Boolean Operations and Constraint Interactions in Optimality Theory*

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Abstract

This paper develops a theory of constraint interactions in which the requirements of two or more individual constraints are co-ordinated as a unit, or *macro-constraint*. Macro-constraints are required to account for certain types of phonological dependency; specifically, cases in which a complex linguistic pattern is co-conditioned by multiple factors. We examine examples of such patterns in Diyari, Zezuru Shona, Dongolese Nubian, and Bolivian Guaraní and show that an analysis which appeals to macro-constraints predicts attested outputs under otherwise standard assumptions concerning the evaluation of interacting constraints in OT. The behaviour of macro-constraints in restricting phonological behaviour reveals intriguing parallels with operations of conjunction, disjunction, and implication familiar from classical (or Boolean) logic. The analogy with logic is developed extensively, focussing on the operation of conjunction, and on differences between conjunction and implication. Finally, we show that the behaviours of constraints interacting under co-ordination bring into sharper focus subtle EVAL effects which do not emerge

* This paper has profitted from the input of a number of colleagues. We thank John Alderete, Laura Benua, Luigi Burzio, Steven Crain, Chip Gerfen, Kleanthes Grohmann, John McCarthy, Tivoli Majors, Alan Prince, Doug Pulleyblank, Paul Smolensky, and Bill Turkel, all of whom made useful comments and contributions at some point, or who discussed the ideas in this paper with one of the authors. We are especially grateful to Laura Downing and Scott Myers for extensive written comments on an earlier version, and for lively discussion. Peter Austin generously corresponded with us concerning the Diyari data. The Bolivian Guaraní data were elicited by Crowhurst in 1996 in Camiri, Bolivia from Bismarck Abayo, Vicenta Camargo, Silvia Chumira, and Floi, native speakers of this language. Crowhurst's fieldwork was funded by a ILAS travel grant and a University Research Council grant, both from the University of North Carolina. Versions of this work have been presented to audiences at NELS, the University of British Columbia, the University of Arizona, and the University of Maryland. Hewitt acknowledges support for this work from SSHRCC grant # 410-92-1629 to Patricia A. Shaw. Comments should be directed to both authors at mjcrowhu@gibbs.oit.unc.edu and mhewitt@din.cc.brandeis.edu.

when constraints are are not co-ordinated, with implications for the treatment of candidates and our understanding of constraint evaluation more generally.

1. Introduction.

In this paper we develop a model within the framework of Optimality Theory (OT)[1] for a class of phenomena which illustrate a type of phonological patterning which is commonplace in natural sound systems. Consider the items in (1).

(1)

a. Conflicting directionality in stress and tone systems.[2]

Dongolese Nubian stress: If a metrical domain contains one or more heavy syllable(s), stress the rightmost heavy syllable; otherwise, stress the initial syllable (Armbruster 1960, 1965).

Shona Complex Tone Pattern: An inflectional H tone links to the second TBU of a verb stem when the initial syllable is not also H-toned (i.e. when it is L-toned); otherwise, the inflectional H links to the stem-final syllable (Fortune 1985; Myers 1987; Odden 1981,1984).

b. *Diyari Templatic stress:* Morphemes of two, four, and five syllables occur with initial and penultimate stress. Monosyllabic morphemes are not stressed, and no syllable immediately preceding a monosyllabic morpheme ever receives stress[3] (based on Austin 1981).

c. *Bolivian Guaraní mobile secondary stress:* Optional secondary stress occurs on the root-initial syllable when it is the first or second syllable of the word. Otherwise, stress occurs on the word-initial syllable (Crowhurst 1996a).

It is not immediately obvious that the descriptions in (1a,b,c) identify phenomena which pattern alike and should on that basis be granted membership in a special class. However, a more careful examination reveals the following property common to each case in (1): A primary, or conditioned pattern occurs when at least two mutually reinforcing requirements are simultaneously satisfied. When one or more of these conditions fails, the primary pattern is blocked and a default pattern, the *otherwise* case, is realised instead.

The mutual dependency holding between factors which constrain the primary pattern emerges most clearly (and perhaps most familiarly) in Dongolese Nubian and other cases of conflicting directionality described in the metrical literature (e.g. Kiparsky 1973; Halle & Vergnaud

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1 For founding discussions of OT, see Prince & Smolensky (1993) and McCarthy & Prince (1993a,b; 1994). The theory has been developed in numerous works by these and many other authors. Many of these works are electronically available from the Rutgers Optimality Archive at (http://ruccs.rutgers.edu/roa.html).

2 The apt expression *conflicting directionality* is due to Zoll (1997).

3 Informed readers will recall that trisyllabic morphemes, restricted to word-initial position, receive initial stress. We will be treating these cases under a different generalization. A complete analysis is presented in §3.

1987; Hayes 1995; and numerous references cited in these works). In Dongolese, stress is optimally assigned to a syllable which is both heavy *and* lies as close as possible to the right edge of the metrical domain (the primary pattern). If no such syllable exists, as in cases where all syllables are light, then both rightmostness and heaviness are dropped as conditions on stressibility, and prominence defaults to the left edge. Primary and default patterns for the other examples in (1) are given in (2).

(2)a. *Shona*.
Primary pattern: H-tone association occurs at the left edge *and* respects the OCP.
Default pattern: Word-final H-tone association.

b. *Diyari.*
Primary pattern: Morpheme alignment with foot structure at the left *and* right edges.
Default pattern: Absence of foot structure within the morpheme.

c. *Bolivian Guaraní.*
Primary pattern: Stress is root initial *and* it must occur within a window of two syllables from the left edge of the word.
Default pattern: Word-initial stress.

