case of language 22.<sup>28</sup>

This language is not predicted with the same constraints in parallel OT because when \*LAPSE and ALIGN- $\times$ -L are both high-ranked, XoXoXo is the preferred output for the six-syllable word (the seven-syllable word would remain oXoXoXo since this candidate has fewer violations of ALIGN- $\times$ -L than XoXoXoX). In HS, the different behavior is due in part to the fact that \*LAPSE is the primary maintainer of rhythmic alternation until the end of the derivation. That is, if \*CLASH also needed to be high-ranked for rhythmic alternation we would not see this contextual non-rhythmicity that arises only in cases where \*LAPSE violations are not decisive.

The third and final source of non-rhythmic stress in the languages in (191) derives from bidirectionality motivated by high-ranking PEAK constraints, which can cause the derivation of stress to begin by placing a stress at one edge and then continuing to stress from the other direction according to the ranking of the other constraints. Language 17 is among the languages in (191) that show the possible consequences of this, with the derivations for this language shown in (198). In this language a stress is first placed on the final syllable to satisfy high-ranking PEAK-R,

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<sup>28</sup>Additional discussion is warranted for languages 15 and 16 because they are also present in foot-based typologies produced by HS but not parallel OT, as mentioned in §5.2.2. The footings that would yield language 15 are: (Xo)(Xo)(Xo) and (Xo)(Xo)(X)(Xo), and the footings that would yield language 16 are: (oX)(oX)(oX) and (oX)(X)(oX)(oX). With feet, these languages arise from a bidirectional derivation with a word-medial monosyllabic foot (though the grid-based versions are derived unidirectionally). In §5.2.2 I noted that representational changes could be made to prevent word-medial monomoraic feet in order to avoid predictions like this, but a similar strategy is not available when stress is represented without constituency.

which dominates \*LAPSE and ALIGN- $\times$ -L. The derivation continues to add stresses from left-to-right, peak-first and on every other syllable because of the rankings PEAK-L » \*LAPSE (for left-edge peak-first) and \*LAPSE » ALIGN- $\times$ -L » ALIGN- $\times$ -R (for iterative left-to-right alternation). In the seven-syllable word this results in an alternating pattern, XoXoXoX, but in the six-syllable word the third step reaches XoXooX, which still has one violation of \*LAPSE. Language 17 continues in the next step to get rid of the lapse even though doing so introduces a violation of \*CLASH. The fact that it is the first syllable of the lapse that receives stress rather than the second follows from the fact that ALIGN- $\times$ -L is the dominant alignment constraint.

(198) Derivation of language 17 (Odd from left + final and antepenult)<sup>29</sup>

6 $\sigma$  oooooX → Xoxxxx → XoXooX → XoXXoX

7 $\sigma$  ooooooX → Xoxxxxx → XoXoooX → XoXoXoX

The non-rhythmicity in (198) is similar to the source of non-rhythmicity that occurs at the end of unidirectional parses as in (196) and (197) above. The difference is that here the high-ranking of \*LAPSE necessitates a \*CLASH violation (in even-parity words in this case) and the ALIGN- $\times$ -L constraints are simply used to determine where the clash will go. (The examples above, including language 22, differ in that a non-clashing candidate is available, e.g., oXoXoX, but oXoXXo is chosen instead specifically because of ALIGN- $\times$ -L's place in the constraint hierarchy, dominating \*CLASH.)

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<sup>29</sup>This is one of four possible derivations that result in this set of outputs. The other three are:

- i. oooooX → Xoxxxx → XooXoX → XoXXoX  
ooooooX → Xoxxxxx → XoooXoX → XoXoXoX
- ii. Xooooo → Xoxxxx → XoXooX → XoXXoX  
Xoooooo → Xoxxxxx → XoXoooX → XoXoXoX
- iii. Xooooo → Xoxxxx → XooXoX → XoXXoX  
Xoooooo → Xoxxxxx → XoooXoX → XoXoXoX

The ranking responsible for language 17 is  $\text{PEAK-R} \gg \text{PEAK-L} \gg *LAPSE \gg *CLASH$ ,  $\text{ALIGN-X-L} \gg \text{ALIGN-X-R}$ . Under this ranking in parallel OT the prediction is instead language 8 from (190),  $6\sigma$ :  $\text{XXoXoX}$ ,  $7\sigma$ :  $\text{XoXoXoX}$  (odd from right + initial). Although the seven-syllable word has the same stress pattern in both language 8 and language 17, the six syllable word differs. In language 17 it is  $\text{XoXXoX}$ , but in language 8 this candidate loses to the globally optimal  $\text{XXoXoX}$ —both feature maximum satisfaction of  $\text{PEAK-R}$ ,  $\text{PEAK-L}$ , and  $*LAPSE$ , and they both have the minimum number of  $*CLASH$  violations that can be incurred by any candidate that satisfies the three higher-ranked constraints, so in a parallel OT evaluation the choice is made by  $\text{ALIGN-X-L}$ , which assigns fewer violations to  $\text{XXoXoX}$  (9 \*'s) than to  $\text{XoXXoX}$  (10 \*'s). HS converges on  $\text{XoXXoX}$  instead because it relies, essentially, on the sequential satisfaction of high-ranked constraints to determine the output. The fact that this ranking yields language 17 in HS but language 8 in parallel OT represents a grid-based analog of what we saw in §5.2.2, where monosyllabic feet were able to appear in bidirectional derivations in HS but not in parallel OT. Here, too, when a  $*CLASH$  violation is unavoidable because of high-ranking  $*LAPSE$  and  $\text{PEAK}$  constraints, gradient grid-mark alignment constraints attract the clash to the dominant alignment edge in parallel OT.

