Generalized alignment and morphological parsing

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This paper argues that metrification has direct access to morphological structure; specifically, it argues for an Optimality-Theoretic model of the morphology-prosody interface in which generalized alignment constraints (which require metrical edges and morphological edges to coincide) interact with other metrical well-formedness constraints (such as constraints on foot form and foot distribution). Evidence comes from four languages: Sibutu Sama, Diyari, Dyirbal, and Warlpiri. Rhythmic stress patterns of these languages reflect morphological structure to different degrees; these differences are captured by the re-ranking of a small set of metrical constraints. It will be shown that the OT model offers a more adequate account of the data than derivational models.*

1. Introduction

Many languages prefer to locate stresses at the edges of morphological domains. This is the *demarcative* property of word-stress (Trubetzkoy 1939). Upon the traditional view, stress at morpheme edges functions as a signal for these morphemes, and thus facilitates lexical identification of morphemes in processing. From a psycholinguistic perspective, this functional view has been corroborated by experiments by Cutler and Norris (1988), who show that edges of words carry a high functional load in word-recognition.

In derivational metrical phonology (Halle & Vergnaud 1987, Hayes 1995), the location of stresses at morpheme edges involves a combination of factors including parametrized stress rules and domains, cyclic stress rule application, destressing and rhythm rules to repair ill-formed outputs of foot construction. However, such indirect accounts reduce the demarcative property of word stress to an accidental constellation of factors, instead of expressing it directly. To overcome these problems, McCarthy and Prince (1993a,b) have proposed that the demarcative property of word stress (as well as other edge-based prosodic phenomena) should be expressed directly in the grammar. Elaborating on the edge-based theory of the syntax-phonology interface found in Selkirk (1986), Cohn (1989), and others, McCarthy and Prince subsume it under the general constraint format of *Generalized Alignment* (GA):

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(1) Generalized Alignment
Align (Cat$_1$, Edge$_1$, Cat$_2$, Edge$_2$) $=_{\text{def}}$
$\forall$ Cat$_1$ $\exists$ Cat$_2$ such that Edge$_1$ of Cat$_1$ and Edge$_2$ of Cat$_2$ coincide.
Where Cat$_1$, Cat$_2$ $\in$ ProsCat $\cup$ GramCat
Edge$_1$, Edge$_2$ $\in$ {Right, Left}

Generalized alignment is the typical format of interface constraints that relate morpho-syntax and phonology. For example, the constraint Align-Stem-L (which we will see in the analysis of Sibutu Sama in Section 2) requires that the left edge of every stem must coincide with the left edge of a foot.

(2) Align-Stem-L
Align (Stem, Left, Ft, Left)
"The left edge of every stem must coincide with the left edge of some foot."

Moreover, generalized alignment subsumes constraints that align two categories in the prosodic hierarchy with one another, for example the syllable (σ) and the prosodic word (PrWd), or foot (Ft) and PrWd. Consider, for example, the alignment constraint Align-Wd-R (3), which states that every PrWd must end in a foot:

(3) Align-Word-R
Align (PrWd, Right, Ft, Right)
"The right edge of every PrWd must coincide with the right edge of some foot."

It is important not to think of alignment constraints as parametrized domain definitions, for the following reason. McCarthy and Prince implement Generalized Alignment in the framework of *Optimality Theory* (Prince & Smolensky 1993). In this theory, there are no sequential derivations by ordered rules, but only universal constraints which evaluate (logically possible) output representations. Well-formedness of outputs is taken to be a relative notion. More precisely, the 'optimal' output that is selected by the grammar is the one that minimally violates the highest-ranking constraints, possibly at the expense of lower-ranked constraints. Constraints are ranked hierarchically in a language-specific manner. What distinguishes grammars of individual languages is the ranking of a finite set of universal constraints.

A conception of alignment as parametric definitions of the morphology-prosody interface misses the important insight that alignment can be obscured in certain contexts due to factors that are not alignment-based. Optimality Theory predicts this situation: alignment constraints naturally interact with the 'pure' prosodic constraints in a single constraint hierarchy, and are in principle violable, as are all constraints. A common kind of interaction between alignment constraints and higher-ranking prosodic well-formedness constraints occurs in languages in which alignment ranks below *Foot Binarity*. Ft-Bin requires that metrical feet (rhythmic units of stress) be analysable as binary - either two syllables or two moras (McCarthy and Prince 1986, 1993a,b, Hayes 1995, Kager 1989, 1993).

(4) Ft-Bin
Feet are binary under syllabic or moraic analysis.

An example of interaction between two 'antagonist' alignment constraints and Ft-Bin occurs in Sibutu Sama (Allison 1979), which will be discussed in more detail in Section 2. Words in this language have main stress on their penultimate syllable, and secondary stress on their initial syllable, for example *bìssaláhan* 'persuading', *bìssalahánna* 'he is persuading'. This shows that, when given the chance, trochaic feet appear at both the right edge and the left edge of the PrWd. However, trisyllabic words lack the initial secondary stress, and have only main stress on their penultimate syllable, for example *bɪssála* 'talk' (not **bìssála*). This stress pattern is due to an interaction of constraints in which Ft-Bin and Align-Wd-R dominate Align-St-L, as indicated in (6):[1]

(5) Ft-Bin   Align-Wd-R
Align-St-L

(Why these constraints, rather than others, are involved, will be motivated in Section 2.) This ranking can be inferred from trisyllabic words, where satisfaction of Ft-Bin and Align-Wd-R is observed at the expense of Align-St-L. Four out of many logically possible metrical structures of *bɪssála* (generated by a component '*Gen*') are represented in (6). The correct structure is (6c), which has a single trochaic (strong-weak) foot over the last two syllables. In 'bracketed grids' notation, feet are represented above the syllable level (the strong syllable by an asterisk, and the weak syllable by a dot). Feet themselves are organized into a higher prosodic unit, the PrWd. An asterisk at this level indicates the main stress, the strongest syllable in the word.

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(6)   a. ( .  *   )     b. ( .     *)     c. (.   *  )     d. (*       )
         (*)(*  .)         (*  .) (*)          .  (* .)        (*    .) .
         *bìs.sá.la        *bìs.sa.lá         bɪs.sá.la       *bís.sa.la
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The 'optimal' candidate is selected by ranked constraints (in a component '*Eval*') in the following way. First observe that Align-Wd-R is satisfied by all structures except (6d). Align-St-L is satisfied by both (6a-b) and (6d), but not by (6c). Two of the candidate structures (6a-b) satisfy both Align-Wd-R and Align-St-L, but both of these violate undominated Ft-Bin, since they contain monosyllabic feet. That is, left-edge and right-edge alignment cannot be simultaneously satisfied in trisyllabic words, due to the foot well-formedness constraint Ft-Bin. Of the two remaining structures (6c-d) that satisfy Ft-Bin, the grammar selects the former, since satisfaction of Align-Wd-R takes priority over satisfaction of Align-St-L.

All this can be expressed in a tableau, a calculational device that was introduced by Prince & Smolensky (1993) to display interactions between constraints for a given input. Candidate outputs (which are arranged vertically in random order) are submitted to simultaneous evaluation by a set of ranked constraints (arranged horizontally in order of the hierarchy). In each cell, violations that a specific candidate incurs with respect to a specific constraint are marked. A constraint violation is indicated by the symbol "*", a fatal violation by "!", and the optimal output by "☞". To save space, I indicate foot bracketing by parentheses "(" ... ")" and PrWd bracketing by square brackets "[" ... "]":

(7)

Input: /bɪssala/		Ft-Bin	Align-Wd-R	Align-St-L
a.	[(bìs).(sá.la)]	*!		
b.	[(bìs.sa).(lá)]	*!		
c. ☞	[bɪs.(sá.la)]			*
d.	[(bís.sa).la]		*!	

Candidate (7c) is 'optimal' since it minimally violates the highest ranking constraints. Crucially, 'optimal' does not imply that no constraint is violated. Output (7c) violates Align-St-L, but only by lack of a better alternative. Inputs that are four syllables long or longer have optimal outputs that satisfy all the constraints considered so far. Consider, for example, [(*bɪs.sa*).(*lá.han*)]. But even these outputs will necessarily violate several constraints, as we will see below.

To establish the language-specific nature of constraint ranking, now consider the stress system of Diyari (Austin 1981), which is the mirror-image of Sibutu Sama's. It has initial main stress, and penultimate secondary stress, for example *pínadu* 'old man' and *Ŋándawàlka* 'to close'. Again trisyllabic words are too short to allow two disyllabic trochees on them - due to undominated Ft-Bin. Diyari chooses to locate this single foot at the left PrWd edge (rather than the right PrWd edge), as expressed in the ranking:

(8) Ft-Bin \ / Align-St-L
Align-Wd-R

See tableau (9) for evaluation of candidates for a trisyllabic word:

(9)

Input: /pinadu/		Ft-Bin	Align-Wd-R	Align-St-L
a.	[(pí.na).(dù)]	*!		
b.	[(bìs.sa).(lá)]	*!		
c.	[pi.(ná.du)]		*!	
d. ☞	[(pí.na).du]			*

Both left-edge and right-edge feet arguably facilitate the identification of prosodic words in connected speech, and thereby the recognition of morphological words with which the PrWds coincide. But evidently languages cannot achieve all 'functionally desirable' goals at the same time, since achievement of one goal is typically at the expense of another. For this reason languages must rank their priorities. Stated in a rather strong way, a grammar is nothing but a characterization of this ranking.