One way of handling the type of phonological co-conditioning which characterises the primary patterns just described is to introduce into the universal constraint set a complex constraint which simply combines all of the factors conditioning some primary pattern. While some accounts of this sort have been technically successful in accounting for phonological facts (e.g. Zoll's 1997 analysis of conflicting directionality),[4] they suffer from at least two shortcomings. The first is that constraints which roll two or more phonological requirements into a single undifferentiated whole recapitulate information stated in simpler constraints; analyses which depend on the complex versions therefore incur a loss of generality. That is, it is *always* possible to break down any such complex constraint into components, each of which expresses a single, independently motivated requirement. The second problem is that simply stating complex constraints so that they refer to two or more separate requirements obscures the nature of the interaction between the individual

[4] Zoll's account is discussed in §5. A pre-OT example of such complex constraints is the grounded constraints of Archangeli & Pulleyblank (1994).

components. Only by making information about these interactions explicit can we reach beyond mechanical superficialities.

We agree, with others, that co-conditioned (morpho-)phonological behaviour is best understood as an effect of complex constraints (Archangeli & Pulleyblank 1994; Smolensky 1995, 1997; Fukazawa & Miglio 1996; Kirchner 1996; Alderete 1997; Zoll 1997). To date, however, no work has undertaken an extended discussion of their nature and of the broader theoretical implications they might have. This work represents an attempt to develop a model consistent with optimality-theoretic assumptions within which we might begin to address these issues.

Our fundamental proposal is that complex constraints are derived constraints, or *macro-constraints*, which co-ordinate the requirements of at least two individual constraints.[5] By *derived constraint*, we mean that macro-constraints are not given by UG, but are the language-specific product or artefact of complex interactions between simple constraints. These complex interactions themselves (the topic for the remainder of the paper) are defined by UG. Thus, the *macro-constraint* has no status as a theoretical primitive; however, we employ the term as a useful analogy.

Beyond simply providing analyses which motivate constraint co-ordination, our discussion is organised around the following questions: *What presumably universal factors limit the co-ordination of specific constraints?* One might imagine, naively, that any two arbitrarily selected constraints may participate in a co-ordinated interaction. We argue in §2 that this cannot be the case for reasons to do with the fundamental nature of constraints, and we propose a principled means of restricting sets of constraints which may interact under co-ordination. Second, *what types of interactions are possible under co-ordination?* To comprehend the meaning of any complex constraint and what it does, it is necessary to understand how each component within the unit functions in relation to other components. It is necessary to understand how the evaluation of each co-ordinate contributes to the evaluation of the macro-constraint. Pretheoretically, we might imagine that the relationship between co-ordinates and what they contribute to the macro-constraint

5 A preliminary and less completely articulated version of this proposal and its consequences was introduced in Hewitt & Crowhurst (1996). This paper represents a considerably expanded revised version of that work.

is always symmetrical, or always asymmetrical. Alternatively, it might be that some co-ordinated relationships are symmterical and others asymmetrical. These are factors to be determined--along with a clear view of what symmetry or asymmetry might mean. In the following sections, we show that phonological behaviour associated with macro-constraints reveals striking parallels between constraint co-ordination and familiar operations of classical propositional logic. We exploit the analogy with logic extensively in developing our model, and argue that, just as between arguments in a Boolean expression, the relationship between co-ordinated constraints is symmetrical in some cases, asymmetrical in others. We argue that some constraint co-ordinations parallel Boolean *conjunction* while others are more appropriately characterised as involving *implicational*. In the mode of *conjunctive co-ordination* introduced here (the special focus of this paper), a candidate must pass every constraint in the relation in order to pass the macro-constraint. This differs the operation of local conjunction introduced by Smolensky (1995, 1997), (see also Suzuki 1995, Fukuzawa & Miglio 1996, Kirchner 1996, and Alderete 1997). We compare the two approaches to conjunction and show them to be complementary. We also discuss connections between both modes of constraint conjunction and classical *disjunction*.

The remainder of the paper is organised as follows. We outline our proposals with respect to constraint co-ordination in §2, then motivate our model by applying it to concrete examples of phonological behaviour. Conjunctive analyses of Diyari stress and the Complex Tone Pattern in Zezuru Shona are presented in §3 and §4, respectively. An analysis of stress in Dongolese Nubian follows in §5. A discussion of local conjunction and disjunction is found in §6. An example of local conjunction (in particular, of self-conjunction) is presented in §7 using original metrical data from Bolivian Guaraní. Concluding remarks in §8 are directed primarily toward identifying directions for future study.

2. Conjunction.

In formal logic, series of expressions may be yoked into complex expressions whose interpretation is tied to the semantics of a Boolean operator or connective. Examples of such complex expressions appear in (3).

(3)	*Conjunction:*	$A \wedge B$	'A and B'
	Disjunction:	$A \vee B$	'A or B'
	Implication:	$A \Rightarrow B$	'If A, then B'

A variety of sound behaviours encountered in phonological systems provide evidence for patterns of constraint interaction which suggest natural language counterparts for the Boolean operations in (3). The case for each is undertaken in later sections, beginning with conjunction. Logical conjunction and its interpretation in an optimality-theoretic grammar are introduced in greater detail in §§ 2.1 and 2.2.

2.1 The bare bones.

A more extended definition of logical conjunction in (4a) states that a conjunction such as $A \wedge B$ is true if and only if each conjoined expression, or proposition, is true. If *true* in Boolean logic corresponds to *passes evaluation* in our constraint system, then we arrive at the optimality-theoretic interpretation of conjunction in (4b).

(4)a.	*Boolean Conjunction:*	The conjunction $A \wedge B$ is true iff proposition A is true *and* proposition B is true.
b.	*Constraint Conjunction:*	A candidate Cand passes a conjunction $A \wedge B$ iff Cand passes constraint A *and* Cand passes constraint B.

