Phonology **27** (2010) 481–526. © Cambridge University Press 2010
doi:10.1017/S0952675710000229

*Serialism and locality in constraint-based metrical parsing**

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This paper proposes a model of stress assignment in which metrical structure is built serially, one foot at a time, in a series of Optimality Theory (OT)-style evaluations. Iterative foot optimisation is made possible in the framework of Harmonic Serialism, which defines the path from an input to an output with a series of gradual changes in which each form improves harmony relative to a constraint ranking. Iterative foot optimisation makes the strong prediction that decisions about metrical structure are made locally, matching attested typology, while the standard theory of stress in parallel OT predicts in addition to local systems unattested stress systems with non-local interactions. The predictions of iterative foot optimisation and parallel OT are compared, focusing on the interactions of metrical parsing with syllable weight, vowel shortening and constraints on the edges of prosodic domains.

1 Introduction

Harmonic Serialism (HS) is a variant of Optimality Theory (OT) that combines optimisation with a derivation. HS is discussed briefly by Prince & Smolensky (2004: 6–7, 94–96), but is put aside in favour of the 'parallel' version of the theory (henceforth PARALLEL OT). While parallel OT assumes no intermediate derivational steps between a phonological underlying form and its corresponding surface form, HS assumes that an input to the grammar is gradually altered to reach its output, with one operation applying at each step. Operations only apply in an HS derivation when they improve performance on the constraint hierarchy of the language. Recent work, initiated by McCarthy (2000, 2006), has demonstrated

* Many thanks are due to John McCarthy and Joe Pater for help with this work. Thanks also to the members of the Fall 2007 3rd year seminar at UMass Amherst and to the audiences of HUMDRUM 2008 at Rutgers and OCP 6 for additional comments. I also owe a great debt to three anonymous reviewers, an anonymous associate editor and the editors of *Phonology* for many more helpful comments, suggestions and criticisms. This research was supported in part by grant BCS-0813829 from the National Science Foundation to the University of Massachusetts, Amherst.

https://doi.org/10.1017/S0952675710000229 Published online by Cambridge University Press

that this essential difference gives HS an advantage over parallel OT in successfully analysing a range of phonological processes (e.g. McCarthy 2000, 2006, 2007a, b, 2008a, b, 2010a, b, forthcoming, Wolf 2008, Elfner 2009, Jesney, forthcoming, Kimper, forthcoming, Pater, forthcoming).

In particular, there is emerging evidence that HS 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, 2010b). McCarthy shows that parallel OT predicts a language with a non-local truncation process if CON contains a constraint against syllable-final obstruents (CODACOND) and a constraint requiring phonological words to end in a consonant (FINALC), each of which receives independent support from phonological typology. When both FINALC and CODACOND 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 (1) with a hypothetical input form. In this same language, no truncation occurs in words that have no sonorant consonants.

(1) *Non-local truncation in parallel OT* (McCarthy 2006)

/palasanataka/	FINALC	CODACOND	MAX
a. palasanataka	*!		
b. palasanatak		*!	*
c. palasanata	*!		**
d. palasanat		*!	***
e. palasana	*!		****
☞ f. palasan			*****

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

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treating each deletion as a separate step.[1] The output in (1) 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 realised until five segments have undergone deletion. HS has been shown to solve similar locality problems for autosegmental spreading (McCarthy 2006, forthcoming, Kimper 2010), metathesis (McCarthy 2006), tone flop (McCarthy 2006) and positional faithfulness (Jesney, forthcoming). This paper adds to this list by showing that the standard theory of stress in parallel OT (McCarthy & Prince 1993a, Prince & Smolensky 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 prediction 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 paper 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.

The organisation of this paper is as follows: §2 provides the details of the present proposal and shows how stress is assigned in HS with these assumptions. §§3–5 turn to cases in which parallel OT predicts non-local stress systems while HS does not (§3 explores this dichotomy with the interaction of syllable weight and metrical parsing, building on a previous discussion by Hyde (2007); §4 shows similar non-local predictions for metrically conditioned quantity adjustments; and §5 turns to a non-local interaction between final syllable extrametricality and foot headedness). §6 briefly compares the theory of stress assignment proposed in this paper with alternatives beyond the standard theory of parallel OT, and §7 concludes.

2 Iterative foot optimisation

This section proposes a model in which word stress is assigned by iteratively building the 'best' foot with a series of optimisations. I will refer to this proposal as Harmonic Serialism with iterative foot optimisation (HS/IFO or IFO). 'Iterative' here refers to the fact that in HS, evaluations occur repeatedly until convergence (see below). First, some background on HS is provided (a more extensive introduction can be found in McCarthy 2010a), followed by an explanation of the assumptions of IFO and an illustration of how it works.

[1] In McCarthy (2006) Harmonic Serialism is called 'persistent OT'.

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2.1 Harmonic Serialism

HS shares with parallel OT several trademark features, including the characterisation 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 an input is mapped onto an output.[2] In parallel OT, any and all mutations of an input are performed in parallel, and the resulting candidates are evaluated once, with a single winner chosen relative to the ranking of the constraints. In contrast, an input to an HS grammar is gradually altered to reach an output, with each step in the derivation chosen by optimisation over a set of alternatives derived by 'do[ing] any *one* thing' to the previous iteration's output (Prince & Smolensky 2004: 6). The same ranking is used at each iteration, and the derivation CONVERGES when the input to a particular iteration is returned as the optimal candidate at that iteration, as this indicates that no additional changes result in a more harmonic output relative to the constraint hierarchy.

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' which characterises the GEN component of parallel OT (McCarthy & Prince 1993b). Instead, it only provides candidates differing in at most one respect from the input at each iteration. The GEN–EVAL relationship is also different in HS, in that GEN and EVAL are in a loop until convergence: GEN produces a set 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 optimisation, 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 and forms that are one change away from the input. Thus, *every* form in an HS derivation is a local optimum. 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

[2] The HS-specific terminology used throughout this section follows McCarthy.

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build one foot). Parallel OT, in contrast, always finds the *global* optimum relative to that input and constraint ranking. The global optimum is the best possible candidate, relative to a given constraint ranking, among the 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 constraint ranking is employed. 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. This paper will argue (along with other recent work, e.g. McCarthy 2006, 2010a, b) 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 not a failure at all.

2.2 Gradualness in IFO

2.2.1 *Representations and operations.* 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. This paper explores the consequences of defining gradualness in metrical structure-building as the addition of one metrical foot.[3] 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. The present proposal is similar in some ways to the theory of Harmonic Parsing, proposed by Prince (1990), which also builds feet serially according to a metric of foot well-formedness.

In order to simplify the discussion, I will assume throughout the paper 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 (2). 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 (2) is optimal.[4]

[3] Unlike recent work by McCarthy (2007a, 2008b), 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 (forthcoming) and Pater (forthcoming).

[4] I assume that underlying foot structure is not at issue here. See McCarthy & Pruitt (forthcoming) for arguments that lexical foot structure is not a viable way of encoding contrastive stress in HS and for an alternative proposal.

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

Faithful candidate	*σσσσσ*				
Monosyllabic foot	(ˈ*σ*)*σσσσ*	*σ*(ˈ*σ*)*σσσ*	*σσ*(ˈ*σ*)*σσ*	*σσσ*(ˈ*σ*)*σ*	*σσσσ*(ˈ*σ*)
Disyllabic trochee	(ˈ*σσ*)*σσσ*	*σ*(ˈ*σσ*)*σσ*	*σσ*(ˈ*σσ*)*σ*	*σσσ*(ˈ*σσ*)	
Disyllabic iamb	(*σ*ˈ*σ*)*σσσ*	*σ*(*σ*ˈ*σ*)*σσ*	*σσ*(*σ*ˈ*σ*)*σ*	*σσσ*(*σ*ˈ*σ*)	

2.2.2 *Faithfulness to foot structure*. 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 this paper I adopt the assumption that feet can be built by GEN, but not altered or removed. I refer to this assumption as STRICT INHERITANCE. Adopting this principle invokes a kind of inviolable faithfulness to metrical structure that is built in the course of a derivation. One consequence of strict inheritance is that foot building can only parse 'free' syllables, i.e. those that are not yet in a foot (Prince 1985).

To see how this assumption works, consider a case in which the candidate with a left-aligned disyllabic trochee, (ˈ*σσ*)*σσσ*, is the most harmonic among the candidates in (2) at the first iteration; the set of candidates for 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 also includes all the candidates derivable from this input by building one licit foot on its remaining free syllables.

(3) *Candidates for second foot in a five-syllable word, given input* (ˈ*σσ*)*σσσ*

Faithful candidate	(ˈ*σσ*)*σσσ*		
Monosyllabic foot	(ˈ*σσ*)(ˈ*σ*)*σσ*	(ˈ*σσ*)*σ*(ˈ*σ*)*σ*	(ˈ*σσ*)*σσ*(ˈ*σ*)
Disyllabic trochee	(ˈ*σσ*)(ˈ*σσ*)*σ*	(ˈ*σσ*)*σ*(ˈ*σσ*)	
Disyllabic iamb	(ˈ*σσ*)(*σ*ˈ*σ*)*σ*	(ˈ*σσ*)*σ*(*σ*ˈ*σ*)	

By assumption, I also impose a ban against the incorporation of free syllables into previously built feet. For instance, if the constraints instead favoured (ˈ*σ*)*σσσσ* in the first iteration, (ˈ*σσ*)*σσσ* would not be a candidate in the second iteration.