Another aspect of Generalized Alignment should be clarified before we proceed. The two categories Cat_1, Cat_2 in an alignment constraint cannot be exchanged without a resulting change of meaning. Crucially, quantification of Cat_1 is *universal*, whereas that of Cat_2 is *existential* ("for each Cat_1 there is some Cat_2 ..."). Accordingly, the alignment constraint below has an interpretation that subtly differs from Align-Wd-L:

(10) ALL-FT-L
Align (Foot, Left, PrWd, Left)
"The left edge of every foot must coincide with the left edge of some PrWd."

If ALL-FT-L were undominated, then no PrWds would arise that have multiple feet, since only one foot per PrWd may satisfy this constraint. It follows directly from the 'multi-stressed' surface PrWds in Sibutu Sama and Diyari that in these languages ALL-FT-L is dominated by other constraints. We already saw the relevant dominating constraint at the top of the hierarchy in Sibutu Sama: ALIGN-WD-R. Since every PrWd must end in a foot, ALL-FT-L is necessarily violated in forms that are longer than two syllables. As we will see below, another constraint that interacts with ALL-FT-L is PARSE-SYLL:

(11) PARSE-SYLL
All σ must be parsed by feet.

When PARSE-SYLL dominates ALL-FT-L, violations of the latter will result since some feet are necessarily located away from the left PrWd edge.

In this paper, I will explore the consequences of this theory for the morphology-prosody interfaces of four languages: Sibutu Sama, Diyari, Dyirbal, and Warlpiri. I will show that morpho-prosodic alignment constraints, as they interact with other constraints in Optimality Theory, form an insightful formalization of the demarcative property of word stress.

2. *Sibutu Sama*

Sibutu Sama is an Austronesian language of the Southern Philippines (Allison 1979). As we saw earlier, it has strict penultimate main stress, while unprefixed words of four or more syllables have an initial secondary stress, as in (13b-d):

(12)	a.	bɪssála	'talk'
	b.	bìssalá-han	'persuading'
	c.	bìssala-hán-na	'he is persuading'
	d.	bìssala-han-kámi	'we are persuading'

The stress pattern diagnoses trochaic feet, rhythm units whose initial syllable is strong, and whose second syllable is weak. One trochee, which has the main stress, parses the two syllables at the word end. Another trochee, at the word beginning, has secondary stress. We have already seen the basic constraint interaction responsible for (12a) in Section 1.

The secondary stress pattern of prefixed words is somewhat more complex than that of unprefixed words. Words which have one or more disyllabic prefixes have a secondary stress on each initial prefix syllable, as well as a secondary stress on the first stem syllable. In (13a), no secondary stress occurs on the stem-initial syllable, which again follows from FT-BIN.

(13)	a.	màka-bɪssála	'able to talk'
	b.	pìna-bìssalá-han	'to be persuaded'
	c.	màka-pàgba-bɪssalá-han[2]	'able to cause persuasion'

Two monosyllabic prefixes act together as a single disyllabic prefix. That is, a secondary stress falls on the first prefix, and another on the first stem syllable:

(14)	a.	kà-pag-bɪssála	'able to talk to each other'
	b.	tà-pag-bìssalá-han	'the thing able to be spoken about'

In words which have only one monosyllabic prefix, the secondary stress fluctuates. It falls either on the monosyllabic prefix or on the stem-initial syllable.[3]

(15)	a.	pàg-bɪssalá-han *or* pag-bìssalá-han	'the thing spoken about'
	b.	pà-mɪssalá-han *or* pa-mìssalá-han	'instrument for speaking'

Words which have a disyllabic prefix followed by a monosyllabic prefix display a similar fluctuation. These carry an initial secondary stress on the disyllabic prefix, and another secondary stress which falls either on the monosyllabic prefix, or on the first syllable of the stem.

(16) a. màka-pag-bìssalá-han *or* màka-pàg-bɪssalá-han
'able to persuade them'

b. tàpag-pa-bìssala-hán-bi *or* tàpag-pà-bɪssala-hán-bi
'you (pl.) are able to make them persuade someone'

We thus observe a preference for both prefix and stem edges to be marked by an initial secondary stress. The challenge is how to account for the fluctuation observed in some forms vs. the fixed pattern in others. As I will show, Optimality Theory offers an elegant analysis of left-edge variability, while derivational theory runs into analytic problems.

My analysis of Sibutu Sama starts with unprefixed words, and takes off from the basic constraint ranking that we found in Section 1, repeated below:[4]

(17) Ft-Bin　　Align-Wd-R
　　　　Align-St-L

Consider the fact that medial secondary stresses do not occur in long unprefixed stems: we have [(*bìs.sa*).*la.han*.(*ká.mi*)] rather than *[(*bìs.sa*).(*là.han*).(*ká.mi*)]. This shows that feet are restricted to peripheral positions even when an exhaustive binary parsing would have been possible. Therefore Parse-Syll must rank below All-Ft-L, the constraint that requires every foot to stand at the left edge of PrWd. Observe that in words longer than two syllables, the main stress foot at the right edge evidently violates All-Ft-L. It is this evidence that we can use to fix the ranking of All-Ft-L below Align-Wd-R, as in tableau (18). I indicate foot brackets by parentheses "(", ")", PrWd edges by "[", "]".

(18) /bɪssalahankami/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Parse-Syll
a. ☞ [(bìs.sa).la.han.(ká.mi)]				****	*
b. [(bìs.sa).(là.han).(ká.mi)]				**,***!*	****
c. [(bís.sa).la.han.ka.mi]		*!			

I assume the interpretation of McCarthy & Prince (1993b), by which violations of All-Ft-L are counted by number of syllables from the left edge of the PrWd, added up for all feet. For example, candidate (18b) incurs a total of six violations, two of which are due to its second foot (*la.han*), and four to its third foot (*ka.mi*).

Let us now turn to prefixed words, where we find cases of demarcative stress. In many (but not all) prefixed words stresses occur at the left edges of roots and prefixes. The question is what predicts the distribution. Demarcative stresses point to a morpho-prosodic alignment constraint Align-St-L, which I repeat below from Section 1:

(19) Align-St-L
Align (Stem, Left, Ft, Left)
"The left edge of every stem must coincide with the left edge of some foot."

Two aspects of this constraint merit attention: its statement and its ranking. First, with respect to its statement, it should be pointed out that I assume a definition of 'stem' as a *recursive* morphological category (McCarthy & Prince 1993b). Accordingly, the notion of *left stem edge* includes every left prefix edge, while the innermost stem edge coincides with the root edge. See the morphological structure in (21):

(20) $_{\text{Stem}}$[ka- $_{\text{Stem}}$[pag- $_{\text{Stem}}$[$_{\text{Root}}$[bɪssala]]]]

With respect to the ranking of Align-St-L, it is clear that it must be dominated by Ft-Bin. This conclusion was reached earlier in Section 1 on the basis of trisyllabic words, e.g. [*bɪs*.(*sá.la*)] > [(*bɪ̀s*).(*sá.la*)]. Prefixed words provide direct support for this ranking: when two monosyllabic prefixes precede the root, Ft-Bin makes sure that only one of these is stressed. We thus find:

(21) Ft-Bin »Align-St-L
[(kà-pag)-bɪs.(sá.la)] > [(kà)-(pàg)(bìs).(sá.la)]

Observe that the ranking of Align-St-L with respect to All-Ft-L can be established as well. Since any non-initial foot incurs a violation of All-Ft-L, it must be that case that the word-medial (but root-initial) foot in the example below is enforced by the higher-ranking Align-St-L:

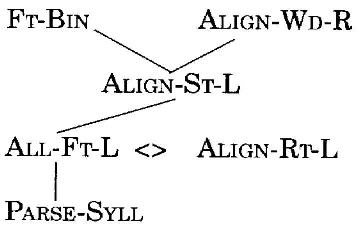
(22) Align-St-L » All-Ft-L
[(pì.na)-(bìs.sa)(lá.han)] > [(pì.na)-bɪs.sa(lá.han)]

As we saw earlier, the medial foot cannot be due to Parse-Syll since that constraint is ranked below All-Ft-L (compare tableau 18).

While (as shown in 20) root edges coincide with innermost stem edges, specific reference to the root is made by a second morpho-prosodic alignment constraint Align-Rt-L, which aligns left root edges with left foot edges.

(23) Align-Rt-L
Align (Root, Left, Ft, Left)

This constraint is undominated in languages that have strict root-initial stress. Although it may seem superfluous in the analysis of Sibutu Sama since we already have Align-St-L, its function will become clear when we discuss variable secondary stress, e.g. [*(pàg-bɪs).sa.(lá.han)*] ~ [*pag-(bís.sa).(lá.han)*]. While the first variant is preferred by All-Ft-L, the second is preferred by Align-Rt-L. I will argue that these constraints are ranked in the same position, in a way to be clarified. The grammar of Sibutu Sama stress can now be stated as a set of ranked constraints as in (24):

(24)


The symbol "<>"between All-Ft-L and Align-Rt-L indicates that these constraints are freely ranked.