The correspondence between (4a,b) is represented in the format of a truth table in (5). By definition, the logical conjunction in (5a) is evaluated as *false* if either or both of the conjoined propositions is false (cf. (ii), (iii), and (iv)).

(5) (a) Boolean conjunction (b) Constraint conjunction

	Proposition A	^	Proposition B			Constraint A	^	Constraint B
i.	T	**T**	T	C	C			
ii.	T	**F**	F				*****	*
iii.	F	**F**	T			*	*****	
iv.	F	**F**	F			*	*****	*

Under our optimality-theoretic interpretation in which the truth value *T* corresponds to *passing evaluation*, any candidate which fails either constraint A or constraint B (or both) fails the conjunction of A and B. Thus, there are two best candidates, (i) and (ii), for constraint A in (5b), and two for Constraint B, (i) and (iii). However, the only candidate which passes *both* constraints is (i). This, then, is the only candidate which passes the conjunction.[6] It is important to emphasise that passing is determined in the manner standard for OT. Thus, if one conjunct is a gradiently evaluated constraint, then a candidate may pass the constraint, and possibly also the conjunction, even if it has incurred a violation. Thus, in conjunction as elsewhere in OT, candidates are compared for relative harmony as opposed to the simple presence or absence of violations.

Before proceeding, we note that the conjunction in (5b) illustrates effects of blending and compressing constraint violations incurred by individual constraints. These effects, as we demonstrate in §§ 3 and 4, are definitional characteristics of conjunction. By blending we mean that in determining that a candidate fails a conjunction, the identity of the constraint that suffered a fatal violation is unimportant; what matters is only that the candidate was not the best candidate for *some* conjunct (cf. the failing candidates (5b.ii) and (5b.iii)). Reduction is illustrated in the evaluation of candidate (5b.iv) above: here, a penalty is assessed against both conjuncts, but together, these are counted as only one violation against the conjunction as a whole. In other words, it is no worse to violate both A and B than it is to violate only A, or only B.[7]

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6 If a conjunction is successful--that is, if some set of candidates pass it--then the candidate set overall is reduced to the passers, and these are evaluated by the next constraint down the hierarchy in the usual manner. Candidates which do not pass the conjunction are literally eliminated from the candidate set. The argument that this is so is presented in a later section.

7 Blending, as described here, is also a hallmark of co-ranking, or crucial non-ranking (Crowhurst 1994, 1997; Itô & Mester, 1996), and thus is insufficient on its own to diagnose conjunctive evaluation. In co-ranking, subsets of individual constraints which have the potential to interact fail to do so in the usual hierarchical sense. That is, none of the constraints, each of which seems to occupy the same position in the phonological constraint

2.2 Argument structure, focus, and co-ordination.

Conjunctive evaluation differs from nonconjunctive evaluation in that when constraints interact conjunctively, their harmonic requirements are co-ordinated. In this section we explore the meaning of co-ordination, and the conditions under which co-ordination is possible.

In classical logic, conjunction is unrestricted; virtually any two expressions may be co-ordinated regardless of their semantics. While the result of conjoining unrelated expressions may sometimes be pragmatically odd, it is always possible to assign an interpretation to a conjunction as long as every conjunct expression can be assigned a truth value. Thus, in a logical grammar which encodes a set of expressions {A, B, C ... n}, the range of combinatorial possibilities is potentially infinite. The conjunction of constraints in OT, on the other hand, cannot be similarly unrestricted. This must be so, not merely for the sake of analytical convenience and theoretical rigour (though these are important considerations), but because of the very nature of constraints themselves.

Consider that every constraint has a FOCUS, which may be defined as the linguistic object upon which some condition of maximum harmony is predicated. Abstracting away from differences due to style, we recognise at the heart of any constraint a definition of a state of maximum harmony holding on some linguistic object in relation to some other linguistic object. (As noted in the introduction, any constraint specifying more than two arguments attempts to capture a complex relationship which should be unpacked.) The linguistic objects so related are expressed as EXPLICIT ARGUMENTS in the statement of a constraint. An explicit argument is any linguistic category referred to directly (named) in the statement of a constraint. For example, the constraint FOOT-TO-HEAD in (6) has two explicit arguments: a foot, and the head of a foot.

(6) FOOT-TO-HEAD: Link (Foot, Head(Foot))
'Every foot is associated to the category head.'

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hierarchy, can be shown to dominate other constraints in the set. Co-ranked constraints behave as though they occupy a single cell in the hierarchy in that a violation of one is as bad as a violation of another. However, co-ranking is unlike conjunctive evaluation in that a violation assessed by each of two co-ranked constraints still counts as two violations. For a detailed recent discussion, see Crowhurst (1997).

In the interest of clarity, explicit arguments should be distinguished from what we call IMPLICIT arguments, which may be identified categories corresponding to explicit arguments by virtue of the transitive dominance relations arising in multi-layered phonological representations. For example, heads of feet are nearly always co-identified with syllables, due to limitations on the size of metrical feet and their heads (though see Rice 1992, Dresher & Lahiri 1990, Crowhurst 1992). The syllable, then, could be seen as an implicit argument corresponding to the explicit argument Head(Foot) in (6).[8]

In every case known to us, the relationship between the arguments of any constraint is asymmetrical, and may be characterised in terms of a universal-existential scope differential. That is, one argument, which we will call the PRIMARY ARGUMENT, identifies the linguistic object upon which some condition of maximum harmony is predicated. Primary arguments are always interpreted with universal scope. A primary argument is easily recognised, even when not formally indicated: it corresponds to the linguistic object or domain for which violations are assessed when a candidate fails to satify the condition specified by the constraint. By contrast, the NONPRIMARY ARGUMENT of any constraint is identified with the condition on the primary argument, and is always interpreted with existential scope.[9]

(6.5)
a. The PRIMARY ARGUMENT of any constraint is:
i. The linguistic object upon which some condition of maximum harmony is predicated.
ii. Always interpreted with universal scope.

b. The NONPRIMARY ARGUMENT of any constraint is:
i. Identified with the condition on the primary argument.
ii. Always interpreted with existential scope.