The analyses in this paper will show that, in general, strict inheritance has positive consequences. However, future work should ultimately sort out how the predictions of IFO with strict inheritance differ from a theory that treats previously built metrical structure with violable faithfulness.[5]

[5] A final assumption that will have to be made is how and at what point in the derivation degrees of stress should be distinguished. There is a range of ways in which the distinction between primary and non-primary stress could be derived in HS, but I will not commit myself to a particular proposal here and will abstract away from degrees of stress for the analyses presented in this paper. (See McCarthy 2008b for one proposal.)

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2.3 Illustration

This section presents a stress derivation in HS/IFO for the language Pintupi (Pama-Nyungan; Northern Territory, Australia; Hansen & Hansen 1969, 1978), which has been analysed as having a quantity-insensitive trochaic stress system (Hayes 1995). Main stress is initial, with secondary stresses falling on odd-numbered non-final syllables. The data in (4) demonstrate 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, since stress is indifferent to them.

(4) *Pintupi stress* (Hansen & Hansen 1969:163)

		Proposed foot structure
ˈt̪uṯaja	'many'	(ˈσσ)σ
ˈmaɭaˌwana	'through (from) behind'	(ˈσσ)(ˌσσ)
ˈpuɭiŋˌkalat̪u	'we (sat) on the hill'	(ˈσσ)(ˌσσ)σ

I analyse Pintupi with left-aligning (that is, left-to-right) syllabic trochees, adapting the standard analysis from Hayes (1995), using constraints developed in McCarthy & Prince (1993a) and Prince & Smolensky (2004).[6] The constraints that will be used inherit their definitions from parallel OT analyses, but they will ultimately result in different predictions in IFO (as the next sections will show) because of the difference between parallel and serial evaluation.

The constraint PARSE-σ, defined in (5a), provides the impetus for foot-building (Prince & Smolensky 2004), while generalised alignment constraints ALLFT-L and ALLFT-R, defined in (5b, c), account for directionality by preferring feet to be aligned as far as possible to the edge of the word (McCarthy & Prince 1993a).

(5) a. PARSE-σ
Assign one violation mark for every syllable that is not a member of some foot.

b. ALLFT-L
For each foot in a word assign one violation mark for every syllable separating it from the left edge of the word.

c. ALLFT-R
For each foot in a word assign one violation mark for every syllable separating it from the 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 (6) are necessary. These are equivalent to the RHTYPE ('rhythmic type') constraints of Prince &

[6] A straightforward introduction to the McCarthy & Prince (1993a) and Prince & Smolensky (2004) theory of stress in parallel OT can be found in Kager (1999: ch. 4).

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Smolensky (2004: 63). Monosyllabic feet are assumed to satisfy both constraints.

(6) a. TROCHEE
Assign one violation mark for a foot whose head is not aligned with its left edge.
b. IAMB
Assign one violation mark for a foot whose head is not aligned with its right edge.

Feet in Pintupi are strictly disyllabic, so a constraint preferring binary feet is needed. I adopt Prince & Smolensky's (2004: 56) foot-binarity constraint, FTBIN, defined in (7), which they adapt from Prince (1980).

(7) FTBIN
Feet are binary at some level of analysis (μ, σ).

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 (7) will be sufficient. It will prevent words in Pintupi from having monosyllabic feet, ruling out parses like ('$\sigma\sigma$)('$\sigma\sigma$)('σ) when it is ranked above PARSE-σ, which successfully accounts for the absence of stress on final syllables in this language.[7] 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 /$\sigma\sigma\sigma\sigma\sigma$/ is ultimately parsed as ('$\sigma\sigma$)('$\sigma\sigma$)σ, in a series of harmonically improving foot-building steps. The derivation will follow the trajectory shown in (8), with a five-syllable word from Pintupi. The following paragraphs provide ranking arguments for the derivation of this form in IFO.

(8) *Syllabic trochee derivation for Pintupi* ['puɭiŋ'kalaʈu]
/puɭiŋkalaʈu/ → ('pu.ɭiŋ)ka.la.ʈu → ('pu.ɭiŋ)('ka.la)ʈu → [('pu.ɭiŋ)('ka.la)ʈu]
'we (sat) on the hill'

[7] 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 §3.1.2.

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In the first step, a left-aligned disyllabic trochee beats every other candidate (see (2) for an exhaustive list). The tableau in (9) shows the first step of the derivation. This and subsequent tableaux in this paper are presented in a modified version of the comparative format of Prince (2002). Each row displays the number of violation marks that the candidate receives on each constraint 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 favours 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 favours the loser. If a losing candidate has the same number of marks for a constraint as the winning candidate, neither a W nor an L is present. This tableau format allows ranking arguments to be displayed clearly. For the intended winner to win, any loser-favouring constraint must be dominated by a winner-favouring constraint, and thus any L in the tableau must be dominated by a W in the same row. For the left-aligned disyllabic trochee to be optimal in the first step of the derivation, the tableau in (9) shows that AllFt-L must dominate AllFt-R (according to row (c)), and Trochee must dominate Iamb (row (d)). Parse-σ must also be high enough ranked to compel building this foot, even though doing so causes violations of Iamb and AllFt-R, as indicated by the location of Ws and Ls in row (a).

(9) *Ranking arguments from first iteration:* Parse-$\sigma \gg$ Iamb, AllFt-R; AllFt-L $\gg$ AllFt-R; Trochee $\gg$ Iamb

/puˌliŋkalaˌtu/	Parse-σ	Trochee	AllFt-L	Iamb	AllFt-R
1st iteration					
a. pu.ˌliŋ.ka.la.ˌtu	W5			L	L
☞ b. (ˈpu.ˌliŋ)ka.la.ˌtu	3			1	3
c. pu.ˌliŋ.ka(ˈla.ˌtu)	3		W3	1	L
d. (pu.ˈˌliŋ)ka.la.ˌtu	3	W1		L	3

For a full 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, (ˈpu.ˌliŋ)(ˈka.la)ˌtu wins over its competitors. As row (a) of the tableau in (10) shows, this requires that one additional ranking be assumed: Parse-$\sigma \gg$ AllFt-L. McCarthy & Prince (1993a) show that this ranking must hold to account for rhythmic stress in parallel OT; otherwise, a single foot remains at the left edge and additional feet are not built. The same holds in IFO.

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(10) *Ranking argument from second iteration:* PARSE-σ ≫ ALLFT-L

(ˈpu.ɭiŋ)ka.la.t̪u	PARSE-σ	ALLFT-L
2nd iteration		
a. (ˈpu.ɭiŋ)ka.la.t̪u	W3	L
☞ b. (ˈpu.ɭiŋ)(ˈka.la)t̪u	1	2

The third iteration requires that (ˈpu.ɭiŋ)(ˈka.la)t̪u again be returned as the best output, indicating that additional foot-building is not harmonically improving and signalling convergence. Because the input to this iteration, (ˈpu.ɭiŋ)(ˈka.la)t̪u, contains only one free syllable, there is only one other candidate for adding foot structure, (ˈpu.ɭiŋ)(ˈka.la)(ˈt̪u). This candidate loses on the grounds that it contains a monomoraic foot, even though it satisfies PARSE-σ perfectly. The ranking FTBIN ≫ PARSE-σ accounts for this, as shown in (11).

(11) *Ranking argument from third iteration:* FTBIN ≫ PARSE-σ

(ˈpu.ɭiŋ)(ˈka.la)t̪u	FTBIN	PARSE-σ
3rd iteration		
☞ a. (ˈpu.ɭiŋ)(ˈka.la)t̪u		1
b. (ˈpu.ɭiŋ)(ˈka.la)(ˈt̪u)	W1	L

The summary tableau in (12) shows the full derivation of this form with this ranking in place.[8] 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 ALLFT-L. This form is passed to the second iteration, where it appears 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 PARSE-σ 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 FTBIN, which outranks PARSE-σ, and the derivation converges by choosing candidate (g).

[8] In this tableau format a winning candidate at a particular iteration is indicated by the tail of an arrow which goes down to the next iteration. The locally faithful candidate at an iteration (the original input or the previous iteration's winner) is listed first. Rows are indexed continuously within the derivational tableaux, to avoid ambiguity in referring to candidates.

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(12)

/puˌlɪŋkalaˌtu/	FtBin	Trochee	Parse-σ	AllFt-L	Iamb	AllFt-R
1st iteration						
a. pu.ˌlɪŋ.ka.la.ˌtu			W5		L	L
b. (ˈpu.ˌlɪŋ)ka.la.ˌtu			3		1	3
c. pu.ˌlɪŋ.ka(ˈla.ˌtu)			3	W3	1	L
d. (pu.ˈˌlɪŋ)ka.la.ˌtu		W1	3		L	3
2nd iteration						
e. (ˈpu.ˌlɪŋ)ka.la.ˌtu			W3	L	L1	L3
f. (ˈpu.ˌlɪŋ)(ˈka.la)ˌtu			1	2	2	4
3rd iteration						
g. (ˈpu.ˌlɪŋ)(ˈka.la)ˌtu			1	2	2	4
h. (ˈpu.ˌlɪŋ)(ˈka.la)(ˈˌtu)	W1		L	W6	2	4
output: (ˈpu.ˌlɪŋ)(ˈka.la)ˌtu						

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

2.4 Summary

IFO proposes that stress patterns emerge from a series of optimisations which successively choose the best foot. Gen produces candidates with one additional foot at each iteration, and the constraint ranking determines which foot is chosen as optimal and passed to the next iteration. The assumption of strict inheritance dictates that which syllables constitute a foot's membership and which syllable is designated as head of that foot are not alterable in the course of deriving word stress.