What remains to be shown is that this hierarchy accounts for all secondary stress patterns attested in prefixed words. The simplest cases are those which have disyllabic prefixes only, since these involve little interaction with Ft-Bin, and the ranking Align-St-L » All-Ft-L essentially suffices to select the correct output.[5] Output candidate (25a) uniquely satisfies both Ft-Bin and Align-St-L, hence it is selected as optimal:

(25) /pina=bɪssalahan/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(pì.na)=(bìs.sa).(lá.han)]				**,****		
b. [(pì.na)=bɪs.sa.(lá.han)]			*!	****	*	**
c. [pi.na=(bìs.sa).(lá.han)]			*!	**,****		**
d. [pi.(nà=bɪs).sa.(lá.han)]			*!*	*,****	*	**
e. [pi.na=bɪs.sa.(lá.han)]			*!*	****	*	****

In the second type of case, Align-St-L is necessarily violated in order to satisfy the higher-ranking constraints (in particular Ft-Bin). This is because these words contain either monosyllabic prefixes or a trisyllabic stem. Here the optimal output is the one which minimally violates Align-St-L (Prince & Smolensky 1993 call this *multiple gradient violation*). In the tableau below, this is candidate (26a):

(26) /maka=bɪssala/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(mà.ka)=bɪs.(sá.la)]			*	***	*	*
b. [ma.(kà=bɪs).(sá.la)]			**!	**,***	*	*
c. [ma.ka=bɪs.(sá.la)]			**!	***	*	***
d. [(mà.ka)=(bìs).(sá.la)]	*!			**,***		

Both next-best competitors (26b-c) have one more violation of Align-St-L.

When two monosyllabic prefixes precede a long root, the prefixes are naturally grouped together in a binary foot, while a second binary foot marks the beginning of the root, as in output candidate (27a). All other (binary) foot parsings are less optimal since they involve minimally two violations of Align-St-L:

(27) /ta-pag=bɪssalahan/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(tà-pag)=(bìs.sa).(lá.han)]			*	**,****		
b. [(tà-pag)=bɪs.sa.(lá.han)]			**!	****	*	**
c. [ta-(pàg=bɪs).sa.(lá.han)]			**!	*,****	*	**
d. [ta-pag=(bìs.sa).(lá.han)]			**!	**,****		**
e. [ta-pag=bɪs.sa.(lá.han)]			**!*	****	*	****
f. [(tà)-(pàg)=(bìs.sa).(lá.han)]	*!*			*,**,****		

Let us now turn to a case in which the selection of the optimal output involves All-Ft-L. In tableau (28) three candidates (28a-c) occur which violate no undominated constraint. All of these violate Align-St-L to some extent:

(28) /ka-pag=bɪssala/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(kà-pag)=bɪs.(sá.la)]			**	***	*	*
b. [ka-(pàg=bɪs).(sá.la)]			**	*,***!	*	*
c. [ka-pag=bɪs.(sá.la)]			***!	***	*	***
d. [(kà)-(pàg)=(bìs).(sá.la)]	*!**			*,**,***		

Three left stem edges occur at distances of one syllable apart, which means that Align-St-L is necessarily violated, because of Ft-Bin (ruling out 28d). However, violation of Align-St-L must be minimal. Therefore (28a-b), each of which have two violations of Align-St-L, are preferred over (28c), which has three. The choice between (28a) and (28b) is due to the next constraint down the hierarchy, All-Ft-L, selecting the output in which the secondary stress foot lies as near to the left PrWd edge as possible. This is (28a). Note that Align-St-L is no ad hoc means of arriving at the correct output here. It was independently motivated by the secondary stress pattern of long monomorphemic words (see again 22).

Finally consider the cases of fluctuating secondary stress. In Optimality Theory, cases of fluctuating outputs can be handled by a *tie* of constraints.[6] This involves crucial non-ranking of potentially antagonistic constraints. When two constraints C_1 and C_2 are ranked in the same position in the hierarchy, the evaluation procedure branches at that point. In one branch, C_1 is ranked above C_2, while in the other branch, the ranking is the reverse. Sibutu Sama has two 'freely' ranked constraints All-Ft-L and Align-Rt-L. In the branch where All-Ft-L ranks higher, the variant with word-initial secondary stress is optimal (cf. 29 i). In the other branch, where Align-Rt-L ranks higher, the one with root-initial secondary stress is optimal (cf. 29 ii):

(29 i) /pag=bissalahan/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(pàg=bis).sa.(lá.han)]			*	***	*	*
b. [pag=(bìs.sa).(lá.han)]			*	*,***!		*
c. [pag=bis.sa.(lá.han)]			**!	***	*	***
d. [(pàg)=(bìs.sa).(lá.han)]	*!			*,***		

(29 ii) /pag=bissalahan/	Ft-Bin	Align-Wd-R	Align-St-L	Align-Rt-L	All-Ft-L	Parse-Syll
a. [(pàg=bis).sa.(lá.han)]			*	*!	***	*
b. ☞ [pag=(bìs.sa).(lá.han)]			*		*,***	*
c. [pag=bis.sa.(lá.han)]			**!	*	***	***
d. [(pàg)=(bìs.sa).(lá.han)]	*!				*,***	

Now the root manifests itself as a morphological domain requiring left-edge stress marking. Compare the tableaux (29i-ii) to the one in (28) of [(*kà-pag*)=*bɪs*.(*sá.la*)], a word of that has two prefixes and a trisyllabic root. Both have identical numbers of syllables before the main stress (three in each case). Whereas secondary stress fluctuates between the first and second syllable in (29), it is fixed on the initial syllable in (28). The difference is due to the fact that the second syllable in (29) is the root-initial syllable, while in (28) it is the first syllable of the prefix (a stem edge, but not a root edge). For demarcative stress, root-edges are more prosodically 'priviliged' than other stem edges. This is due to the fact that the edge referred to by Align-Rt-L is a special case of the edge referred to by Align-St-L. Effects of the 'specific' constraint Align-Rt-L are in some contexts obscured by the general constraint Align-St-L (for example in [(*tà-pag*)=(*bɪ̀ssa*).(*láhan*)], see again 27). Still, Align-Rt-L makes its presence felt in other contexts, where multiple candidates pass evaluation by Align-St-L.

The branching tableaux (30 i-ii) for *maka-pag=bɪssalahan* work likewise:

(30 i) /maka-pag=bɪssalahan/	Ft-Bin	Align-Wd-R	Align-St-L	All-Ft-L	Align-Rt-L	Parse-Syll
a. ☞ [(mà.ka)-(pàg=bɪs).sa.(lá.han)]			*	**,*****	*	*
b. [(mà.ka)-pag=(bìs.sa).(lá.han)]			*	***,*****!		*
c. [(mà.ka)-pag=bɪs.sa.(lá.han)]			**!	*****	*	***
d. [ma.ka-pag=(bìs.sa).(lá.han)]			**!	***,*****		***
e. [ma.(kà-pag)=(bìs.sa).(lá.han)]			**!	*,***, *****		*
f. [ma.ka-pag=bɪs.sa.(lá.han)]			**!*	*****	*	*****
g. [(mà.ka)-(pàg)=(bìs.sa).(lá.han)]	*!			**,***, *****		

(30 ii) /maka-pag=bɪssalahan/	Ft-Bin	Align-Wd-R	Align-St-L	Align-Rt-L	All-Ft-L	Parse-Syll
a. ☞ [(mà.ka)-(pàg=bɪs).sa.(lá.han)]			*	*!	**,*****	*
b. [(mà.ka)-pag=(bìs.sa).(lá.han)]			*		***,*****	*
c. [(mà.ka)-pag=bɪs.sa.(lá.han)]			**!	*	*****	***
d. [ma.ka-pag=(bìs.sa).(lá.han)]			**!		***,*****	***
e. [ma.(kà-pag)=(bìs.sa).(lá.han)]			**!		*,***, *****	*
f. [ma.ka-pag=bɪs.sa.(lá.han)]			**!*	*	*****	*****
g. [(mà.ka)-(pàg)=(bìs.sa).(lá.han)]	*!				**,***, *****,	

To sum up, the central feature of this analysis is an interaction between morpho-prosodic alignment constraints (Align-St-L, Align-Rt-L) that embody 'demarcative' stress and prosodic well-formedness constraints that are blind to morphological domains (Ft-Bin, All-Ft-L). This interaction produces a complex pattern in which some (but not all) morpheme edges are signalled by stress. The generalization is captured that left stem edges are signalled 'maximally' by stress, that is, precisely to the extent that foot well-formedness (Ft-Bin) allows it. Even if stem alignment is maximally satisfied, indeterminacies remain with respect to the choice of stem edges to be marked. I have shown that precisely in this situation, where different outputs meet the goal of left stem alignment to the same extent, variability arises. Precedence is then given to either the marking of root edges or to PrWd-initial stress. I have analysed this by a free ranking of a pair of antagonist constraints, a morpho-prosodic alignment constraint (Align-Rt-L) and a prosodic well-formedness constraint (All-Ft-L).