The other languages in (191) that involve a bidirectional derivation are 18-21, 26, and 27. Languages 18 and 19 differ from the others in that the bidirectional parse yields a word-internal stress lapse, rather than a clash. This is consistent with attested bidirectional stress systems, which display an internal lapse rather than a clash, including Garawa (Furby 1974), which shows the pattern of language 19. (Though its mirror image, the pattern in 18, is not attested.) In languages

20, 21, 26, and 27 a word-internal clash results from the bidirectional derivation because of the ranking \*LAPSE » \*CLASH, as in language 17 just illustrated.<sup>30</sup>

The HS-only grid-based stress patterns in (191) each display at least one of these three sources of non-rhythm, and several of them display more than one. In general, it is clear that HS, as compared to parallel OT, suffers from an overgeneration problem when constituent representations are not assumed. Most of the languages in (191) would not be derivable with constituent representations under the current assumptions. Assuming that previously-built metrical structure is respected, a derivation with feet would prevent many of the clashes seen in (191) simply because the relevant stressless syllables would already be grouped into a foot with a stressed syllable. In language 11, for example, the derivation proceeds left-to-right trough-first and builds oXoXoX, but then it adds a stress on the initial syllable to satisfy PEAK-L, creating a clash, XXoXoX. With feet, in contrast, the left-to-right trough-first equivalent would be (oX)(oX)(oX), which cannot become (X)(X)(oX)(oX) at the next step under the assumptions I have used throughout the dissertation. Even if PEAK constraints were retained (the ALIGNHD constraints are a primary-stress-specific version of such constraints), the use of feet would limit their ability to add stresses after a rhythmic stress pattern has already been constructed, preventing some of the undesirable predictions that arise in HS with grid constraints. The same can be said at least for languages 12-14, 17, and 23-27, which would all be difficult to derive with feet and which are all unattested.

The conclusion from this comparison is that constituent representations work together with serialism to produce rhythmic and nearly-rhythmic stress patterns. Attempting to account for rhythmic patterns by placing grid marks directly with

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<sup>30</sup>Languages 18 and 19 are also predicted with foot-based representations in both parallel OT and HS when constraints like ALIGNHD or ALIGNWD are added to motivate bidirectionality. Languages 20 and 21 are predicted with feet in HS, but not parallel OT. See also fn. 28.



constraints like \*LAPSE and \*CLASH leads to the prediction of many non-rhythmic patterns and to typological overgeneration in HS compared to parallel OT.

## 5.4 Chapter summary and conclusion

In this chapter I have considered rhythmic stress from multiple points of view: with and without feet in HS and in parallel OT. Section 5.2 demonstrated that the foot-based representations and constraints that account for strictly alternating patterns predict a relatively small symmetric typology in both HS and parallel OT, but that differences in the treatment of monosyllabic feet suggest an advantage for serialism over parallelism with the standard representational assumptions. Section 5.3 presented a similar comparison without feet and showed that grid-based constraints are treated differently in parallel OT and HS, with considerable overgeneration in the latter framework as a result of sequential rather than simultaneous satisfaction of constraints that directly reference rhythm.

The results of this chapter suggest a generalization to be made about metrical constituency and mode of evaluation. When the mode of evaluation is serial, constituent representations are superior to direct reference to rhythm in accounting for stress patterns in a reasonably typologically restrictive way. Feet are a successful means of accounting for rhythm in HS because they encapsulate the notion of alternation (by being generally binary with one strong and one weak element). In contrast, direct reference to rhythm, while relatively successful in parallel OT where the whole pattern can be optimized at once, is problematic in HS, where intermediate stages of a derivation struggle to represent rhythm without access to all of the grid marks and their possible configurations.

Furthermore, the results hint at another generalization: standard constituent representations function best when the mode of evaluation is serial, as evidenced by §5.2.2 and also by the locality results of chapter 2. Serialism ensures that feet

function as intended to achieve alternation, with alignment constraints showing consistent behavior in HS but not in parallel OT. Taken together, the results of this chapter suggest, at the very least, a tight connection between metrical representations and the grammar responsible for building those representations.

## CHAPTER 6

### CONCLUSION

This dissertation has focused the consequences of serial evaluation for typological predictions in metrical stress. Chapter 2 argued that Harmonic Serialism was better equipped than parallel Optimality Theory to capture a generalization about locality in stress systems under standard representational assumptions. Chapter 3 presented a case for limited parallelism in stress by showing that the range of attested patterns of primary stress is best captured by a model that treats the assignment and reassignment of primary stress as a ‘free’ operation. Chapter 4 discussed primary stress further by arguing for a particular definition of primary stress alignment and by presenting evidence that vacuous satisfaction of primary stress constraints makes problematic typological predictions, which were then argued to be solved by non-vacuous constraint schemata in combination with HS’s restricted GEN. Finally, chapter 5 made some comparisons between the representation of alternating stress patterns with feet and without feet and discussed how parallel OT and HS differ in their predictions under each set of representational assumptions. Taken together, these chapters suggest that HS provides a viable framework for the modeling of stress typology.

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