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 preceding analysis. 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 McCarthy & Prince (1993a) and Prince & Smolensky (2004) are widely used in parallel OT, as are the representational assumptions on which they are based. It is reasonable 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 emphasise that the specifics of the discussion depend, as always, on one's assumptions about Gen and Con.

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3 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 generalised trochee languages (Kager 1992a, b, citing Hayes 1991). Two of the languages that are claimed to exemplify this stress pattern are Estonian (Hint 1973, Prince 1980, Kager 1992a, b) and Weŋgaia (Hercus 1969, 1986, Hyde 2007). This stress pattern is shown schematically in (13).

(13) *Generalised trochee pattern*

a. *Odd-parity words*
$\sigma\sigma\sigma\sigma H \rightarrow (\text{'}\sigma\sigma)(\text{'}\sigma\sigma)(\text{'}H)$
$\sigma\sigma\sigma\sigma L \rightarrow (\text{'}\sigma\sigma)(\text{'}\sigma\sigma)L$

b. *Even-parity words*
$\sigma\sigma\sigma\sigma \rightarrow (\text{'}\sigma\sigma)(\text{'}\sigma\sigma)$

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 generalised 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 generalised trochee languages in the standard theory of stress in parallel OT. The constraints required by the standard theory to analyse the attested generalised 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 Weŋgaia to illustrate the attested generalised trochee pattern. §3.1 provides analyses of Weŋgaia in IFO and in parallel OT with the standard stress constraints. In §3.2 I summarise Hyde's discussion of the problematic predictions of the standard theory, but reconceptualise the problem as one of (non-)locality. Finally, in §3.3 I show that this errant prediction does not arise from the minimally different serial analysis, and discuss the properties of IFO that make this true.

3.1 Local weight-sensitivity in Weŋgaia

Weŋgaia (Pama-Nyungan; Southeastern Australia (extinct); Hercus 1969, 1986) has a stress pattern that is similar to that of Pintupi, which was discussed in the previous section. Main stress is initial, with secondary

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stresses on remaining odd-numbered syllables. But while stress never falls on the final syllable in Pintupi, in Weɽgaia a final odd-numbered syllable is stressed if (and only if) it is heavy, making it a canonical generalised trochee stress pattern. Vowel length in Weɽgaia is limited to initial position (Hercus 1986 : 81), and thus only closed syllables are able to induce final stress in odd-parity words.[9] (14a) shows words with an even number of syllables, (b) odd-parity words with a final light syllable and (c) odd-parity words with a final heavy syllable.

(14) *Weɽgaia stress* (Hercus 1969, Hyde 2007)

			Proposed foot structure
a.	ˈgaba	‘to chase’	(ˈLL)
	ˈwiɽimˌbuliŋ	‘spider’	(ˈLH)(ˌLH)
b.	ˈdaguŋga	‘to punch someone’	(ˈLH)L
	ˈdelguna	‘to cure’	(ˈHL)L
c.	ˈbunaˌɖug	‘broad-leaved mallee’	(ˈLL)(ˌH)
	ˈgeɟauˌwil	‘a lot, many’	(ˈLH)(ˌH)

3.1.1 *HS analysis*. The stress pattern of Weɽgaia can be analysed in IFO with essentially the same ranking as Pintupi, discussed in §2.3. Stress is assigned iteratively left-to-right, so the ranking PARSE-$\sigma \gg$ ALLFT-L $\gg$ ALLFT-R is needed, the ranking TROCHEE $\gg$ IAMB accounts for the preference for left-headed feet and the ranking FTBIN $\gg$ PARSE-σ ensures that there will be no monomoraic feet.[10] The following paragraphs illustrate the analysis with examples.

The tableau in (15) shows the derivation of an even-parity word, in which an input with the light–heavy sequence /LHLH/ is parsed as (ˈLH)(ˈLH). In the first iteration, the candidate with a disyllabic left-aligned trochee, (ˈwi.ɽim)bu.liŋ, 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 ALLFT-L. This form is passed to the second iteration, where the addition of another disyllabic foot is found to be harmonically improving, so (ˈwi.ɽim)(ˈbu.liŋ) 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

[9] Diphthongs may also appear word-finally, but whether they necessarily receive stress in this position is not completely consistent in the source.

[10] The grammar must restrict vowel length to initial (main stress) position in both Pintupi and Weɽgaia, 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 Weɽgaia, 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, which would not significantly affect the discussion in this section.

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derivation shows that, in general, parsing is insensitive to syllable weight in generalised trochee languages, since parsing this word yields two feet with heavy syllables in weak position.

(15) /LHLH/ → ('LH)('LH)

/wiɽimbuliŋ/	FtBin	Parse-σ	AllFt-L	AllFt-R
1st iteration				
a. ('wi)ɽim.bu.liŋ	W1	W3		W3
b. wi('ɽim)bu.liŋ		W3	W1	2
c. ('wi.ɽim)bu.liŋ		2		2
2nd iteration				
d. ('wi.ɽim)bu.liŋ		W2	L	2
e. ('wi.ɽim)('bu.liŋ)			2	2
3rd iteration				
f. ('wi.ɽim)('bu.liŋ)			2	2
output: ('wi.ɽim)('bu.liŋ)				

The tableau in (16) shows a derivation for an odd-parity word ending in a light syllable. The first iteration chooses the disyllabic left-aligned trochee as the best foot, just as in (15). In the second iteration the 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-σ. The output is ('del.gu)na.

(16) /HLL/ → ('HL)L

/delguna/	FtBin	Parse-σ	AllFt-L	AllFt-R
1st iteration				
a. ('del)gu.na		W2		W2
b. ('del.gu)na		1		1
c. del('gu.na)		1	W1	L
2nd iteration				
d. ('del.gu)na		1		1
e. ('del.gu)('na)	W1	L	W2	1
output: ('del.gu)na				

However, in the tableau in (17) an input with the shape /LLH/ becomes output ('LL)('H), with parsing sensitive to the weight of the last syllable. At the first iteration, the candidate ('bu.na)ɖug, with a disyllabic left-aligned trochee, is the winner. At the second iteration this candidate is compared with a candidate that has the last syllable footed, ('bu.na)('ɖug). The latter wins because it better satisfies Parse-σ while also satisfying the bimoraic minimum on feet, since the final syllable is heavy. The third

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iteration shows convergence, which occurs because no more metrification is possible, and thus the output is (ˈbu.na)(ˈɖug).

(17) /LLH/ → (ˈLL)(ˈH)

/bunaɖug/	FtBin	Parse-σ	AllFt-L	AllFt-R
1st iteration				
a. (ˈbu)na.ɖug	W1	W2		W2
b. (ˈbu.na)ɖug		1		1
c. bu.na(ˈɖug)		W2	W2	L
2nd iteration				
d. (ˈbu.na)ɖug		W1	L	1
e. (ˈbu.na)(ˈɖug)			2	1
3rd iteration				
f. (ˈbu.na)(ˈɖug)			2	1
output: (ˈbu.na)(ˈɖug)				

The grammar of a generalised trochee language like Weŋgaia must allow both (ˈσσ) and (ˈH), while banning (ˈL) (Prince (1980; see also Kager 1992a, b). Our definition of FtBin encodes this preference by allowing (ˈσσ) and (ˈH), but not (ˈL), 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, disyllabic feet are preferred, other things being equal, since monosyllabic heavy feet are limited to final position. The IFO analysis presented above is able to capture this generalisation as a result of relatively high-ranked Parse-σ, which prefers a larger foot in IFO; when one foot is added at a time, a larger foot means fewer remaining unparsed syllables. Thus, Parse-σ in IFO mimics to some extent the maximality condition of rule-based metrical parsing (Prince 1980, Halle & Vergnaud 1987: 15, Hayes 1995: 102–103), with the crucial difference being that it is violable. We will see in the next section that an analysis of Weŋgaia in parallel OT requires an additional constraint to favour disyllabic feet, because Parse-σ does not function as a maximality condition when metrical parses are compared in parallel.

3.1.2 *Parallel OT analysis.* Hyde (2007) shows that it is not possible to account for the Weŋgaia stress pattern using only the standard parsing constraints (AllFt-L/R, Parse-σ, FtBin) in parallel OT, but that a high-ranked rhythm constraint like *Clash, defined in (18) (Prince 1983, Selkirk 1984, Kager 1994), makes an analysis possible.

(18) *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

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(19) shows that this input is incorrectly parsed as *(ˈdel)(ˈgu.na), rather than the correct (ˈdel.gu)na. The grammar of Weɽgaia must permit (ˈH) feet in order to account for mappings like /bunaɖug/ → (ˈbu.na)(ˈɖug), but in (19) the incorrectly optimal candidate capitalises on this by placing a monosyllabic foot in *initial* position in order to achieve better overall satisfaction of PARSE-*σ*.

(19) /HLL/ ↛ (ˈHL)L

/delguna/	FTBIN	PARSE-*σ*	ALLFT-L	ALLFT-R
☜ a. (ˈdel.gu)na		1		1
☞ b. (ˈdel)(ˈgu.na)			1	2

Since the wrong winner, (19b), 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/ → (ˈH)(ˈLL) in (19), and instead predicts the right result for this input, as shown in (20). This ranking is consistent with the other attested mappings in Weɽgaia, since no surface forms in the language violate *CLASH.