Let us now see how rule-based metrical theory would analyse this stress pattern. I first consider an analysis which is based on stem-initial foot assignment, followed by clash resolution to 'repair' any ill-formed outputs. I will present an analysis cast in the framework of Halle & Vergnaud (1987) and Halle & Kenstowicz (1991). However, this choice of specific framework is not essential, since the analysis could be translated into other frameworks (e.g. Hayes 1981, Hammond 1988) without loss of key insights. The analysis contains the following rules, distributed over cyclic and noncyclic blocks:

(31) Cyclic Stress Erasure Convention
Metrification (right to left).
On line 0 construct binary left-headed constituents from right to left and assign line 1 asterisks to the heads.
On line 1 construct unbounded right-headed constituents and assign a line 2 asterisk to the heads.
Conflation
Conflate lines 1 and 2.

Noncyclic Idiosyncratic boundary assignment
Assign a left constituent boundary at the left edge of stem.
Metrification (left to right)
On line 0 construct binary left-headed constituents from left to right and assign line 1 asterisks to the heads.
Clash Deletion
Delete a line 1 asterisk (in context specified below).

Cyclic stress rules, which are triggered by suffixes, together produce a single primary-stressed left-headed foot at the right edge of the stem (secondary stresses are all wiped out by Conflation). In the noncyclic block, a left foot boundary is 'idiosyncratically' assigned to every left stem edge (compare the analysis of Diyari in Halle & Kenstowicz 1991). Purely for presentational reasons, I have marked this boundary by '['. This must be respected by left-to-right metrification (due to the 'Free Element Condition', Prince 1985). This rule set accounts for long unprefixed words (see 32), as well as for words with disyllabic prefixes (see 33), without additional rules. In derivations below, the first stage represents the output of the cyclic block (where Conflation has already applied), the second stage represents the result of (noncyclic) idiosyncratic boundary assignment, and the final stage represents the result of (noncyclic) left-to-right metrification:[7]

```
(32)       *                      *                    *
       (      *)             (         *   )       (*       *)
        *   * (*   *)        [*   *  (*   *)       [*   *) (*   *)
       bɪs.sa.la-han    →    bɪs.sa.la-han    →    bɪs.sa.la-han
```

```
(33)          *                        *                      *
          (          *)        (              *)       (*          *      *)
          *  *   *   * (*  *)   [* *   [* *  (*    *)    [* *) [*    *)(*   *)
          pi.na- bɪs.sa.la-han → pi.na- bɪs.sa.la-han → pi.na- bɪs.sa.la-han
```

In words with monosyllabic prefixes, the problem is how to account for the fluctuation of secondary stress. This analysis sets up monosyllabic feet in intermediary stages of the derivation, and then trims back any ill-formed outputs by clash resolution. Clash Deletion is obligatory (since no clashes appear at the surface), but the choice of the stresses to be deleted is left unspecified (to capture the stress fluctuation). As stated before, Clash Deletion takes place at a stage of the noncyclic derivation where all stems (including roots and prefixed domains) have initial stresses. Below, the line 1 elements which are optionally deleted have been underlined. Those which are obligatorily deleted have been doubly underlined.

```
(34)  a.              *           b.               *
           (*  *      *)               (*  *   *    *)
           [*) [*   *)(*   *)          [*) [*)  [*) (*  *)
           pag-bɪs.sa.la.han           ka-pag=bɪs.sa.la

      c.                  *       d.                        *
           (*  *    *     *)           (*       *    *       *)
           [*) [*)  [*   *)(*  *)      [*   *) [*)  [*  *)(*   *)
           ta-pag=bɪs.sa.la.han        ma.ka-pag=bɪs.sa.la.han
```

Next consider the application of Clash Deletion, which forms the heart of the analysis. The only correct way to insure the distribution of secondary stresses is by applying the following three rules, in the order given below:

```
(35)  a.   * → Ø/      * ___ *

                            *
      b.   * → Ø/      ___ *

      c.   * → Ø /     ___ *   or    * ___   (choice free)
```

First, line 1 asterisks that are in 'double clash' are deleted by rule (35a). Next, asterisks that are in clash with a following stronger stress are deleted by rule (35b). Finally, rule (35c) freely resolves any remaining clashes by deleting either the lefthand or righthand

second line 1 asterisk involved. The derivations below illustrate these rules.

```
(36)            *                      *                        *
       (*   *      *)           (*   *      *)            (*          *)
       [*) [*   *)(*  *)  n.a. [*) [*   *)(*  *)  (35c) [*) [*   *)(*  *)
       pag-bɪs.sa.la.han   →   pag-bɪs.sa.la.han   →   pag-bɪs.sa.la.han

                                                                *
                                                         (    *    *)
                                                         [*) [*   *)(*  *)
                                                    or   pag-bɪs.sa.la.han
```

```
(37)            *                       *                         *
       (*   *    *   *)          (*       *   *)           (*              *)
       [*) [*)  [*) (*  *) (35a) [*) [*)  [*) (*  *) (35b) [*) [*)  [*) (*  *)
       ka-pag=bɪs.sa.la    →     ka-pag=bɪs.sa.la    →     ka-pag=bɪs.sa.la
```

The ordering between rule (35a) and both other rules (35b-c) is crucial; if, in derivation (37), rule (35b) applied first[8], deleting the line 1 asterisk over the syllable [bɪs], the result would not be distinguishable from the input of derivation (36). Consequently it is incorrectly predicted that [*ka-pag=bɪs.sa.la*] has two possible stressings, namely [*kà-pag=bɪs.sá.la*] and *[*ka-pàg=bɪs.sá.la*]. Thus, the analysis expresses the 'priviliged' status of left root edges (over left stem edges in general) in a highly indirect fashion, by extrinsic rule ordering. There is no (obvious) way of making Clash Deletion sensitive to the difference between root and other stem edges. Even if reference to morpheme edges by destressing were feasible, it would lead to a fragmentation of the generalization that stress maximally signals morphological edges. This would be partly due to 'idiosyncratic boundary assignment', and partly to Clash Deletion. This is a typical case of a conspiracy, for which a rule-based analysis offers no explanation.

This problem set aside, a rule-based analysis misses another generalization. Foot binarity is only indirectly accounted for by a conspiracy of rules. Monosyllabic feet are set up at intermediate levels of the derivation, after which stress clashes are resolved by destressing. The constraint-based analysis captures this generalization by undominated FT-BIN.

Of all metrical frameworks that have been proposed in recent years, the one that places most emphasis on 'edge marking' is that of Halle & Idsardi (1995), and for that reason I will test it. This theory offers the possibility of placing foot boundaries at edges of morphological domains, which is precisely what seems relevant for the pattern of secondary stress in prefixed words in Sibutu Sama. I will show that an analysis of this pattern is possible in the Halle & Idsardi theory, but only at a high cost: the assignment of stem-initial feet must be given look-ahead power.

Before I sketch the actual analysis of Sibutu Sama, let me briefly recapitulate the basic ideas of this theory of stress. As in Halle (1990) and Halle & Kenstowicz (1991), foot boundaries "(" and ")" are independent formal objects, which may be manipulated (inserted, deleted) without automatic manipulation of a paired bracket. This assumption is taken to its fullest consequence in Halle & Idsardi (1995), who reduce metrification to assignment of (unpaired) constituent boundaries, or 'parentheses'. Heads are located at edges of metrical constituents on a parametric basis, projecting either the leftmost or the rightmost element. For example:

(38) HEAD: L
Project the leftmost element of each constituent onto the next line of the grid.

In Sibutu Sama, this rule would govern the assignment of heads of line 0 constituents.

In Halle & Idsardi's theory, a special role is played by rules inserting parentheses prior to iterative metrification. *Edge Marking* rules, for example, which are functionally similar to alignment constraints in OT, project edges of specific morphemes as metrical constituent edges. This theory is strongly parametric, and for each Edge Marking, three parameters have to be set: (i) choice of a left (or right) parenthesis to be inserted, (ii) choice of the position of insertion to the left (or to the right) of a peripheral element in the domain, and (iii) choice of the leftmost (or rightmost) element in the domain (this is the peripheral element referred to in (ii)).

For example, for Sibutu Sama the following pair of Edge Marking rules seem to be required:

(39) EDGE (ROOT): LLL
Place a left parenthesis to the left of the left-most element in the root.

(40) EDGE (STEM): LLL
Place a left parenthesis to the left of the left-most element in the stem.

If both rules apply blindly, and heads are projected accordingly, we would arrive at structures that are similar to the ones in (34), and the problem of how to apply Clash Deletion would return with identical force. However, an interesting aspect of Halle & Idsardi's theory is that rules may be blocked due to 'avoidance constraints'. For example, the equivalent of 'clash avoidance' (and to some extent, 'foot binarity') in this theory is the avoidance constraint (41), which rules out a sequence of parentheses that are separated by only a single grid element:

(41) AVOID (x(

This constraint plays an important role in the theory, since it governs the application of iterative metrification. Halle & Idsardi (1995:424) emphasize the function of derivation:

> "Since disfavored configurations are not allowed to arise, the origin of each parenthesis is very much at issue. Simply put, parentheses that get placed first preclude the introduction of later parentheses that would result in a disfavored situation. As a result, in avoiding a configuration such as (x(, the presence of a parenthesis will prevent the introduction of a parenthesis both to the left and to the right".