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[8] The distinction we are making here between explicit and implicit arguments has potential implications for the model we are developing. Specifically, we might ask the question, if only constraints which share an argument in common are conjoinable (read on), must the shared argument be an explicit argument of every conjunct, or could the argument be an implicit argument of one or more of the conjoined constraints? At present, we must leave this question to be answered by further research.

[9] One class of apparent exceptions to these definitions are the OCP constraints. However, If OCP constraints are seen not as restrictions on sequences of objects, but rather as adjacency restrictions on individual objects, then this class of constraints can also be seen to fit the schema outlined here. That is, an OCP constraint could easily be stated as in (i). In this case, it doesn't much matter which F is interpreted as the primary, and which as the nonprimary argument.

(i) OCP(F): A feature F may not occur adjacently to a feature F.

Examples of constraint families for which the relationship between the arguments of a constraint has been formally defined in published work are the ALIGN family (MP 1993b), the LINK family (Crowhurst 1996a, refining a proposal in Hewitt 1994; see also the ASSOCIATE family in Walker 1994), and CORRESPONDENCE (MP 1995).

To resume our discussion of focus, the focus of any constraint corresponds to the primary argument. Furthermore, the focus identified for any constraint is unique; no constraint should be stated so as to specify multiple foci.

(7) FOCUS (OF A CONSTRAINT)$_{def}$:
- i. Every constraint has a unique focus.
- ii. A constraint's focus is identified by the universally quantified argument.

To provide concrete examples, each of the constraints NOCODA (MP 1993b) and σ-TO-FOOT stated in (8) has as its primary argument and focus the syllable.

(8) a. NOCODA : Align (σ, Right, Vowel, Right)
"**Every syllable** ends with some vowel."

b. σ-TO-FOOT: Link (σ, Foot)
"**Every syllable** is associated to some foot."

The notion of focus is important because in the model developed herein, a conjunction functions as a macro-constraint. As such, it must be uniquely focussed on some linguistic object, just as unconjoined constraints are. As the focus of any constraint is identified by its primary argument, the focus of a conjunction must likewise correspond to a primary argument. This, we propose, must be an argument specified by every conjunct constraint. And, if the conjunction is to have a unique focus, the argument 'passed up' from each conjunct to the macro-constraint must designate the same linguistic object. The focus of the conjunction is represented notationally as a raised expression to the right of the operator $\wedge$, as shown in the hypothetical example in (9).

(9) *Conjunction:* NOCODA $\wedge^{\sigma}$ σ-TO-FOOT

The conjunction in (9) is interpreted as meaning that any syllable must be coda-free *and* associated to a foot. The failure of either condition results in the failure of the conjunction.

Under the reasoning set out above, only constraints whose statements specify a common argument may be conjoined. Viewed in these terms, the shared argument criterion is no unprincipled stipulation, but imposes a natural limit on constraint co-ordination in OT which is consistent with, and even expected within the broader theoretical framework. In fact, our intuition is that things could not sensibly be otherwise: a conjunction is a complex constraint which co-ordinates distinct harmonic requirements on a specific linguistic element. From this perspective, it would make no sense to conjoin a constraint like NoCoda with PRWD-TO-FOOT in (10); since these constraints do not refer to the same objects (i.e., they do not share an argument), it is not possible to identify a linguistic element for which harmonic requirements can be co-ordinated.

(10) PRWD-TO-FOOT: Link (**PrWd**, Foot)
("**Every PrWd** is associated to some foot". Assign one * for each footless PrWd.)

The proposals introduced so far raise questions, both conceptual and mechanical, about conjunction. We conclude this section by considering two, leaving further issues to be resolved in later sections. First, we have reasoned that a conjunction, like any individual constraint should have a unique focus. What implications does this claim have for the evaluation of specific individuals in candidate forms?

When candidates are matched against a nonconjunctively evaluated constraint, for example NoCoda in (8a), every element which matches the constraint's focus (in this case, every syllable) is scrutinised. Therefore, EVAL may potentially return as many penalties against NoCoda as there are syllables in a candidate. Similarly, a conjunction may return up to *n* violations for a candidate containing *n* elements which match the focus. To make this point more concrete, we consider how the candidates in (11), which reflect different syllabic analyses of a hypothetical input /opondamba/, would be evaluated with respect to the conjunction NoCoda $\wedge^{\sigma}$ σ-to-Foot in (9). (Syllables in these candidates are indexed so that they may be easily referred to in following figures.)

(11) a. (o pon)(dam ban) b. o pon (dam ban)
$\sigma_\alpha\ \sigma_\beta\ \ \sigma_\gamma\ \sigma_\delta$ $\sigma_\alpha\ \sigma_\beta\ \ \sigma_\gamma\ \sigma_\delta$

Each syllable in the candidate representation is evaluated in parallel for harmonic status with respect to the conjunction. If one (or more) of the conjuncts is violated by a given syllable, a single mark is assessed in the conjunction cell in the tableau. The chart in (12) presents a syllable-by-syllable display in which *micro-violations*--violations of the individual conjuncts NoCoda and σ-to-Foot --are registered as 'x' and every *macro-violation*--a violation assessed for the conjunction as a whole for any focal element (here, a syllable)--appears as an asterisk '*'.