(20) /HLL/ → (ˈHL)L *in parallel OT*

/delguna/	*CLASH	FTBIN	PARSE-*σ*	ALLFT-L
☞ a. (ˈdel.gu)na			1	
b. (ˈdel)(ˈgu.na)	W1		L	W1

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/ → (ˈdel.gu)na, but then /bunaɖug/ would be incorrectly parsed as (ˈbu.na)ɖug rather than the correct (ˈbu.na)(ˈɖug). Similarly, a definition of FTBIN that preferred feet to be strictly bimoraic would correctly account for /bunaɖug/ → (ˈbu.na)(ˈɖug), but would not correctly analyse /delguna/, which surfaces with a trimoraic foot, (ˈdel.gu)na. Thus, a constraint defined as a bimoraic *minimum*, as FTBIN has been defined here, is necessary for an analysis of Weɽgaia and other generalised trochee languages, in both IFO and in parallel OT. In the IFO analysis incremental foot building accounts for the limited distribution of (ˈH), while in the parallel OT analysis this is achieved with *CLASH.

3.2 Non-local weight-sensitivity (unattested)

It is clear that a relatively straightforward analysis of Weɽgaia is possible in both IFO 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 §3.1.2 predict other partially quantity-sensitive stress patterns which are non-local and are not attested, revealing

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an overgeneration 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 Karttunen (2006) and Frampton (2007).

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 ≫ AllFt-L ≫ *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 (21).

(21) *Left-to-right parsing*

/LLLLL/	FtBin	Parse-σ	AllFt-L	*Clash
☞ a. ('LL)('LL)L		1	2	
b. ('LL)('LL)('L)	W1	L	W6	
c. L('LL)('LL)		1	W4	

However, as shown in (22), an initial heavy syllable is parsed into a monosyllabic foot, as permitted by FtBin, in order to better satisfy Parse-σ.

(22) *Maximal parsing with initial heavy syllable*

/HLLLL/	FtBin	Parse-σ	AllFt-L	*Clash
☞ a. ('H)('LL)('LL)			4	1
b. ('HL)('LL)L		W1	L2	L
c. ('HL)('LL)('L)	W1		W6	L

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 (23). *Clash will not be respected, because it is low-ranked, unlike in generalised trochee languages.

(23) *Maximal parsing with medial heavy syllable*

/LLHLL/	FtBin	Parse-σ	AllFt-L	*Clash
☞ a. ('LL)('H)('LL)			5	1
b. ('LL)('HL)L		W1	L2	L
c. ('LL)('HL)('L)	W1		W6	L

The tableau in (24) shows that this language is indeed only partially quantity-sensitive. The input /HLHLH/ has three heavy syllables, and

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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-σ. When several heavy syllables can serve this purpose, the choice between them is made by ALLFT-L, as comparing candidate (a) with (b) and (c) in tableau (24) reveals.[11]

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

/HLHLH/	FTBIN	PARSE-σ	ALLFT-L	*CLASH
☞ a. ('H)('LH)('LH)			4	1
b. ('HL)('H)('LH)			W5	1
c. ('HL)('HL)('H)			W6	L
d. ('HL)('HL)H		W1	L2	L

The tableaux in (25) show furthermore that heavy syllables in even-parity words are not parsed into monosyllabic feet, even when PARSE-σ can be equally satisfied by doing so (e.g. (25b.ii)).

(25) *Even parity; no weight-sensitivity*

a.

/HLLL/	FTBIN	PARSE-σ	ALLFT-L	*CLASH
☞ i. ('HL)('LL)			2	
ii. ('H)('LL)L		W1	L1	W1

b.

/HLLH/				
☞ i. ('HL)('LH)			2	
ii. ('H)('LL)('H)			W4	W1

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 (26), where σ = any weight (H or L).

[11] 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 (24)) and is related to the known preference for alignment constraints to attract monosyllabic feet towards the dominant edge of alignment in parallel OT (Crowhurst & Hewitt 1995a). Alignment constraints in IFO do not show this behaviour.

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(26) *Schematic summary of predicted language*

a. *Even-parity words*
$\sigma\sigma\sigma\sigma \rightarrow (\text{'}\sigma\sigma)(\text{'}\sigma\sigma)$

b. *Odd-parity words*
$L\sigma L\sigma L \rightarrow (\text{'}L\sigma)(\text{'}L\sigma)L$
$H\sigma\sigma\sigma\sigma \rightarrow (\text{'}H)(\text{'}\sigma\sigma)(\text{'}\sigma\sigma)$
$L\sigma H\sigma\sigma \rightarrow (\text{'}L\sigma)(\text{'}H)(\text{'}\sigma\sigma)$
$L\sigma L\sigma H \rightarrow (\text{'}L\sigma)(\text{'}L\sigma)(\text{'}H)$
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 (21), 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 (22), while for /HLLL/ it is ('HL)('LL), with the heavy syllable parsed into a disyllabic foot with the immediately following syllable, as in (25a). 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 generalisation 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 (this can be confirmed by consulting (26)). 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 (§2.3) 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.

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In this sense, the prediction is nearly identical in character to the non-local truncation example.[12]

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 Weŧgaia, 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. 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 overgeneration 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 analyse Weŧgaia and similar languages without venturing well beyond the standard theory. The burden of responsibility for this prediction lies with PARSE-σ and FTBIN when implemented with parallelism.[13] But a constraint like PARSE-σ 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 §3.1. Some of the characteristics of this strange language appear to be due to gradient alignment constraints (ALLFT-L/R). Nonetheless, theories that abandon gradient alignment in favour of other constraints to model directionality (e.g. Kager 2001, McCarthy 2003) will still predict non-local partially quantity-sensitive stress patterns if PARSE-σ and FTBIN are retained; when high-ranked, these constraints conspire to place monosyllabic feet wherever necessary to maximise the parsing of the whole word, despite the preferences of lower-ranking constraints.

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-σ and FTBIN, in favour of constraints from the NON-FINALITY family. In the next section I show that HS allows

[12] 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.

[13] Hyde (2007) also provides arguments that PARSE-σ and FTBIN are the locus of this problem.

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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 §6.

3.3 Why HS is local

The previous section showed that parallel OT predicts an unattested language with the ranking FTBIN ≫ PARSE-σ ≫ ALLFT-L ≫ *CLASH. In IFO, on the other hand, the attested generalised trochee pattern is produced under this ranking, as was evidenced in §3.1.[14] 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 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 (ˈHL)(ˈLL) and input like /HLL/ to become (ˈH)(ˈLL), while also generating a pattern that looks left-to-right in a word comprising an odd number of light syllables, /LLLLL/ → (ˈLL)(ˈLL)L. These input–output pairs would require derivations like those in (27).

(27) *Derivations required for hypothetical language*

a. /HLLL/ → (ˈHL)LL → (ˈHL)(ˈLL)
b. /HLL/ → (ˈH)LL → (ˈH)(ˈLL)
c. /LLLLL/ → (ˈLL)LLL → (ˈLL)(ˈLL)L

There is no ranking of the standard constraints that will produce the derivations in (27) with IFO. At the first iterations, a ranking that would prefer /HLLL/ → (ˈHL)LL, as required for (a), would also prefer /HLL/ → (ˈHL)L, contrary to what is found in (b). The tableaux in (28) show this result. These inputs are treated the same at the first iteration. The grammar does not have the foresight to know that (ˈH)(ˈLL) is the global optimum for input /HLL/, so it will not take this into account at the first

[14] 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.

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iteration and choose ('H)LL instead. Furthermore, the assumption of strict inheritance prevents the actual first iteration's optimum, ('HL)L, from becoming ('H)('LL) at a subsequent step.[15]

(28) *Disyllabic trochee preferred in both derivations: first iteration*

	/HLL/	FtBin	Parse-σ	AllFt-L	*Clash
a.	i. ('H)LL		W2		
	☞ ii. ('HL)L		1		
b.	/HLLL/				
	i. ('H)LLL		W3		
	☞ ii. ('HL)LL		2		

In a similar way, a ranking that would produce /HLL/ → ('H)LL as is needed for (27b), would also prefer /HLLL/ → ('H)LLL, contrary to (27a). This is shown in (29). These tableaux show that when a constraint favouring ('H) over ('HL), which I abbreviate *('HL), outranks Parse-σ, it favours ('H) in *both* derivations, not just (29a).[16]

(29) *Monosyllabic heavy preferred in both derivations: first iteration*

	/HLL/	FtBin	*('HL)	Parse-σ	AllFt-L	*Clash
a.	☞ i. ('H)LL			2		
	ii. ('HL)L		W1	L1		
b.	/HLLL/					
	☞ i. ('H)LLL			3		
	ii. ('HL)LL		W1	L2		

Thus the combination of outputs in the unattested language from §3.2, though all optimal under the same ranking in parallel OT, cannot be modelled as outputs in the same language in HS/IFO with these constraints.

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

[15] If strict inheritance 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 strict inheritance is abandoned, which I have not attempted to address here. For IFO to fully reproduce the non-local language from §3.2 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.

[16] Actually, the ranking in (29) will favour building ('LL) feet before monosyllabic feet, though the eventual output will be the same as that intended here.

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constraints were admitted into the theory this prediction would not hold, as it would then be possible to assess the consequences of 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.

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 only on the basis of 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 typology. Global parsing maximisation 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.

4 Repairs to foot form

The relationship between quantity and stress is bidirectional – just as languages like Weŋgaia 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.

4.1 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

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and some Italian dialects, and it is usually argued to be motivated by a preference for trochaic feet to group elements of equal weight (e.g. McCarthy & Prince 1986, Prince 1990, Hayes 1995; 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 underparsed ('H)L. Fijian (Austronesian; Fijian Islands; Schütz 1985, Dixon 1988) will be used to exemplify trochaic shortening.

The stress system of Fijian is quantity-sensitive, and is analysed 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. The data in (30) 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.