I will return to this later. Let us now develop the analysis. As in the analysis discussed earlier, the cyclic block produces outputs that have a single, right-aligned primary stress foot, while in the noncyclic block prefixes are metrified together with the root. I make the assumption that Edge Marking applies iteratively through the domain, and that it may be blocked by the avoidance constraint (41). For 'Edge (stem): LLL', left-to-right iterative application will be shown to be crucial. A further necessary assumption is that the pair of Edge Marking rules differ in their obligatoriness. Specifically, 'Edge (root): LLL' is optional, while 'Edge (stem): LLL' is obligatory.

Derivations in (42) run downward from the first stage (the input to the noncyclic block). Consecutive stages represent the effects of 'Edge (root): LLL', 'Edge (stem): LLL', and 'Head: L'. In the lefthand derivation (of double-prefixed *kà-pag=bɪssála*), the optional rule 'Edge (root): LLL' is blocked by the avoidance constraint (41). The origin of blocking is the left parenthesis of the main stress constituent, assigned at an earlier stage of the derivation (in the cyclic block). Next 'Edge (stem): LLL' applies obligatorily, from left to right through the domain. It assigns a left parenthesis at the leftmost stem edge, while it is blocked by constraint (41) at both following stem edges.

```
(42)      a.            x        b        x
                        x)                x)
           x   x    x (x x)     x    x  x (x  x)
          ka-pag=bɪs.sa.la     pag=bɪs.sa.la.han

                                          x
  Edge                                    x)
  (root):  blocked              x   [x  x (x x)    (non-application)
  LLL                          pag=bɪs.sa.la.han

                        x                                 x
  Edge                  x)                                x)
  (stem): [x  x    x  (x x)    blocked             [x    x x (x  x)
  LLL     ka-pag=bɪs.sa.la                         pag=bɪs.sa.la.han
                        x                  x              x
           x            x)          x      x)      x      x)
  Head:   [x  x    x (x x)     x   [x  x (x  x)   [x    x x  (x  x)
  L       ka-pag=bɪs.sa.la     pag=bɪs.sa.la.han  pag=bɪs.sa.la.han
```

In contrast, the righthand derivation (42b) (of single-prefixed *pag=bɪssalahan*, where secondary stress fluctuates) branches at the point where the optional 'Edge (root): LLL' applies. In the lefthand branch, where it applies, 'Edge (stem): LLL' is blocked by the avoidance constraint. 'Head: L' then locates the secondary stress on the second syllable. But in the righthand branch of this derivation, where optional 'Edge (root): LLL' is not applied, 'Edge (stem): LLL' is obligatorily applied from left to right, resulting in the same output structure as derivation (42a).

This derivational analysis embodies the same essential insight as the constraint-based analysis: prosodic well-formedness takes priority over demarcative stress. On details both analyses compare as follows. The constraint-based analysis subordinates Align-St-L to Ft-Bin, where the derivational analysis blocks Edge Marking by 'Avoid (x('. The constraint-based analysis has a 'free' ranking of a morpho-prosodic alignment constraint (Align-Rt-L) and a prosodic well-formedness constraint (All-Ft-L), where the derivational analysis has an optional application of 'Edge (root): LLL', and left-to-right application of obligatory 'Edge (stem): LLL'. Now, given the conclusion that both analyses derive the correct outputs, does this undermine the argument (given earlier) for a constraint-based theory? In my opinion, it does not, for the following general reasons.

To express the generalisation that prosodic well-formedness takes priority over demarcative stress, this analysis required two crucial assumptions: (i) iterativity of Edge Marking, and (ii) the blocking of Edge Marking by the avoidance constraint. The first of these assumptions introduces a redundancy in the theory: iterativity has now become a property of both 'morphology-blind' metrification (Iterative Constituent Construction in Halle & Idsardi 1995) and 'morphology-sensitive' metrification (i.e., Edge Marking). This loses the generalisation, adequately expressed in the constraint-based analysis, that both kinds of directionality are due to a *single* constraint: All-Ft-L. Factoring out the effects of directionality from morpho-prosodic alignment, and making both compete for potential metrical parsings, is a result that is inherent to Optimality Theory. The second assumption (blocking) is more difficult to argue against, precisely because this assumption lies at the heart of Optimality Theory. Halle & Idsardi essentially propose a mixed theory, which has both rules and avoidance constraints that may block these. To restrict the types of devices in the theory, it is arguably preferrable to have a theory that has one or the other, but not both. Since avoidance constraints seem required in any theory, the logical strategy seems to be the complete elimination of rules, which is in fact what Optimality Theory sets out to accomplish.

3. The recursive PrWd in Diyari, Dyirbal, and Warlpiri

I now turn to three Australian languages, Diyari, Dyirbal, and Warlpiri, which display demarcative stress effects in morphologically complex words (consisting of root plus suffixes). All three languages have initial main stress[9], and alternating stress in the rest of the word. However, the languages differ in suffix 'coherence', that is, the extent to which foot parsing is allowed to cross morpheme edges. In all three languages, polysyllabic suffixes behave differently from monosyllabic suffixes, while in some languages roots and all suffixes behave differently. This variation will be shown to result from a re-ranking of the following four constraints:

(43) a. Align-Right: Align (Stem, Right, PrWd, Right)
b. Align-Rt-R: Align (Root, Right, PrWd, Right)
c. Parse-Syll: All σ must be parsed by feet.
d. All-Ft-L: Align (Foot, Left, PrWd, Left)

Diyari has the most rigid morpho-prosodic alignment of the three languages, prohibiting any feet that cross morpheme boundaries. This follows from an undominated ranking of Align-St-R above

Parse-Syll, see (44a). (Here the ranking of Align-Rt-R cannot be determined since its effects are hidden behind Align-Right, a more general constraint.) Dyirbal is equally strict in aligning the right edge of the root with a PrWd edge, but it differs from Diyari in allowing feet to be built across other right stem edges. This is due to a demotion (as compared to Diyari) of Align-Right below All-Ft-L and Parse-Syll, see (44b). Finally, Warlpiri is the least restrictive of the three languages in its right edge alignment. It allows footing across right root edges under pressure of Parse-Syll, see (44c).

(44) a. Diyari: Align-Right (Align-Rt-R) » **Parse-Syll** » All-Ft-L
b. Dyirbal: Align-Rt-R » **Parse-Syll** » All-Ft-L » Align-Right
c. Warlpiri: **Parse-Syll** » Align-Rt-R, Align-Right » All-Ft-L

In sum, what we will see in the following sections on Diyari, Dyirbal, and Warlpiri, is a progressive upgrading of Parse-Syll over alignment constraints. For reasons that will be discussed below, the morpho-prosodic alignment effects seen in these languages are most adequately analysed as the result of the a mapping of morphological structure into Prosodic Word structure. Demarcative stress then becomes a direct effect of the opacity of the Prosodic Word edges for foot parsing.

3.1. Diyari

Diyari is a Pama-Nyungan language of South Australia (Austin 1981). It stress pattern strongly depends on morphological structure, and has been previously analysed by Poser (1989), Idsardi (1992), McCarthy & Prince (1994), and Crowhurst (1994), among others. Primary stress falls on the first syllable of a root. Secondary stress falls on the first syllable of a polysyllabic suffix, and on the third syllable of a four syllable morpheme. See the examples in (45)[10]:

(45)	a.	2	kána	'man'
	b.	3	pínadu	'old man'
	c.	4	wílapìna	'old woman'
	d.	2+1	kána-ni	'man-Loc'
	e.	3+1	púluru-ngi	'mud-Loc'
	f.	2+2	kána-wàra	'man-Pl'
	g.	3+2	pínadu-wàra	'old man-Pl'
	h.	4+2	wílapìna-wàra	'old woman-Pl'
	i.	2+4	táyi-yàtimàyi	'to eat-Opt'
	j.	2+1+1	máda-la-ntu	'hill-Charac-Propr'
	k.	2+1+2	kána-ni-màta	'man-Loc-Ident'
	l.	2+2+1	kána-wàra-ngu	'man-Pl-Loc'
	m.	3+2+2	kána-wàra-ngùndu	'man-Pl-Abl'
	n.	3+2+2+1	yákalka-yìrpa-màli-na	'to ask-Ben-Recip-Part'

Observe the asymmetry between polysyllabic morphemes (which are all stressed on the initial syllable) and monosyllabic morphemes (which are never stressed). McCarthy and Prince (1994) argue that the 'monosyllable' effect is due to a strict alignment between the stem and PrWd, which are both taken as recursive categories. That is, the PrWd is self-embedding, copying the recursive structure *Stem -> Stem + Af* (which is marked by curly brackets below):

(46)		*Morphological structure*	*PrWd structure*
	a.	{{{mada} la}ntu}	[[[mada] la] ntu]
	b.	{{puluru} ngi}	[[puluru] ngi]
	c.	{{pinadu} wara}	[[pinadu] wara]
	d.	{{{kana} ni}mata}	[[[kana] ni] mata]

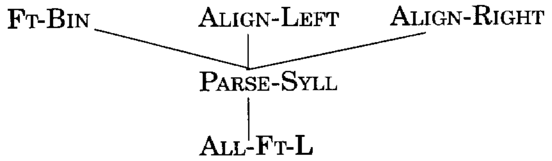
McCarthy & Prince attribute this 'stem-recursion' effect to two alignment constraints at the top of the hierarchy.