(12)

Cand1
$(\sigma_\alpha\ \sigma_\beta)(\sigma_\gamma\ \sigma_\delta)$

Conjunction:			*	*	*
Foci		σ_α	σ_β	σ_γ	σ_δ
Constraints:	NoCoda		x	x	x
	σ-to-F				

Cand2
$\sigma_\alpha\ \sigma_\beta\ (\sigma_\gamma\ \sigma_\delta)$

Conjunction:		*	*	*	*
Foci		σ_α	σ_β	σ_γ	σ_δ
Constraints:	NoCoda		x	x	x
	σ-to-F	x	x		

The tableau format for the information graphically represented in (12) is shown in (13). Both micro-violations and macro-violations are shown with a subscript identifying the focal element which incurred the violation. Macro-violations are centred under the $\wedge$ operator. Only macro-violations are crucial for the evaluation of candidates. For this reason, we adopt the convention of enclosing micro-violations in parentheses.

(13) Hypothetical ranking: X » NoCoda $\wedge^{\sigma}$ σ-to-Foot » Y

Candidates:	X	NoCoda	$\wedge^{\sigma}$	σ-to-Foot	Y
Cand1 C	…	(*β *γ * δ)	*β *γ *δ		…
Cand2	…	(*β *γ * δ)	*α *β *γ *δ!	(*α *β)	…

The preceding discussion of conjunctive evaluation and focal elements makes the following point: we noted above that conjunctive evaluation has the effect of compressing micro-violations. By compression, we mean that under the assumption that conjunctions are evaluated categorically, a given focal element may violate the conjunction only once, so that two penalties (one for each constraint) against the same syllable in (13) count as a single macro-violation. For example, σ_β in Cand2 fails both NoCoda and σ-to-Foot, but these micro-violations are registered as a single violation against the conjunction as a whole. However, this levelling across violations does not mean that a conjunction may be violated only once for any given candidate, if a candidate contains more than one focal element. To make this point clear, we return to Diyari in §3.

The purpose of this section has been to present in broad strokes a model in which the evaluation of individual constraints may be co-ordinated as part of complex constraints, or macro-constraints. We have introduced our model by focussing intially on the mechanics and evaluation of constraint conjunctions. The bare bones discussion in this section will be refined and amplified with further details and arguments as we proceed with discussions and analyses of the the data which motivate our proposals. In section 3, we move to a discussion of morpheme-prosody alignment in Diyari, followed by an analysis of the Shona Complex Tone Pattern in section 4.

3. Templates R Us: conjunction and stress assignment in Diyari.

The conjunctive evaluation of individual constraints, discussed in §2, is motivated by surface dependencies in which two distinct patterns are co-distributed: either both patterns are present, or both are absent. This effect is especially well-illustrated by cases which have been analysed in terms of what we shall call morpho-prosodic templates. Morpho-prosodic templates have been proposed to account for correspondences between morphological and prosodic categories (MCats and PCats, respectively).[10] A language which displays evidence for such a templatic relationship is Diyari, a Pama-Nyungan language of Australia described by Austin (1981). In Diyari, foot boundaries are co-located with morpheme boundaries, subject to a minimum size constraint on the foot. The analysis developed in this section closely follows proposals advanced by Hewitt & Crowhurst (1996), who analyze Diyari's pattern of footing through a conjunction of ALIGN constraints, capturing a templatic correspondence between MCat, a morpheme, and PCat, a foot. Diyari is presented as the first case study for conjunction because it illustrates especially clearly the pattern of co-distribution and dependency which identifies the phenomenon. Beyond providing an account of Diyari, we argue that a conjunctive treatment of morpho-templatic phenomena successfully addresses problems encountered by prior OT analyses advanced by MP (1993a) and Kager (1994).

The examples in (14) from Austin (1981:30-31) show that primary stress is word-initial, assigned to the first syllable of the root. Secondary stress falls on the third syllable of quadrisyllabic morphemes, (14c,i), and on the initial syllable of every suffix of two or four syllables, (14e,f,g,h,i).[11] Monosyllabic morphemes are not stressed individually, (14e,h), or in sequence, (14d). The foot structure we assume is shown in the second column.[12]

(14) *Diyari*

a.	ká=a	(ká.=a)	'man'
b.	pínadu	(pí.na) du	'old man'
c.	Nándawàlka	(Nán.da)(wàl.ka)	'to close'
d.	má¶a-ḻa-ṉi	(má.¶a)-ḻa-ṉi	'hill-char-LOC'
e.	púl^{y}udu-ṉi-màṯa	(pú.l^{y}u) du-ṉi-(mà.ṯa)	'mud-LOC-IDENT'
f.	pínadu-wà˙a	(pí.na) du-(wà.˙a)	'old man-PLURAL'
g.	ká=a-wà˙a	(ká.=a)-(wà.˙a)	'man-PLURAL'
h.	=ánda-na-màṯa	(=án.da)-na-(mà.ṯa)	'hit-PART-IDENT'
i.	táyi-yàtimàyi	(tá.yi)-(yà.ti)(mà.yi)	'to eat-OPT'
j.	wíntaranàya	(wínta)ra(nàya)	'how long' PA

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10 We adopt the label morpho-prosodic template to distinguish these cases from purely phonological prosodic templates, such as the elements of the prosodic hierarchy (Selkirk 1980, 1984). The most prominent examples of morpho-prosodic templates are probably reduplicative templates.