(30) *Fijian stress*
(Hayes 1995: 142–143, *from* Schütz 1978, 1985, Dixon 1988)

			Proposed foot structure
a.	ˈlako	‘go’	(ˈLL)
	βiˈnaka	‘good’	L(ˈLL)
	ˌmbeːˈleti	‘belt’	(ˌH)(ˈLL)
	paˌroːkaˈramu	‘programme’	L(ˌH)L(ˈLL)
b.	kiˈlaː	‘know’	L(ˈH)
	ˌndokeˈtaː	‘doctor’	(ˌLL)(ˈH)
	ˌndaiˌrekiˈtaː	‘director’	(ˌH)(ˌLL)(ˈH)

There are no words in Fijian which 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 (31) demonstrate.

(31) *Fijian shortening* (Schütz 1985: 528, Dixon 1988: 26–27)

a.	ˈmbuː	‘grandmother’
	ˈmbu-ŋgu	‘my grandmother’
	ˈðaː	‘bad’
	ˈða-ta	‘hate/consider bad-TRANS’
b.	ˈsiβi	‘exceed’
	ˌsiːˈβi-ta	‘exceed-TRANS’

The roots in (a) consist of a single heavy syllable whose vowel is shortened when a 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

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penultimate position. Fijian trochaic shortening is obligatory when the HL sequence is word-final, but is optional when a heavy syllable precedes an unparsed light syllable elsewhere in the word. For reasons of space I concentrate here on deriving the variant in which trochaic shortening applies word-finally but not word-medially.

4.1.1 *HS analysis.* In an HS analysis, an input like /si:βi/ 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 (32a) or foot-building first, as in (32b). Of the two logically possible orders, only (32b) 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 (32a), would not improve harmony (McCarthy 2008b).[17] On the other hand, motivating shortening in (32b) 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.

(32) *Possible orderings of shortening and foot-building*

a. */si:βi/ → si.βi → ('si.βi)

b. /si:βi/ → ('si:.βi) → ('si.βi)

The IFO analysis will again use the standard stress constraints PARSE-σ, ALLFT-L/R and FTBIN to analyse 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 & Smolensky's (2004) RHHRM ('rhythmic harmony') is violated by an ('HL) foot in their analysis of Latin stress, Alber (1997) and McCarthy (2008b) adopt a constraint that summarises the Iambic/Trochaic Law of Hayes (1995) by preferring balanced trochees and unbalanced iambs and Kager (1999) adopts a constraint sensitive to rhythm on the moraic level, called RH-CONTOUR, to penalise both an ('HL) trochee and an (L'L) iamb.[18] Any

[17] A high-ranking general constraint against long vowels or heavy syllables could of course produce the derivation in (32a), but it would also shorten every long vowel in the word/language.

[18] A point of difference among these sources is whether the constraint that penalises ('HL) also penalises ('LH). 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

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of these would suffice for an analysis of trochaic shortening here. I adopt the constraint in (33), which penalises both ('HL) and ('LH).

(33) BALANCEDTROCHEE (BALTROCH)
Assign one violation mark for a trochee that groups elements of unequal quantity.

There must be a markedness constraint ranked above BALTROCH, 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 is achieved with a constraint that prefers a foot aligned to the right edge of the word, defined in (34) (from McCarthy & Prince 1993a).

(34) ALIGNWD-R
Assign one violation mark for a word that does not have a foot at its right edge.

The tableaux in (35) and (36) demonstrate the ranking required for these parses. ALIGNWD-R dominates BALTROCH to motivate ('HL) word-finally, as shown in (35).

(35) *Final HL sequence parsed as* ('HL)

/siːβi/	ALIGNWD-R	BALTROCH	PARSE-σ
1st iteration			
☞ a. ('siː.βi)		1	
b. ('siː)βi	W1	L	W1

And to ensure that the language prefers ('H)L word-medially, BALTROCH must dominate PARSE-σ, which would otherwise exert its preference for the larger ('HL) foot in word-medial positions as well, as shown in (36).

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

pa.roː.ka('ra.mu)	ALIGNWD-R	BALTROCH	PARSE-σ
2nd iteration			
a. pa('roː.ka)('ra.mu)		W1	L1
☞ b. pa('roː)ka('ra.mu)			2

Finally, the relevant faithfulness constraint against shortening is MAX-μ, which assigns a violation mark for a mora in the input that does

grounds. A constraint like WEIGHT-TO-STRESS can also be used to rule out ('HH) feet in moraic trochee languages like Fijian.

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not have a correspondent in the output, under the assumption that vowel shortening involves the loss of a mora.

The rankings ALIGNWD-R ≫ BALTROCH ≫ PARSE-σ and BALTROCH ≫ MAX-μ have just been established. We also assume that TROCHEE and FTBIN are undominated, and that the ranking PARSE-σ ≫ ALLFT-R ≫ ALLFT-L accounts for iterative right-to-left footing. Under this ranking, the word-final HL sequence of /si:βi/ will be parsed and shortened with the derivation in (37a), while the non-final HL sequence in /paro:karamu/ will be parsed as ('H)L and does not undergo shortening, surfacing as pa('ro:)ka('ra.mu) according to the derivation in (37b) (the relevant tableaux are omitted for reasons of space).[19]

(37) *Fijian derivations*

a. /si:βi/ → ('si:.βi) → ('si.βi) → [('si.βi)]

b. /paro:karamu/ → pa.ro:.ka('ra.mu) → pa('ro:)ka('ra.mu) → [pa('ro:)ka('ra.mu)]

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 prioritisation. The ('HL) foot is the best way to satisfy ALIGNWD-R in Fijian, since FTBIN is undominated; and because of the ranking BALTROCH ≫ 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 2008b).[20]

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 ALIGNWD-R at the expense of foot form. Although Fijian corrects the dispreferred foot in a subsequent

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

[20] An anonymous reviewer voices a concern regarding the ('HL) step, namely, how children could ever learn to posit the intermediate structure with no surface evidence for it. The answer 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 & 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.

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step, other languages 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 & Kiparsky 1996, Alber 1997, 2005). In Finnish, a disyllabic foot appears at the left edge of the word, satisfying ALIGNWD-L no matter the weight of the initial two syllables. Elsewhere in the word, foot-building is sensitive to weight in that violations of general ALLFT-L are sacrificed in order to avoid ('LH) feet, and ternary rhythm may result. The HS analysis, in which a surface ill-formed foot is (temporarily) tolerated to satisfy ALIGNWD-R, receives some support from the fact that other languages display the same trade-off overtly, because they demonstrate that sacrificing the preferred foot form is indeed an attested way of satisfying an ALIGNWD constraint.

4.1.2 *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 it must do so non-derivationally, and the required ranking is somewhat different. The analysis presented in this section is essentially the same as the analysis of Fijian in Kager (1999).

The IFO analysis required the ranking ALIGNWD-R ≫ BALTROCH to motivate the intermediate step, but no such step is involved in the parallel OT analysis. The constraints cannot be ranked in parallel OT, because all surface forms satisfy both of them.[21] Conversely, no ranking between MAX-μ and PARSE-σ was justified in the IFO analysis, because the constraints were not in conflict at any point in the derivation, but in parallel OT the ranking must be MAX-μ ≫ PARSE-σ in order to limit shortening to only word-final HL sequences (on the assumption that we are deriving the variant of Fijian in which word-medial shortening does not occur). Tableau (38) shows the necessity of this ranking. Candidate (c), with word-medial shortening, would allow better satisfaction of PARSE-σ, but it violates the higher-ranked MAX-μ.

(38) *Moraic trochees in parallel OT*

/paro:karamu/	FTBIN	ALIGNWD-R	BALTROCH	MAX-μ	PARSE-σ
☞ a. pa('ro:)ka('ra.mu)					2
b. pa('ro:)('ka)('ra.mu)	W1				L1
c. pa('ro.ka)('ra.mu)				W1	L1
d. pa('ro:.ka)('ra.mu)			W1		L1

The tableau in (39) shows further how the output with shortening is derived using this ranking.

[21] See McCarthy (2006, 2010a) for discussion of these kinds of ranking differences between parallel OT and HS.

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(39) *Trochaic shortening in parallel OT*

/siːβi/	FtBin	AlignWd-R	BalTroch	Max-μ	Parse-σ
a. siː.βi		W1		L	W2
b. siː('βi)	W1			L	W1
c. ('siː.βi)			W1	L	
☞ d. ('si.βi)				1	

4.2 Non-local trochaic shortening (unattested)

IFO and parallel OT are equally able to account for Fijian trochaic shortening in penultimate syllables, 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 AlignWd-R, BalTroch and FtBin prevents word-final ('H)L, ('HL) and H('L) from being optimal, favouring instead ('LL). But the ranking and behaviour of Parse-σ and Max-μ is a crucial difference between the theories. Unlike IFO, the parallel OT analysis requires that Max-μ dominate Parse-σ in order to limit shortening to only word-final HL sequences. In IFO the constraints were unrankable because they did not conflict. If this ranking is reversed to Parse-$\sigma \gg$ Max-μ, an unattested language with non-local shortening is predicted to exist by the parallel theory, but not the serial one. The following paragraphs demonstrate why this prediction is undesirable.

Under a ranking such as BalTroch, Parse-$\sigma \gg$ Max-μ, the high ranking of Parse-σ and BalTroch will conspire to produce non-local shortening patterns. For this illustration we can otherwise keep the ranking the same as in the Fijian analysis: Parse-$\sigma \gg$ AllFt-R $\gg$ AllFt-L for iterative right-to-left parsing, and undominated Trochee and FtBin for minimally bimoraic trochees. (The ranking of AlignWd-R is not 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 (40), 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).