(47) a. Align-Left Align (Stem, Left, PrWd, Left)
b. Align-Right Align (Stem, Right, PrWd, Right)

Together, these constraints have the effect that every stem edge (right or left) coincides with a PrWd edge. The assumption is that PrWd forms an absolute barrier for footing, due to the stricly layered nature of categories of the prosodic hierarchy, in which PrWd dominates Ft. Note that the crucial constraint of the pair of (47) that blocks the rightward alternation of stress across right stem boundaries is Align-Right. In contrast, Align-Left plays no crucial rôle for stress, producing stacks of left PrWd boundaries at the word beginning.

To obtain the effect of 'iterative', left-edge-oriented feet in four-syllable stems and suffixes, Parse-Syll must dominate All-Ft-L. The complete ranking (following McCarthy & Prince 1994) is below:

(48)



I have not included Align-Rt-R in the hierarchy, since its ranking cannot be properly established. Its effects, if any, are obscured by Align-Right, a more general constraint, which is undominated. (Assuming again that every root edge is a stem edge.) In the tableaux (49-50) no candidates are considered that violate undominated Align-Left.

(49) Input:/mada-la-ntu/	Ft-Bin	Align-St-R	Parse-Syll	All-Ft-L
a. ☞ [[[(má.da)]-la]-ntu]			**	
b. [[(má.da)]-(là-ntu)]		*!		**
c. [[[(má.da)]-(là)]-(ntù)]	*!*			**, ***

(50) Input: /puluru-ngi/	Ft-Bin	Align-St-R	Parse-Syll	All-Ft-L
a. ☞ [[(pú.lu).ru]-ngi]			**	
b. [(pú.lu).(rù-ngi)]		*!		**
c. [[(pú.lu).(rù)]-(ngì)]	*!*			**, ***

(51) Input: /pinadu-wara/	Ft-Bin	Align-St-R	Parse-Syll	All-Ft-L
a.☞ [[(pí.na).du]-(wà.ra)]			**	***
b. [[(pí.na).du]-wa.ra]			**!*	***
c. [(pí.na).(dù-wa).ra]		*!	*	**

(52) Input: /kana-ni-mata/	Ft-Bin	Align-St-R	Parse-Syll	All-Ft-L
a.☞ [[[(ká.na)]-ni]-(mà.ta)]			*	***
b. [[[(ká.na)]-ni]-ma.ta]			**!*	
c. [[(ká.na)]-(nì-ma).ta]		*!	*	**

In this analysis, the 'monosyllable' effect is a direct consequence of morpho-prosodic alignment and foot well-formedness. No monosyllabic suffix may be stressed since (by Ft-Bin) this would require a foot whose weak syllable is part of a following suffix, thus fatally violating Align-Right. Moreover, each polysyllabic suffix must begin with a foot: when a binary foot can be built without violating alignment, Parse-Syll forces it.

Why should PrWd mediate between morphological structure and foot structure, while in Sibutu Sama the leading hypothesis was that feet directly align with stem/root edges? Could the analysis of Sibutu Sama perhaps be restated using a recursive PrWd? Or alternatively, could the analysis of Diyari perhaps be restated by a judicious appeal to constraints that directly align feet and right stem edges?

To start with the last question, let us consider a direct-reference analysis of Diyari. Such an analysis has been proposed by Crowhurst (1994). Without reference to PrWd, the effect that morphemes behave as prosodic islands must be stated differently. The crucial contrast is that between four-syllable monomorphemic words, which have two feet [(*wíla*)(*pìna*)] on the one hand, and words that consist of a trisyllabic root and a monosyllabic suffix, which have only a single foot [(*púlu*)*ru-ngu*], on the other hand. The prosodic difference cannot be attributed to an interaction of yet another constraint, Align-St-R (i.e.: Every stem must end in a foot), and Parse-Syll, since both examples end in a right stem edge. Therefore opacity of morpheme edges for footing must be stated in a direct way. Crowhurst (1994) proposes a constraint to this effect:

(53) Tautomorphemic-Foot (Taut-F)
$*_{F}(\sigma\ _{M}[\sigma)$

This constraint is violated by any foot whose syllables belong to different morphemes. Or, to state it differently, feet may not be split between morphemes. As for descriptive adequacy, Taut-F is satisfactory. However, by allowing it into the universal constraint inventory, we in fact introduce a second type of constraint to match up morphological and prosodic edges. (Let us refer to this as a 'discontinuity constraint'.) A maximally constrained view of the morphology-prosody interface is one that has only a single type of device for this purpose: Generalized Alignment. For this general reason, I propose not to use discontinuity constraints such as Taut-F, until we have compelling evidence for such constraints.

Given the conclusion that a recursive PrWd analysis is maximally adequate for Diyari, why not attempt a similar analysis for Sibutu Sama? The answer to this question is relatively simple. Recall that the constraint All-F-L, which refers to the left edge of PrWd, played a crucial role in this analysis. The left edge of PrWd that was referred to by All-F-L crucially coincides with the left edge of the grammatical word, see again tableaux (29i) and (30i). Nonrecursivity of PrWd can be guaranteed by the constraint in (54), which is undominated in Sibutu Sama:

(54) Align-PrWd-L
Align (PrWd, Left, GramWd, Left)
"The left edge of every Prosodic Word must coincide with the left edge of some Grammatical Word."

Let us now compare this optimization analysis of Diyari stress with a rule-based metrical analysis. In the literature several analyses have been proposed, all of which use directional footing. The first analysis, due to Poser (1989), uses cyclic foot construction from left to right. Monosyllabic feet are constructed so as to mark off the end of each cyclic domain (cf. 55ab). At the end of the derivation, all monosyllabic feet fall victim to *Monosyllabic Destressing* (cf. 55c).

```
(55)         *                  *                     *
            (*    *)           (*    *   *   )       (*         *   )
      1st   (*  *) (*)   2nd  (*  *) (*) (*  *)  Mono. (*  *)  *  (*  *)
      cycle [pí.na.du]   cycle [pí.na.dù -wà.ra]  Destr. [pí.na.du -wà.ra]
```

The problem with this analysis is that it crucially uses monosyllabic feet, while at the surface all monosyllabic feet have disappeared. Moreover, the minimal word of Diyari is disyllabic, providing even more evidence for strict foot binarity. Using monosyllabic feet at intermediate stages of the derivation makes this analysis highly abstract[11].

A non-cyclic variant of this analysis, which is suggested by Halle and Vergnaud (1987:93) in their comments on Poser's analysis, assumes that in Diyari each morpheme constitutes a stress domain on its own. Foot construction is rightward within a stress domain. As in Poser's analysis, there is complete destressing of monosyllabic feet[12].

```
(56)   *                          *
      (*       *   *  )          (*              )
      (*  *) (*)  (*  *)         (*  *)  *   (*  *)
      [ká.na] [ní] [má.ta]   →   [ká.na] [ni] [má.ta]
```

Observe that monosyllabic morphemes are first footed by monosyllabic feet, before they fall victim to destressing. Like Poser's analysis, this misses the generalisation of foot binarity, and it incorrectly predicts that Diyari has monosyllabic words.

3.2. Dyirbal

Dyirbal is a Pama-Nyungan language spoken in North Queensland, Australia (Dixon 1972). Its stress pattern (which has been analysed by Crowhurst 1994) differs from the Diyari pattern in an interesting way. Root-final syllables are always unstressed (as in Diyari), but sequences of suffixes display an alternating stress pattern, starting on the first syllable of a sequence of suffixes, which is marked in boldface in (57c-g). Alternating stress ignores the difference between monosyllabic and polysyllabic suffixes (57f-g). As in the Sibutu Sama examples, I have indicated root edge by "=", and stem edges by "-":

(57)	a.	2+1	wáynydyi=nyu	'motion uphill-Rel.Cl.'
	b.	3+1	búrgurrum=bu	'jumping ant-Erg'
	c.	2+1+1	wáynydyi=**ngú**-gu	'motion uphill-Rel.Cl.-Dat'
	d.	2+1+1+1	nyínay=**má**-riy-ma-n	'sit-Com-Refl-Com-P/P'
	e.	3+1+1+1	bánagay=**mbá**-ri-nyu	'return-Refl-Com-Pres/Past'
	f.	2+1+2	dyángga=**ná**-mbila	'eat-Pron-with'
	g.	3+1+2	bánagay=**ná**-mbila	'return-Pron-with'

Observe that the first syllable following the root is prosodically signalled by a stress, except where foot binarity forbids this (57a-b). This post-root stress is 'demarcative' in the sense that it signals the end of the root, even though stress is itself not present on the morphological category whose edge is being signalled, but rather on the immediately following syllable.

In sum, while alternating stress in Diyari respects right edges of both roots and stems, alternating stress in Dyirbal only respects right root edges, and it freely crosses other right stem edges. PrWd structure only partially 'copies' morphological structure:

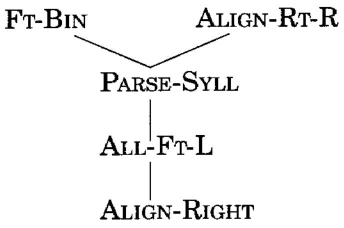
(58)		*Morphological structure*	*Prosodic structure*
	a.	{{burgurrum} =bu}	[[(búr.gu).rrum]-bu]
	b.	{{banagay} =na} -mbila}	[[(bá.na).gay]-(ná-mbi).la]

Prosodic parsings are partially due to the strict alignment of the right root edge and the right PrWd edge. The responsible constraint, Align-Rt-R, is another variation on the Generalized Alignment schema, with *GramCat* taking the value Root:

(59) Align-Rt-R
Align (Root, Right, PrWd, Right)
"The right edge of every root must coincide with the right edge of some PrWd."