11 The stress patterns for the quadrisyllabic suffix in Diyari *yàtimàyi* 'optative' and the five syllable root *wíntaranàya* were confirmed by Peter Austin (personal e-mail communication, April 29, 1997). He also notes that *yàtimàyi* is the only quadrisyllabic suffix and may once have been bimorphemic, composed of -yati- 'lest' and -mayi- 'emphatic (after imperative infl.)'. *Wíntaranàya* is the only unreduplicated root of five syllables. Austin (1981) informs us that a sequence *winta* 'when' (cited in the glossary to Austin 1980) exists independently, but that there is no evidence for independent items *ranaya*, *naya*, or *ra*.

12 The symbols [˙ ¶ =] represent retroflex consonants.

The important observations are, first, that foot structure is never assigned across morpheme boundaries, and second, whether and how a morpheme is stressed depends on the number of syllables: morphemes of at least two syllables have stress, while monosyllabic morphemes never do. Several prior analyses have departed from the assumption (implicit or explicit) that the domain of stress assignment is the morpheme (Poser 1986, 1989; Hewitt 1992; Crowhurst 1994; Kager 1994). On this account, bisyllabic foot structure is assigned to every morpheme large enough. All accounts assume that monosyllabic morphemes are not footed due to a ban on degenerate feet. Furthermore, the morpheme-as-stress-domain generalisation provides an explanation for why foot structure is not assigned across morpheme boundaries to strings of monosyllabic suffixes. However, the morpheme-as-stress-domain generalisation is not quite sufficient: we make the further observation that with the exception of trisyllabic morphemes (see below),[13] all morphemes longer than one syllable are stressed in a manner consistent with the presence of a foot at both edges of the morpheme. When dual-edge alignment is not possible, as in the case of monosyllabic morphemes which are too small to support a foot, foot structure is absent--or so we infer from the absence of stress.

The challenge for Diyari lies in accounting for the unusually intimate relationship between metrical and morphological structure: foot-building is usually not restricted by stem-internal morpheme boundaries. In the remainder of this section, we pursue a templatic analysis of Diyari stress. In §3.1 we briefly review the origins of templatic analyses of MCat-PCat correspondences, and demonstrate that a Generalised Alignment (GA) account along the lines of MP (1993b) is unsuccessful in accounting for the data. In §3.2 we argue that the templatic effects observed follow from the conjunction of two ALIGN constraints (a modified GA account which builds on MP's original intuition). Finally, in §3.3 we compare our account to one proposed by Kager (1994).

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[13] While trisyllabic roots are common, trisyllabic suffixes are nonexistent, a point to which we return below.

3.1 Testing Templatic Alignment Relations.

Morpho-prosodic templates were originally conceived by MP (1986) to account for the fact that the form of a reduplicative morpheme is often determined by a prosodic constituent such as the syllable, foot, or minimum word. An example, from MP's (1986) analysis of reduplication in Manam (e.g. *salaga* > *salaga**laga***), appears in (15a). In the OT literature, PS propose templatic constraints such as (15b), which establish a correspondence between a lexical category and a prosodic category.[14]

(15) a. Reduplicative Morpheme = Foot (MP 1986:38-39)
b. LEXCAT = PCAT

More recently, M&P (1993b) argue that morpho-prosodic templates have no independent theoretical status, and that effects identified with them follow from the requirements of ALIGN constraints which enforce correspondences between the *edges* of two categories, as in (16).[15]

(16) RED = FOOT: Align (RED, Left, Foot, Left) , Align (RED, Right, Foot, Right)
("Every RED is left/right aligned with some foot"; one * per misaligned RED)

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[14] Other approaches to templatic effects have appealed to the notions *GCat is a PCat* and *GCat is the content of PCat*. Following Ito & Mester (1994) the *is a* relation requires a one-to-one mapping between the contents of a morpheme and a dominating foot (a refinement of the original *GCat=PCat*). A constraint like *Morpheme is a Foot* requires the morpheme to be uniquely contained within a single foot; no part of the morpheme may be shared with another foot and no part of the morpheme may fall outside the foot. Conversely, the *is the content of* relation does not require a one-to-one correspondence; the relation holds as long as a path exists between the foot node and all the contents of a morpheme. (It is possible for part of a morpheme to be ambipodic from this perspective.) It should be immediately clear that neither the *is a* nor the *is the content of* relation is adequate to capture the properties of Diyari forms like (ɴánda)(wàlka), in which the morpheme's edges are aligned with the edges of different feet. The advantage of formalizing Diyari's morpheme-to-foot correspondence in terms of ALIGN constraints is that nothing in Generalized Alignment theory forces a unique relationship between a single morpheme and a single foot as long as the edges of the universally quantified argument (here, the morpheme) are properly aligned.

[15] The constraints in (16) are stated in the formal notation of Generalized Alignment, defined by MP (1993b:2) as follows:

Align (Cat1, Edge1, Cat2, Edge2) $=_{def}$
$\forall$ Cat1 $\exists$ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide,
where Cat1, Cat2 $\in$ PCat $\cup$ GCat
Edge1, Edge2 $\in$ {Right, Left}

The "Align" operator takes two arguments, Prosodic and/or Grammatical categories, and two of their edges. "Align" quantifies universally over the first constituent/edge pair and existentially over the second constituent/edge pair. Alignment constraints can be read in the following manner: "For every constituent X there is a constituent Y, such that the specified edges of X and Y coincide."

MP posit no special dependency between the ALIGN constraints in (16); they are fully independent, though unranked with respect to one another.[16]

An unmodified GA analysis along the lines of (16) for Diyari footing would adopt the 'template' in (17a). The templatic constraints INITIAL-FT and FINAL-FT, stated in (17b,c), demand same-edge alignment between any morpheme and some foot.