(40) *Maximal parsing possible without shortening*

/LLLLH/	BalTroch	Parse-σ	Max-μ	AllFt-R
☞ a. ('LL)('LL)('H)				4
b. L('LL)('LL)		W1	W1	L2
c. L('LL)('LH)	W1	W1		L2

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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 (41). In this case, best satisfaction of PARSE-σ and constraints on foot form (BALTROCH 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.[22]

(41) *Shortening for maximal parsing*

/LLLH/	BALTROCH	PARSE-σ	MAX-μ	ALLFT-R
☞ a. ('LL)('LL)			1	2
b. ('LL)('LH)	W1		L	2
c. L('LL)('H)		W1	L	L1

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 (42). 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.

(42) *Right-to-left parsing*

/LLLLL/	BALTROCH	PARSE-σ	MAX-μ	ALLFT-R
☞ a. L('LL)('LL)		1		2
b. ('LL)('LL)L		1		W4

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 in fact slightly more complicated than the tableaux in (40)–(42) 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 heavy syllables satisfying this requirement,[23] and shortens all other heavy syllables in the word to create ('LL) feet. Such a stress system has not been attested.

[22] This example involves shortening what would have been an ('LH) foot rather than ('HL). I defined BALTROCH 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 if it has the same position in the ranking as BALTROCH currently has.

[23] Only one heavy needs to be parsed alone to ensure that an even number of syllables is left over. This 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 §3.2.

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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 §3.2, 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 PARSE-σ and MAX-μ 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, PARSE-σ and MAX-μ 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 (43), with the final heavy syllable in (43a) parsed as a monosyllabic foot and the final heavy syllable in (43b) parsed as the dependent in a disyllabic foot. These steps cannot be made simultaneously optimal in IFO, by extension of the reasoning in §3.3, without spurious constraints that refer directly to word parity. Thus IFO predicts that metrically conditioned quantity adjustments should be local.

(43) a. /LLLLH/ → LLLL('H) → LL('LL)('H) → ('LL)('LL)('H)
b. /LLLH/ → LL('LH) → LL('LL) → ('LL)('LL)[24]

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 §3 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

[24] Or possibly LLLH → LL('HL) → ('LL)('HL) → ('LL)('LL).

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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.

5 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 & Smolensky 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 would be assigned to the final syllable through the default stress algorithm is instead realised on the penultimate syllable. Prince & Smolensky call this process 'rhythmic reversal' (2004: 65).[25] 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 Yidiŋ, a language that has been presented as a counterexample to this typological claim.

5.1 Local rhythmic reversal in Axininca

Stress in the Apurucayali dialect of Axininca (Payne *et al*. 1982, McCarthy & 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 (44a). However, stress nearly always avoids the final syllable (words with diphthongs in the final syllable are the exception). As a result, disyllabic words have initial stress, as in (44b), while polysyllables ending in an even number of light syllables vary between shifting the last stress to the penult and omitting the stress altogether, (44c).[26] In the

[25] Prince & Smolensky cite Choctaw, Munsee, Southern Paiute, Ulwa and Axininca as languages that show this process at least in disyllabic words. Southern Paiute (which they analyse; 2004: 65) and Axininca (which I analyse 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 (2008b).

[26] Determining which syllable receives primary stress requires a comparison between the last two feet based partly on a prominence scale (Payne *et al*. 1982). I ignore those distinctions here.

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analysis below I focus on deriving the variant with rhythmic reversal (i.e. penult stress), following an analysis in the standard theory by McCarthy & Prince (1993b).

(44) *Axininca stress*
(McCarthy & Prince 1993b: 159–160, Payne *et al*. 1982: 188–189, 193)

a.	tʃʰoˈrina	‘species of palm’
	iˈtʃʰikaˈkina	‘he has cut me’
b.	ˈsari	‘macaw’
	ˈkito	‘shrimp’
c.	kiˈmiˈtaka ~ kiˈmitaka	‘perhaps’
	hoˈtiˈtana ~ hoˈtitana	‘he let me in’

McCarthy & Prince (1993b) analyse 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 in the same 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.ˈtʃʰi)(ka.ˈki)na ‘he has cut me’, (ˈsa.ri) ‘macaw’ and (ki.ˈmi)(ˈta.ka) ‘perhaps’. The constraint militating against final stress is Non-finality, defined in (45), which must outrank Iamb because it can compel a trochee to be built.

(45) Non-finality
Assign one violation mark for a word whose final syllable is stressed (McCarthy & Prince 1993b: 160).

We must also assume the ranking Parse-$\sigma \gg$ AllFt-L $\gg$ AllFt-R in order to enforce iterative left-to-right parsing, Iamb $\gg$ Trochee in order to have a default preference for right-headed feet and FtBin $\gg$ Parse-σ because feet surfacing in Axininca never contain fewer than two moras. The final ranking that must be assumed is Parse-$\sigma \gg$ Iamb, which accounts for the fact that a trochaic foot surfaces word-finally even though leaving the syllables unfooted would allow vacuous satisfaction of Iamb. The ranking is exemplified in the tableaux that follow.

The derivation of the regular iambic stress pattern in an odd-parity word will proceed as shown in (46). Non-finality 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 FtBin, and (e) emerges as the winner.

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(46) *Odd-parity words parsed into iambs in HS*

/itʃʰikakina/	FtBin	Parse-σ	AllFt-L	Iamb	Trochee
1st iteration					
a. (i.ˈtʃʰi)ka.ki.na		3			1
b. (ˈi.tʃʰi)ka.ki.na		3		W1	L
2nd iteration					
c. (i.ˈtʃʰi)ka.ki.na		W3	L		L1
d. (i.ˈtʃʰi)(ka.ˈki)na		1	2		2
3rd iteration					
e. (i.ˈtʃʰi)(ka.ˈki)na		1	2		2
f. (i.ˈtʃʰi)(ka.ˈki)(ˈna)	W1	L	W6		2
output: (i.ˈtʃʰi)(ka.ˈki)na					

A derivation of a word with an even number of light syllables in Axininca is shown in (47). 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 Non-finality 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.

(47) *Rhythmic reversal in HS*

/hotitana/	Non-fin	Parse-σ	AllFt-L	Iamb	Trochee
1st iteration					
a. ho.ti.ta.na		W4			L
b. (ho.ˈti)ta.na		2			1
c. (ˈho.ti)ta.na		2		W1	L
2nd iteration					
d. (ho.ˈti)ta.na		W2	L	L	1
e. (ho.ˈti)(ta.ˈna)	W1		2	L	W2
f. (ho.ˈti)(ˈta.na)			2	1	1
3rd iteration					
g. (ho.ˈti)(ˈta.na)			2	1	1
output: (ho.ˈti)(ˈta.na)					

As this analysis shows, it is straightforward to account for Axininca's rhythmic reversal in HS/IFO using the stress constraints of the standard

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theory. The constraint against final stressed syllables becomes relevant when parsing the final syllables of a word, and it enforces its preference then.[27]

5.2 Non-local rhythmic reversal (unattested)

McCarthy & Prince's (1993b) analysis of Axininca rhythmic reversal in parallel OT, which derives the correct optima with the same ranking, is equally straightforward on the surface. However, the standard constraints in parallel OT also predict a language with *global* rhythmic reversal, in which the effect of NON-FINALITY is to change foot structure throughout the entire word. The winning candidate for input /hotitana/ is (ho.ˈti)(ˈta.na), which has a stress clash. If we assume that CON contains the constraint *CLASH, which was in fact shown to be necessary for a standard theory analysis of Weŋgaia in §3, it must be low-ranked for the analysis of Axininca. But factorial typology includes a ranking that is just like that in Axininca, but with *CLASH high-ranked, and in such a language (ho.ˈti)(ˈta.na) will lose to a candidate with reversal in both feet, (ˈho.ti)(ˈta.na). This is shown in (48). The winning candidate in (48) 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.

(48) *Global rhythmic reversal in parallel OT* (*Pseudo-Axininca*)

/hotitana/	*CLASH	NON-FIN	PARSE-σ	ALLFT-L	IAMB	TROCHEE
a. ho.ti.ta.na			W4	L	L	
b. (ho.ˈti)(ta.ˈna)		W1		2	L	W2
c. (ho.ˈti)(ˈta.na)	W1			2	L1	W1
d. (ˈho.ti)ta.na			W2	L	L1	
☞ e. (ˈho.ti)(ˈta.na)				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. Cavineŋa, Key 1968),

[27] To account for the variation in penult stress, e.g. [ho.ˈti.ˈta.na ~ ho.ˈti.ta.na] '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, favouring candidate (d) in (47) instead.

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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 generalisations.

For example, according to the asymmetric foot typologies of McCarthy & Prince (1986), Hayes (1995) and others, trochees ideally group elements of equal weight (see also §4), 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 (L'H) (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 (48) is a language in which stressed syllables in even-parity words are shortened, to obey constraints that want trochees to be balanced, 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 NON-FINALITY in combination with *CLASH and constraints on foot form. This is illustrated schematically in (49) and (50). 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.