The grammar of Dyirbal ranks ALIGN-RT-R higher than PARSE-SYLL and ALL-FT-L, as can be inferred from the absolute integrity of the right root edge with respect to footing. However, ALIGN-RIGHT is demoted to a ranking below ALL-FT-L, since any morpheme edges other than root edges can be freely crossed by footing (cf. 57f-g). This leads to:

(60)



Tableaux are given in (61-63). From here on, to save space, I will no longer consider any candidates that violate FT-BIN:

(61) /burgurrum=bu/	FT-BIN	ALIGN-RT-R	PARSE-SYLL	ALL-FT-L	ALIGN-RIGHT
a. ☞ [[(búr.gu).rrum]=bu]			**		
b. [(búr.gu).(rrùm=bu)]		*!		**	*

(62) /waynydyi=ngu-gu/	FT-BIN	ALIGN-RT-R	PARSE-SYLL	ALL-FT-L	ALIGN-RIGHT
a. ☞ [[(wáyny.dyi)]=(ngù-gu)]				*	*
b. [[[(wáyny.dyi)]=ngu]-gu]			*!*		
c. [[[(wáyny.dyi)]=(ngù)]-(gù)]	*!*				

(63) /banagay=mba-ri-nyu/	FT-BIN	ALIGN-RT-R	PARSE-SYLL	ALL-FT-L	ALIGN-RIGHT
a. ☞ [[[(bá.na).gay]=(mbà-ri)]-nyu]			**	***	*
b. [[[(bá.na).gay]=mba]-(rì-nyu)]			**	****!	*
c. [[[[(bá.na).gay]=mba]-ri]-nyu]			***!*		
d. [[(bá.na).(gày=mba)]-(rì-nyu)]		*!		**,****	**

The evidence that ALL-FT-L dominates ALIGN-ST-R is given in the following tableau:

(64) /{banagay}-na-mbila /	FT-BIN	ALIGN-RT-R	PARSE-SYLL	ALL-FT-L	ALIGN-RIGHT
a. ☞ [[(bà.na).gay]-(nà-mbi).la]			**	***	*
b. [[[(bà.na).gay]-na]-(mbì.la)]			**	****!	
c. [[(bà.na).(gày-na)]-(mbì.la)]				**,****	*
d. [[(bà.na).(gày)]-(nà-mbi).(là)]	*!*				

Recursive PrWd structures are independently motivated by phonotactic constraints of the language. Dyirbal syllables have obligatory onsets. The PrWd boundary after the root predicts absence of (re-)syllabification of a root-final consonant with a following suffixal vowel. This is confirmed by three phonotactic rules of Dyirbal (Dixon 1972: 272-274). First, all affixes begin with a single consonant, just like roots. That is, affixes cannot take the root-final consonant as their onset. Second, root-final consonants are limited to the set {m, n, nʸ, l, r, rr, y} excluding obstruents and /ɴ/, i.e. essentially the set of possible codas. That is, by the following PrWd boundary, the root-final consonant must be syllabified as a coda. Third, at a root-affix boundary, certain consonant clusters (e.g. /nʸɴ/) which are ruled out in morpheme-internal contexts are allowed. The wider range of clusters follows directly from the PrWd boundary after the root.

3.3. *Warlpiri*

Warlpiri is a Pama-Nyungan language spoken in the Northern Territory, Australia (Nash 1986 and later analyses by Poser 1989 and Berry 1992). Its stress pattern is partly identical to that of Diyari and Dyirbal, as witnessed by the examples in (65). Secondary stresses fall on (i) the initial syllable of polysyllabic morphemes, and (ii) on the third syllable of four syllable morphemes.

(65)				
	a.	2	wáti	'man'
	b.	3	wátiya	'tree'
	c.	4	mánangkàrra	'spinifex plain'
	d.	2+1	wáti-ngka	'man-LOC'
	e.	2+2	ngáti-nyànu	'mother-POSS'

f.	2+3	yárla-kàrlangu	'yam species-digger'
g.	3+2	yáparla-ngùrlu	'father's mother-Elat'
h.	2+2+1	yápa-rlàngu-rlu	'person-for example-Erg'
i.	4+1	mánangkàrra-rla	'spinifex-Loc'
j.	4+4	ngátinyànu-ngàtinyànu	'mother-Poss-Pl'

Observe the minimal stress pair (attributed by Nash to unpublished work by Ken Hale) formed by the segmentally identical examples in (65g-h). This pair shows that the morphological interpretation of words may crucially depend on prosodic information. It provides an ideal example of how demarcative stress can actually have a distinctive function as well, even in a so-called *fixed* stress language, in which stress is entirely predictable.

Warlpiri differs from Diyari and Dyirbal in the words of (66). Secondary stress falls on the third syllable of a trisyllabic root followed by a single monosyllabic suffix (66a), and on the first syllable in a sequence of monosyllabic suffixes (66b-d).

(66)	a.	3+1	wátiyà-rla	'tree-Loc'
	b.	2+1+1	wáti-ngkà-rlu	'man-Loc-Erg'
	c.	3+1+1	wátiya-rlà-rlu	'tree-Loc-Erg'
	d.	4+1+1	mánangkàrra-rlà-rlu	'spinifex-Loc-Erg'

As Dyirbal, Warlpiri has alternating stress in a series of (monosyllabic) affixes. In (66b-d), alternating stress starts on the first post-root syllable (as in Dyirbal), except in (66a), where a final syllable of a trisyllabic root is stressed before a single monosyllabic affix. The latter example shows that in Warlpiri Parse-Syll ranks above both Align-Right and Align-Rt-R. In Dyirbal, analogous examples had no secondary stress. Finally, in (66c) the secondary stress on the fourth, rather than third, syllable shows that right root edges are still respected wherever possible, that is, when Parse-Syll does not dictate matters. This shows that All-Ft-L is ranked below Align-Rt-R, or Align-Right.

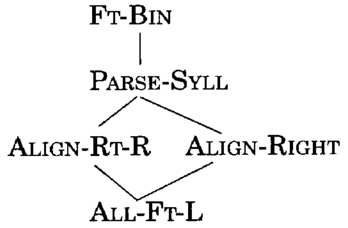
Complex verbs (examples are all from Berry 1992) confirm this picture:

(67)	a.	3+1	wírnpirlì-mi	'whistle-NPast'
	b.	2+1+1+2	páka-rnì-nja-kùrra	'hit-NPast-Inf-Comp'
	c.	2+2+1+1	párnka-pàrnka-mì-rra	'run-run-NPast-forth'
	d.	3+1+1+1	wírnpirlì-nja-yà-ni	'whistle-Inf-go-NPast"
	e.	3+1+1+2	wírnpirli-jà-lpa-jàna	'whistle-Past-Aux-them'
	f.	4+1+1+2	wálapàrri-rnì-nja-kùrra	'test-NPast-Inf-Comp'

Observe that the metrical parsings are much more compact than they are in Diyari, and even in Dyirbal. This can be seen in examples with trisyllabic roots that are followed by a sequence of morphemes that has an odd number of syllables (67a, d). The root-final syllable is stressed in these cases, which points to high-ranking Parse-Syll.

The stress pattern of Warlpiri can be related to that of Diyari and Dyirbal by a another simple re-ranking of constraints, in the following way:

(68)



Parse-Syll has again been promoted as compared to Dyirbal, and it is only dominated by Ft-Bin. No unary feet occur. The precise ranking of Align-Right is more difficult to establish, for the following reasons. The only types of word where morphology may influence stress at all are those with an odd number of syllables, since Parse-Syll and Ft-Bin, by themselves, determine the perfect binary rhythm of words with even numbers of syllables. In words that have an odd number of syllables, those that have a trisyllabic root all place stress on the post-root syllable, e.g. [(*wá.ti*).*ya*=(*rlà-rlu*)] due to Align-Rt-R. It would take an even-numbered root that is followed by an odd numbered suffix sequence to find out whether stem alignment has any influence at all, e.g. a word of the syllable count 2+1+2. Both Nash (1986) and Berry (1992), in stating the general patterns of stress, claim that the first syllable of a polysyllabic morpheme is stressed, but both fail to provide examples of the type 2+1+2. Assuming the correctness of this generalization, the parsing must be [[[(σσ)]=σ]-(σσ)] rather than [[(σσ)]=(σ-σ)σ]. Stem alignment is given priority over left-edge foot alignment. This establishes the ranking Align-Right » All-Ft-L.