(17) a. MORPHEME = FOOT: INITIAL-FT , FINAL-FT
b. INITIAL-FT: Align (Morpheme, Left, Foot, Left)
c. FINAL-FT: Align (Morpheme, Right, Foot, Right)
("Every morpheme is left/right aligned with some foot"; one * per misaligned morpheme.)

However, an analysis in which the ALIGN constraints in (17) are evaluated independently of one another fails to capture the very templatic effects MP's GA analysis was intended to accommodate.

Initial-Ft and Final-Ft demand the presence of foot structure at morpheme edges. For their effects to be asserted, they must dominate *STRUC(FT) in (18).[17]

(18) *STRUC(FT): Avoid foot structure. (One * for every foot not present at input.)

If *Struc(Ft) were dominant, the introduction of foot structure to satisfy the template would never be optimal (modulo the effects of other, dominant constraints). That is, if either Initial-Ft or Final-Ft were ranked below *Struc(Ft), morpheme-foot alignment at the lower-priority edge should be sacrificed to minimise assaults on *Struc(Ft). An orthodox GA account therefore requires the partial hierarchy in (19).

(19) INITIAL-FT , FINAL-FT » *STRUC(FT)

As long as both Initial-Ft and Final-Ft outrank *Struc(Ft), no advantage is gained by ranking one templatic constraint over the other; they are therefore left unranked, as per (16).

[16] It is interesting that a GA account based on (16) fails to account for the very reduplicative phenomena which inspired it. A refinement of the GA account of reduplication is undertaken in Crowhurst (in prep.).

[17] *Struc constraints were proposed by Zoll (1993). A correspondence-theoretic alternative to *Struc(Ft) would be a constraint requiring any foot present at output to have a correspondent at input. The net result would be the same.

When an input candidate contains only morphemes containing exactly two or four syllables, the hierarchy in (19) predicts the attested results. This outcome is illustrated in Tableau (20) with the inputs /{Nandawalka}/ and /{ka=a}{wa˙a}/, where each morpheme is enclosed in curly brackets (cf. *N ándawàlka* in (14c) and *ká= a-wà˙ a* in (14g)).

(20) Inputs: /{Nandawalka}/ and /{ka=a}{wa˙a}/

Candidates:		Initial-Ft	Final-Ft	*Struc(Ft)
1a.C	(Nán da)(wàl ka)			**
1b.	(Nán da) wal ka		*!	*
1c.	Nan da (wál ka)	*!		*
1d.	Nan da wal ka	*!	*	
2a.C	(ká =a)-(wà ˙a)			**
2b.	(ká =a)-wa ˙a	*!	*	*
2c.	ka =a-(wá ˙a)	*!	*	*
2d.	ka =a-wa ˙a	*! *	**	

The only candidates which pass both ALIGN constraints are (20.1a) and (20.2a); these are selected as optimal, even though each violates *Struc(Ft) twice. All other candidates fail Initial-Ft, Final-Ft, or both. (The same outcome results under any ranking of Initial-Ft and Final-Ft, as long as both dominate *Struc(Ft).) Note that a templatic analysis in the sense intended here does not entail a perfect one-to-one correspondence between morphemes and feet. Candidate (20.1a) based on a single-morpheme input succeeds even though it has two feet because both edges of the morpheme are properly aligned; nothing requires that these edges be aligned with those of a single foot.

The form that crucially motivates Final-Ft in our analysis, and hence, footing at both edges of a morpheme (the basis of the template effect), is the five syllable form *wíntaranàya* in (14j) with initial and penultimate stress. If not for this form, then the stress pattern encountered with shorter morphemes could be analysed as a left-to-right pattern generated by the familiar constraint ALL-FEET-LEFT, which requires every foot to be left-aligned within its PrWd. Tableau (21) is extended below to illustrated the treatment of *wíntaranàya* under the current analysis.

(21) Input: /{wintaranaya}/

Candidates:		Initial-Ft	Final-Ft	*Struc(Ft)
3a.☞	(wín ta) ra (nà ya)			**
3b.	(wín ta) ra na ya		*!	*
3c.	(wín ta)(rà na) ya		*!	**
3d.	win ta ra (ná ya)	*!		*
3e.	win ta ra na ya	*!	*	

The analysis pursued so far has been successful only because the structures of the inputs analysed have permitted perfect alignment with no conflicts. However, if the templatic ALIGN constraints are to be evaluated independently of one another (as orthodoxy requires), then under the usual assumptions, when it is not possible to satisfy both constraints simultaneously, EVAL will select a candidate which satisfies one or the other whenever conditions permit. Initial-Ft and Final-Ft effects should be blocked only by a dominant constraint which forces a mismatch between the categories involved in the templatic relationship. The constraint which fills this role in Diyari is FTMIN(σ) in (22).

(22) FTMIN(σ): $*\,[\sigma]_F$ (One * per monosyllabic foot.)

FtMin(σ) penalises degeneracy, and so introduces a conflict in forms containing morphemes of one syllable. Since these are never footed, we infer that FtMin(σ) is more highly ranked than the templatic constraints.[18] Adding FtMin(σ) to the hierarchy already established results in (23).

(23) FTMIN(σ) » INITIAL-FT , FINAL-FT » *STRUC(FT)

The new hierarchy predicts the attested outcome for forms like *=ánda-na-màṯa*, (14h), in which a monosyllabic morpheme is sandwiched between longer, properly aligned morphemes: since a monosyllabic sequence cannot be footed without violating dominant FtMin(σ), the morpheme {na} remains unfooted.[19] The crucial test cases are provided by forms such as *má¶ a-*

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18 Further evidence of FtMin(σ)'s high ranking is that trisyllabic roots are not doubly stressed (i.e. **pínadù*, **pínàdu*). We deal with trisyllabic roots below.