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

/HLHL/	I/TL	*CLASH	NON-FIN	IAMB	MAX-μ
a. (H'L)(H'L)	W2		W1	L	L
b. ('HL)('HL)	W2			2	L
c. (L'L)(L'L)			W1	L	2
d. (L'L)('LL)		W1		L1	2
☞ e. ('LL)('LL)				2	2

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

/LLLLL/	I/TL	*CLASH	NON-FIN	IAMB	DEP-μ
a. (L'L)(L'L)L	W2				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 analyse Weŋgaia in parallel OT, NON-FINALITY is crucial in the analysis of Axininca and many other languages, and languages with iambic lengthening and trochaic shortening

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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-μ and MAX-μ. 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 (NON-FINALITY) has conspired with *CLASH to effect 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 NON-FINALITY from changing the preferred foot type throughout the word. Furthermore, if the ranking instead favoured right-to-left directionality, then words of both parity counts would be affected in the same way by NON-FINALITY; 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 NON-FINALITY is quite limited in HS/IFO. This is in clear contrast to the behaviour of these constraints in the standard theory of parallel OT, in which optimisation is performed over all possible metrical parses, and which predicts languages that show non-local constraint trade-offs as a result.

5.3 An apparent counterexample

The stress pattern described in the previous section and illustrated in (49) and (50) displays an improbable pattern of stressed syllable shortening and lengthening and is clearly unattested. However, there is one language, Yidiɲ, that is claimed to have a stress system similar enough in some ways to this unattested language to warrant additional discussion. This section describes Yidiɲ stress and briefly discusses why it is a challenge for both HS/IFO and parallel OT. Although Yidiɲ 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 Yidiɲ 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 Yidiɲ, a language of Australia. Stress in Yidiɲ is characterised by both strict alternation of stress by syllables and quantity-sensitivity. Long vowels count as heavy and may occur in any syllable except the first. For words with an odd number of syllables only the stress pattern in (51a) 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

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vowel in other even-numbered syllables as well. This stress system is unusual in being both quantity-sensitive and strictly alternating (cf. Hayes 1995),[28] as well as in the interdependence of stress and vowel length in odd-parity words.

(51) *Rhythmic alternation in Yidiɲ*
($\underline{\sigma}$ = may contain a long vowel; $\underline{\underline{\sigma}}$ = must contain a long vowel)

a. *Odd parity*	b. *Even parity*	c. *Even parity*
$\sigma\ {}'\underline{\sigma}\ \sigma\ {}'\underline{\underline{\sigma}}\ \sigma$	${}'\sigma\ \sigma\ {}'\underline{\sigma}\ \sigma$	$\sigma\ {}'\underline{\sigma}\ \sigma\ {}'\underline{\sigma}$

On the basis of these facts, most previous analyses of Yidiɲ stress[29] have assumed 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 weight. Hung (1993, 1994), for example, argues that Yidiɲ is an essentially iambic language and that the preference for trochees in even-parity words is driven by NON-FINALITY (though trochees are blocked when a long vowel appears in an even-numbered syllable). This description makes Yidiɲ 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.[30] 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 (51c)).

On the surface, a consideration of Yidiɲ's stress system appears to highlight a dichotomy between a theory that undergenerates and a theory that overgenerates. The IFO prediction that stress systems should be local makes it difficult to adapt a traditional analysis of Yidiɲ, but parallel OT's global parsing with the standard constraints predicts in addition to Yidiɲ many non-local stress patterns that are unattested, as evidenced by the

[28] Hayes (1995: 72), on the relationship between quantity and alternation in general, notes: 'it appears that heavy syllables invariably interrupt any alternating count of light syllables'. In Yidiɲ, 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).

[29] There have been many analyses since Dixon (1977a, b). See e.g. Crowhurst & Hewitt (1995b) and references cited therein.

[30] Most of the other analyses of Yidiɲ 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 NON-FINALITY, *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.

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minimally different problematic prediction in §5.2 and the predictions discussed in §§3 and 4.

However, there are significant reasons to doubt whether any parallel OT analysis actually *can* account for Yidiɲ's stress system when its additional complexities are taken into account. The central difficulty for an analysis in parallel OT is that stress and vowel length have a necessary interdependence, but vowel length in Yidiɲ 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 [gin.ˈdaːn] in the absolutive (bare) form, but as faithful [gin.da.nu-] 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 Yidiɲ stress in parallel OT almost impossible if the predictable vowel length in forms like [gin.daːn] 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 Yidiɲ'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 Yidiɲ. In IFO it is possible to analyse Yidiɲ'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 Yidiɲ's morphophonology. With vowel length prespecified, an IFO analysis could treat Yidiɲ as a right-aligning trochaic system that requires heavy syllables to be stressed and every word to end in a foot.[31] 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 Yidiɲ are adopted (e.g. Crowhurst & Hewitt 1995b), though such solutions would have to be pursued with care to ensure that the genuinely problematic predictions discussed in the previous section are not reintroduced as well.

Yidiɲ is sometimes put forward 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 favour of that conclusion. Despite the difficulty for HS/IFO posed by current characterisations of this language, it is quite possible that future work sensitive to the role of morphology in Yidiɲ'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.

[31] I thank the anonymous associate editor for suggesting an analysis along these lines.

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6 Alternatives to the standard theory

The main focus of this paper 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 paper from two 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 a brief comparison with rule-based derivational stress.

6.1 Non-finality-based parallel OT

The comparison between IFO and parallel OT in §3 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-σ, 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 NON-FINALITY 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 generalised trochee languages and extends to many other areas of stress typology as well.[32] Throughout, I have identified the problematic predictions discussed in this paper 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 paper are less impressive when compared to the quite different theory of Hyde, but IFO nonetheless retains an advantage. Hyde's solution fails to generalise 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 words with no sonorant consonants

[32] In other work, Hyde assumes that all feet are binary and that syllables may be ambipodal (e.g. Hyde 2002), but this assumption is not a crucial part of the analysis proposed in Hyde (2007).

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(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 §§3–5 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 analysing stress in HS provides solutions to problems beyond those that have been the focus of this paper, for which Hyde's theory can offer no comparable advantage. McCarthy (2008b) argues that metrically conditioned syncope cannot be coherently analysed 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 syllabification and stress assignment. Elfner cites Kiparsky (forthcoming) for arguments against extant parallel OT approaches, which typically analyse 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 epenthesised into extrametrical positions cannot opaquely affect stress assignment when in fact such cases are attested.

Kimper (forthcoming) shows that serial prosodic structure building in HS can be combined with a theory of variable constraint ranking to analyse attested cases of prosodic local optionality that are not analysable 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.

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Finally, Jesney (forthcoming) 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 paper and other recent work suggests that HS consistently solves locality problems which are not limited to stress, and that analysing stress in a framework with serial optimisation provides benefits beyond the locality effects discussed in this paper. 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 optimisation in metrical structure nonetheless suggest that the breadth of problems solved by HS make iterative foot optimisation worthy of further consideration.

6.2 Derivational rule-and-constraint-based theories

The locality results described in this paper derive primarily from the fact that IFO, unlike parallel OT, builds feet incrementally. In this way IFO is similar in many respects to rule-based, or rule-and-constraint-based, models of stress, such as Hayes (1995), which is also implemented with incremental foot-building and generally makes the same or similar representational assumptions as those adopted here.[33] But while IFO and these rule- and constraint-based theories share serialism and representations, a crucial difference is that IFO assumes ranked and

[33] In principle, other representational and operational assumptions that have been proposed in derivational models of stress could be explored as alternative ways to implement IFO, though the extent to which the predictions in this paper hold under different definitions of GEN remains to be determined.

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violable constraints to determine the descriptive dimensions of a stress pattern, while most other derivational models determine directionality, foot-headedness, iterativity, etc., for each language parametrically, with constraints that are inviolable.

For IFO and other OT-based models, violable constraints predict 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 & Smolensky 2004: ch. 4). In the analysis of Fijian, for example, HS/IFO permits an ('HL) foot to be built at the word edge only, because satisfaction of high-ranked ALIGNWD-R requires the preference for balanced trochees to be (temporarily) overridden. Similarly, Axininca prefers iambic feet, but will tolerate a trochaic foot to avoid stressing the final syllable. Non-uniformity of this kind is well attested both in stress and in other domains (see e.g. McCarthy 2002: §3.2), and the ability of OT's ranked and violable constraints to account for this behaviour carries over to HS as well.

7 Conclusion

This paper has demonstrated the potential for Harmonic Serialism with iterative foot optimisation 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 optimisations, 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 analysed 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 analyse 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 (operations 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 paper 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.