Let us now consider some crucial tableaux. The first presents the argument for ranking Parse-Syll above all three alignment constraints:

(69) /watiya-rla/	Ft-Bin	Parse-Syl	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [(wá.ti).(yà-rla)]			*	*	**
b. [[(wá.ti).ya]-rla]		*!*			
c. [[(wá.ti).(yà)]-(rlà)]	*!*				**,***

Next, consider tableau (70), which shows that Align-Rt-R dominates All-Ft-L:

(70) /watiya=rla-rlu/	Ft-Bin	Parse-Syll	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [[(wá.ti).ya]=(rlà-rlu)]		*		*	***
b. [[(wá.ti).(yà=rla)]-rlu]		*	*!	*	**
c. [[[(wá.ti).ya]=rla]-rlu]		**!*			
d. [[[(wá.ti).(yà)]=(rlà)]-(rlù)]	**!*				**,***,****

Finally, tableau (71) shows the activity of Align-Right[13] in a word of the type 2+2+1:

(71) /yapa-rlangu-rlu/	Ft-Bin	Parse-Syll	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [[[(yá.pa)]-(rlà.ngu)]-rlu]		*			***
b. [[(yá.pa)]-rla.(ngù-rlu)]		*		*!	***
c. [[[(yá.pa)]-(rlà.ngu)]-(rlù)]	*!				**,****

A further set of data is relevant now. Verbs consist of a verb stem plus an Auxiliary word, which contains aspectual and pronominal suffixes. Secondary stresses in the Auxiliary word alternate rightward on monosyllabic suffixes, the last of which is unstressed. I indicate the right edge of the verb stem by "#":

(72)		
	a. wángka-mi # ka	'to speak-NPast-Pres'
	b. wángka-mi # kà-rna	'to speak-NPast-Pres-I'
	c. wángka-mi # kà-rna-ngku	'to speak-NPast-Pres-I-You'
	d. wángka-mi # kà-rna-ngkù-lu	'to speak-NPast-Pres-I-You-Pl'
	e. wángka-mi # kà-rna-ngkù-lu-rla	'to speak-NPast-Pres-I-You-Pl-Dat'

The Auxiliary word behaves as an independent domain for stress. This result can be achieved by the following undominated constraint:

(73) **Align-V-R**
Align (Verb Stem, R, PrWd, R)

The analysis is illustrated by the following tableaux, where I omit Ft-Bin to save space.

(74) /wangka-mi # ka/	Align-V-R	Parse-Syll	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [[[(wángka)]-mi]-ka]		**			
b. [[(wángka)]-(mì-ka)]	*!				**

(75) /wangka-mi # ka-rna/	Align-V-R	Parse-Syll	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [[[(wángka)]-mi]-(kà-rna)]		*		*	***
b. [[[[(wángka)]-mi]-ka]-rna]		**!*			
c. [[[(wángka)]-(mì-ka)]-rna]	*!			*	**

(76) /wangka-mi # ka-rna-ngku/	Align-V-R	Parse-Syll	Align-Rt-R	Align-Right	All-Ft-L
a. ☞ [[[[(wángka)]-mi]-(kà-rna)]-ngku]		**		*	***
b. [[[[(wángka)]-mi]-ka]-(rnà-ngku)]		**		*	****!
c. [[[[[(wángka)]-mi]-ka]-rna]-ngku]		***!*			
d. [[[(wángka)]-(mì-ka)]-(rnà-ngku)]	*!			**	**,****

Let us now consider a rule-based metrical account of Warlpiri stress. On the one hand, it is clear that setting up each morpheme as an independent stress domain (the Halle & Vergnaud analysis of Diyari) does not work for Warlpiri, as foot construction may cross morpheme edges, in contrast to the situation in Diyari. On the other hand, a cyclic analysis based on monosyllabic feet and monosyllabic foot destressing also fails. Poser (1989:142) proposes a post-cyclic *Merger* rule for Warlpiri which restructures two monosyllabic feet into a single disyllabic foot. See (77):

```
(77)     *                 *                           *
        (*    *)  Foot    (*    *    *)  Merger       (*    *     )
        (*  *)(*)         (*  *)(*)  (*)              (*  *)(*    *)
       [wá.ti.yà]  →     [wá.ti.yà -rlà]  →          [wá.ti.yà -rla]
```

Merger misses the generalization of foot binarity. A further complication resides in the fact that *Merger* must apply directionally from right to left, as demonstrated by (78):

```
(78)     *                         *                        *
        (*    *    *    *         (*    *    *     )       (*          *     )
        (*  *)(*) (*)  (*)        (*  *)(*)  (*    *)      (*  *) *   (*     *)
       [wá.ti.yà -rlà-rlù]→  [wá.ti.yà -rlà -rlu]  →  [wá.ti.ya -rlà -rlu]
```

It is unclear why *Merger* should apply leftward, since foot construction is rightward. Observe that *Merger* must be followed by *Monosyllabic Destressing* to eliminate the monosyllabic foot on the third syllable of (78). Monosyllabic destressing constitutes a further indication of the missed generalization of foot binarity. Finally, *Merger* runs into empirical problems with respect to the Auxiliary word pattern of (72). Leftward *Merger* predicts the incorrect patterns of (79):

(79) a. *wángka-mi # ka-rnà-ngku'to speak-NPast-PRES-I-You'
b. *wángka-mi # ka-rnà-ngku-lù-rla 'to speak-NPAST-PRES-I-You-PL-DAT'

To repair this defect, it must be stipulated that *Merging* applies rightward, rather than leftward, in Auxiliary words. This stipulation is completely ad hoc.

To wind up the discussion of Warlpiri, an OT analysis has clear advantages. First, it directly expresses foot binarity. Secondly, since it does not rely on directional foot construction, it does not produce conflicting directionalities of foot construction versus foot restructuring (Poser's *Merging*) on the one hand, or of foot restructuring in Auxiliary words versus foot restructuring in all other cases on the other hand.

Comparing the stress patterns of Diyari, Dyirbal, and Warlpiri, we find that all three languages are variations on a theme: the interaction of morpho-prosodic alignment and prosodic well-formedness constraints. Differences are entirely due to re-rankings of a small set of constraints.

4. Conclusions

In this paper I have argued that the demarcative function of stress can be formalized in an insightful way by Generalized Alignment (McCarthy & Prince 1993). Alignment constraints are crucially violable, and may be dominated by one another as well as by general prosodic well-formedness constraints that govern the shape and position of feet. The re-ranking of constraints produces smaller and more significant variations in stress patterns, instantiated by different languages. This OT-based approach of the prosody-morphology interface contrasts sharply with that of a purely derivational theory, which has rules only. Such a theory reduces demarcative stress to a rule-conspiracy, and offers no explanation of it. A derivational theory that has both rules and avoidance constraints has several other disadvantages, the most important being the duplication of theoretical means and mechanisms.

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Notes

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[1] I have omitted the constraint that is responsible for the distinction between main stress and secondary stress. In Sibutu Sama, as well as in Diyari (discussed below), main stress falls on the foot that stands at the edge of the PrWd that occurs in the highest-ranked ALIGN-WD constraint (the final foot in Sibutu Sama, and the initial foot in Diyari). Although cross-linguistically a correlation exists between the edge of the main stress and the directionality of footing, it is only statistical, not complete. See Hayes (1995) for recent discussion.

[2] Allison claims that words with two disyllabic prefixes have no stem-initial stress, something for which I can provide no explanation.

[3] Observe the nasal substitution ([b] ~ [m]) in the initial consonant of the stem 'to speak' after the prefix /paN-/, cf. (14a) vs. (15a), which applies across the prefix-stem boundary. This may be taken as evidence that prefix and stem form a single PrWd, on the tentative assumption that nasal substitution has PrWd as its domain.

[4] In addition to these, undominated WD-HEAD-RIGHT requires that the rightmost foot in PrWd is the most promiment one.

[5] In prefixed words, left stem edges are indicated by "-", and root edges by "=". Suffix edges are not indicated.

[6] Crucial nonranking of constraints was observed as a theoretical option in Prince & Smolensky (1993), but left out of consideration due to lack of positive evidence for it. It has since been argued to be the optimality-theoretic counterpart of optional rule application by Kiparsky (1993), Kager (1994, 1996) and Anttila (1995).

[7] It is unclear how the theory of Halle & Vergnaud (1987) would account for the fact that long unprefixed words have maximally one secondary stress, since it assumes that metrification is universally iterative.

[8] This order of rules is actually predicted by the *Trigger-Prominence-Principle* of Hammond (1988), according to which clashes involving the main stress must be resolved first.

[9] Analogously to my discussion of Sibutu Sama, I will assume that primary stress is due to an undominated constraint WD-HEAD-LEFT requiring that the leftmost foot in PrWd be the most promiment one. I will leave this constraint out of consideration in what follows, along with the position of the head in the foot (due to undominated FTFORM=TROCHEE).

[10] Where glosses do not indicate case, forms are Absolutive.

[11] A variation on this cyclic analysis, due to Steriade (1988), and slightly revised by Hewitt (1992), avoids monosyllabic feet, but instead assumes that Stray Syllable Adjunction (SSA) applies cyclically to adjoin leftward any stray syllables left over at the end of the domain. The assumption that SSA is a cyclic rule radically contrasts with the standard view of SSA as an automatic principle applying at the end of the word level derivation, however.

[12] Halle and Kenstowicz (1991) and Idsardi (1992) modify this analysis such that a left foot parenthesis is inserted at each morpheme boundary by Edge Marking.

[13] ALL-FT-L is not crucial here. See earlier comments on the ranking of ALIGN-RIGHT » ALL-FT-L.

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