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REFERENCES

Alber, Birgit (1997). Quantity sensitivity as the result of constraint interaction. In Geert Booij & Jeroen van de Weijer (eds.) *Phonology in progress : progress in phonology*. The Hague: Holland Academic Graphics. 1–45.
Alber, Birgit (2005). Clash, Lapse and Directionality. *NLLT* **23**. 485–542.
Anttila, Arto (1997). Deriving variation from grammar. In Frans Hinskens, Roeland van Hout & W. Leo Wetzels (eds.) *Variation, change and phonological theory*. Amsterdam & Philadelphia: Benjamins. 35–68.
Anttila, Arto (2002). Morphologically conditioned phonological alternations. *NLLT* **20**. 1–42.
Boersma, Paul (1997). How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* **21**. 43–58.
Crowhurst, Megan & Mark Hewitt (1995a). Directional footing, degeneracy, and alignment. *NELS* **25**. 47–61.
Crowhurst, Megan & Mark Hewitt (1995b). Prosodic overlay and headless feet in Yidiɲ. *Phonology* **12**. 39–84.
Dixon, R. M. W. (1977a). *A grammar of Yidiɲ*. Cambridge: Cambridge University Press.
Dixon, R. M. W. (1977b). Some phonological rules in Yidin^{y}. *LI* **8**. 1–34.
Dixon, R. M. W. (1988). *A grammar of Boumaa Fijian*. Chicago & London: University of Chicago Press.
Elfner, Emily (2009). Syllabification and stress-epenthesis interactions in Harmonic Serialism. Ms, University of Massachusetts. Amherst. Available as ROA-1047 from the Rutgers Optimality Archive.
Frampton, John (2007). Weak local parsing in a theory without foot inventories. Ms, Northeastern University. Available (September 2010) at http://www.math.neu.edu/ling/pdffiles/WLP.pdf.
Halle, Morris & Jean-Roger Vergnaud (1987). *An essay on stress*. Cambridge, Mass.: MIT Press.
Hansen, Kenneth C. & Lesley E. Hansen (1969). Pintupi phonology. *Oceanic Linguistics* **8**. 153–170.
Hansen, Kenneth C. & Lesley E. Hansen (1978). *The core of Pintupi grammar*. Alice Springs: Institute for Aboriginal Development.
Hanson, Kristin & Paul Kiparsky (1996). A parametric theory of poetic meter. *Lg* **72**. 287–335.
Hayes, Bruce (1991). Metrical stress theory: principles and case studies. Ms, University of California, Los Angeles. Revised version published as Hayes (1995).
Hayes, Bruce (1995). *Metrical stress theory : principles and case studies*. Chicago: University of Chicago Press.
Hayes, Bruce (1997). Anticorrespondence in Yidiɲ. Ms, University of California, Los Angeles. Available (September 2010) at http://www.linguistics.ucla.edu/people/hayes/yidiny/anticorresp.pdf. Revised version published as Hayes (1999).
Hayes, Bruce (1999). Phonological restructuring in Yidiɲ and its theoretical consequences. In Ben Hermans & Marc van Oostendorp (eds.) *The derivational residue in phonological Optimality Theory*. Amsterdam: Benjamins. 175–205.
Hercus, Luise A. (1969). *The languages of Victoria : a late survey*. 2 vols. Canberra: Australian Institute of Aboriginal Studies.
Hercus, Luise A. (1986). *Victorian languages : a late survey*. Canberra: Australian National University.
Hint, Mati (1973). *Eesti keele sõnafonoloogia*. Vol. 1: *Rõhusüsteemi fonoloogia ja morfofonoloogia põhiprobleeemid*. Tallinn: Eeste NSV Teaduste Akadeemia.

https://doi.org/10.1017/S0952675710000229 Published online by Cambridge University Press

Hung, Henrietta (1993). Iambicity, rhythm, and non-parsing. Ms, University of Ottawa. Available as ROA-9 from the Rutgers Optimality Archive.
Hung, Henrietta (1994). *The rhythmic and prosodic organization of edge constituents*. PhD dissertation, Brandeis University. Available as ROA-24 from the Rutgers Optimality Archive.
Hyde, Brett (2002). A restrictive theory of metrical stress. *Phonology* **19**. 313–359.
Hyde, Brett (2007). Non-finality and weight-sensitivity. *Phonology* **24**. 287–334.
Jesney, Karen (forthcoming). Positional faithfulness, non-locality, and the Harmonic Serialism solution. *NELS* **39**. Available as ROA-1018 from the Rutgers Optimality Archive.
Kager, René (1992a). Are there any truly quantity-insensitive systems? *BLS* **18**. 123–132.
Kager, René (1992b). Shapes of the generalised trochee. *WCCFL* **11**. 298–312.
Kager, René (1993). Alternatives to the iambic-trochaic law. *NLLT* **11**. 381–432.
Kager, René (1994). Ternary rhythm in alignment theory. Ms, Utrecht University. Available as ROA-35 from the Rutgers Optimality Archive.
Kager, René (1999). *Optimality Theory*. Cambridge: Cambridge University Press.
Kager, René (2001). Rhythmic directionality by positional licensing. Handout of paper presented at the 5th Holland Institute of Linguistics Phonology Conference, Potsdam. Available as ROA-514 from the Rutgers Optimality Archive.
Karttunen, Lauri (2006). The insufficiency of paper-and-pencil linguistics: the case of Finnish prosody. In Miriam Butt, Mary Dalrymple & Tracy Holloway King (eds.) *Intelligent linguistic architectures: variations on themes by Ronald M. Kaplan*. Stanford: CSLI. 287–300.
Key, Mary Ritchie (1968). *Comparative Tacanan phonology: with Cavineña phonology and notes on Pano-Tacanan relationship*. The Hague & Paris: Mouton.
Kimper, Wendell (2010). Domain specificity and Vata ATR spreading. Paper presented at the 34th Penn Linguistics Colloquium.
Kimper, Wendell (forthcoming). Locality and globality in phonological variation. *NLLT*.
Kiparsky, Paul (forthcoming). *Paradigm effects and opacity*. Stanford: CSLI.
McCarthy, John J. (2000). Harmonic serialism and parallelism. *NELS* **30**. 501–524.
McCarthy, John J. (2002). *A thematic guide to Optimality Theory*. Cambridge: Cambridge University Press.
McCarthy, John J. (2003). OT constraints are categorical. *Phonology* **20**. 75–138.
McCarthy, John J. (2006). Restraint of analysis. In Eric Baković, Junko Ito & John J. McCarthy (eds.) *Wondering at the natural fecundity of things: essays in honor of Alan Prince*. Santa Cruz: Linguistics Research Center. 213–239. Also in Sylvia Blaho, Patrik Bye & Martin Krämer (eds.) *Freedom of analysis?* Berlin & New York: Mouton de Gruyter. 203–231.
McCarthy, John J. (2007a). *Hidden generalizations: phonological opacity in Optimality Theory*. London: Equinox.
McCarthy, John J. (2007b). Slouching towards optimality: coda reduction in OT-CC. In Phonological Society of Japan (ed.) *Phonological Studies 10*. Tokyo: Kaitakusha. 89–104.
McCarthy, John J. (2008a). The gradual path to cluster simplification. *Phonology* **25**. 271–319.
McCarthy, John J. (2008b). The serial interaction of stress and syncope. *NLLT* **26**. 499–546.
McCarthy, John J. (2010a). An introduction to Harmonic Serialism. *Language and Linguistics Compass* **4**. 1010–1018.
McCarthy, John J. (2010b). Studying GEN. *Journal of the Phonetic Society of Japan* **13:2**. 3–12.

https://doi.org/10.1017/S0952675710000229 Published online by Cambridge University Press

McCarthy, John J. (forthcoming). Autosegmental spreading in Optimality Theory. In John A. Goldsmith, Elizabeth Hume & W. Leo Wetzels (eds.) *Tones and features*. Berlin & New York: Mouton de Gruyter. Available (September 2010) at http://works.bepress.com/john_j_mccarthy/100.
McCarthy, John & Alan Prince (1986). *Prosodic morphology*. Ms, University of Massachusetts, Amherst & Brandeis University.
McCarthy, John J. & Alan Prince (1993a). Generalized alignment. *Yearbook of Morphology 1993*. 79–153.
McCarthy, John J. & Alan Prince (1993). *Prosodic morphology I : constraint interaction and satisfaction*. Ms, University of Massachusetts, Amherst & Rutgers University. Available as ROA-482 from the Rutgers Optimality Archive.
McCarthy, John J. & Kathryn Pruitt (forthcoming). Sources of phonological structure. In Hans Broekhuis & Ralf Vogel (eds.) *Linguistic derivations and filtering : minimalism and Optimality Theory*. London: Equinox.
Moreton, Elliott (2004). Non-computable functions in Optimality Theory. In John J. McCarthy (ed.) *Optimality Theory in phonology : a reader*. Malden, Mass. & Oxford: Blackwell. 141–163.
Pater, Joe (forthcoming). Serial Harmonic Grammar and Berber syllabification. In Toni Borowsky, Shigeto Kawahara, Takahito Shinya & Mariko Sugahara (eds.) *Prosody matters : essays in honor of Elisabeth Selkirk*. London: Equinox.
Payne, David L., Judith K. Payne & Jorge Sanchez Santos (1982). *Morfología, fonología, y fonética del Asheninca del Apurucayali* (*Campa-Arawak preandino*). Pucallpa, Peru: Instituto Lingüístico de Verano.
Prince, Alan (1980). A metrical theory for Estonian quantity. *LI* **11**. 511–562.
Prince, Alan (1983). Relating to the grid. *LI* **14**. 19–100.
Prince, Alan (1985). Improving tree theory. *BLS* **11**. 471–490.
Prince, Alan (1990). Quantitative consequences of rhythmic organization. *CLS* **26:2**. 355–398.
Prince, Alan (2002). Arguing Optimality. In Angela C. Carpenter, Andries W. Coetzee & Paul de Lacy (eds.) *Papers in Optimality Theory II*. Amherst: GLSA. 269–304.
Prince, Alan & Paul Smolensky (2004). *Optimality Theory : constraint interaction in generative grammar*. Malden, Mass. & Oxford: Blackwell.
Schütz, Albert J. (1978). English loanwords in Fijian. In Albert J. Schütz (ed.) *Fijian language studies : borrowing and pidginization*. Suva: Fiji Museum. 41–50.
Schütz, Albert J. (1985). *The Fijian language*. Honolulu: University of Hawaii Press.
Selkirk, Elisabeth (1984). *Phonology and syntax : the relation between sound and structure*. Cambridge, Mass: MIT Press.
Tesar, Bruce (2004). Using inconsistency detection to overcome structural ambiguity. *LI* **35**. 219–253.
Tesar, Bruce & Paul Smolensky (2000). *Learnability in Optimality Theory*. Cambridge, Mass.: MIT Press.
Wolf, Matthew (2008). *Optimal interleaving : serial phonology–morphology interaction in a constraint-based model*. PhD dissertation, University of Massachusetts, Amherst.

https://doi.org/10.1017/S0952675710000229 Published online by Cambridge University Press