19 To explain why the foot structure *(=ánda)-(nà-ma)ṯa is not attested in these cases, the nonconjunctive analysis requires the additional assumption that a constraint which orients feet toward the left edge of the word (i.e. All-Feet-Left: Align(Foot, Left, PrWd, Left)) is ranked lower than Final-Ft.

la-*ni* which contain sequences of adjacent monosyllabic morphemes. Spans of monosyllabic morphemes are not assigned foot structure. However, the analysis of the input /{ma¶a}{la}{ni}/ in tableau (24) shows that this outcome is unexpected under the hierarchy in (23).

(24) Input: /{ma¶a}{la}{ni}/

Candidates:		FtMin(σ)	Initial-Ft	Final-Ft	*Struc(Ft)
a. D	(má ¶a)-(là-ni)		*	*	**
b.	(má ¶a)-la-ni		**!	**	*
c.	ma ¶a-la-ni		**! *	***	
d.	(má ¶a)-(là)-(nì)	*!*			***

Contrary to what we actually find in Diyari, the hierarchy considered here predicts that foot structure *should* be assigned to a span of two monosyllabic morphemes, as in (24a).[20] This is because under any ranking of Initial-Ft and Final-Ft, the candidate in (24a) incurs fewer ALIGN violations than any other candidate, except for (24d), which is rejected by FtMin(σ). Under the analysis which posits FtMin(σ) dominance over the two independently evaluated ALIGN constraints, templatic behaviour is expected to vanish; the effect should be restricted to morphemes of two, four, or even five syllables--exactly those inputs which permit perfect alignment and in which there is no conflict with FtMin(σ).

3.2 A conjunctive analysis of Diyari.

The intuition we seek to capture, the essence of the morpho-prosodic template, is that every morpheme is required to begin and to end with some foot. Proper dual-edge alignment, furthermore, is the *only* way to satisfy the template; alignment at *one* edge of a morpheme is no better than alignment at *neither* edge. In fact, when a morpheme cannot be aligned at both edges with a foot, it is usually better not to have foot structure at all.[21] These generalisations could be

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[20] The same unattested result is predicted when a monosyllabic suffic follows a trisyllabic root, as in *púlʸudu-ni-màta*. Here, too, the conventional GA analysis predicts a foot spanning a morpheme boundary, **púlʸudù-ni-màta*. Crowhurst (1994b) proposed a constraint TAUTOMORPHEMIC FOOT, $*_F[\sigma\ _M[\ \sigma]$, which assessed a violation if a foot spans a morpheme boundary. While Crowhurst's constraint is descriptively adequate for Diyari, it captures the templatic relationship between morphemes and feet less directly than the present account.

[21] The one excption occurs with trisyllabic roots, which bear initial primary stress. Our discussion of these cases is postponed until the main thrust of the analysis has been developed.

captured in an optimality-theoretic analysis if the evaluation of Initial-Ft and Final-Ft could be co-ordinated so that violating both ALIGN constraints for any morpheme is no worse than violating only one of them. This is exactly the result achieved when Initial-Ft and Final-Ft are yoked in conjunction. The conjunction we require, with the morpheme as focus, appears in (25).

(25) INITIAL-FT $\wedge^{Morph}$ FINAL-FT

In respects other than conjoining Initial-Ft and Final-Ft, the hierarchy proposed earlier remains unchanged. The tableau in (26) shows that the conjunctive analysis yields the same, attested outcomes as the nonconjunctive analysis (cf. tableau (21)) for the inputs /{wintaranaya}$_{\alpha}$/ and /{ka=a}$_{\alpha}${wa˙a}$_{\beta}$/, which contain only morphemes which permit perfect alignment without violating FtMin(σ).[22]

(26) Inputs: /{wintaranaya}/ and /{ka=a}$_{\alpha}${wa˙a}$_{\beta}$/

Candidates:		FtMin(σ)	Initial-F	$\wedge^{Morph}$	Final-F	*Struc(F)
1a.☞	(wín ta) ra (nà ya)					**
1b.	(wín ta) ra na ya			*!	(*)	*
1c.	(wín ta)(rà na) ya			*!	(*)	**
1d.	win ta ra (ná ya)		(*)	*!		*
1e.	win ta ra na ya		(*)	*!	(*)	
2a.☞	(ká =a)-(wà ˙a)					**
2b.	(ká =a)-wa ˙a		(*$_{\beta}$)	*$_{\beta}$!	(*$_{\beta}$)	*
2c.	ka =a-(wá ˙a)		(*$_{\alpha}$)	*$_{\alpha}$!	(*$_{\alpha}$)	*
2d.	ka =a-wa ˙a		(*$_{\alpha}$ *$_{\beta}$)	*$_{\alpha}$! *$_{\beta}$	(*$_{\alpha}$ *$_{\beta}$)	

The argument for the conjunction in (25) turns on forms containing a sequence of monosyllabic morphemes (e.g. *má¶ aḻa-ṉi*), which the nonconjunctive account predicts should be footed. As already noted, perfect morpheme-foot alignment in these cases is precluded by FtMin(σ). The treatment of the input /{ma¶a}$_{\alpha}${ḻa}$_{\beta}$ {ṉi}$_{\gamma}$/ under the analysis modified to include conjunction is shown in tableau (27).

[22] When more than one focal element (or morpheme) is present, these and any corresponding violations of the conjunction are indexed in (26) and subsequent tableaus, as first illustrated in section 2. This is an expository device designed only to keep track of violations, and of course, indices have no special status in the model we are proposing.

(27) Input: /{ma¶a}$_{\alpha}${l̲a}$_{\beta}$ {n̲i}$_{\gamma}$/

Candidates:		FtMin(σ)	Initial-F	∧Morph	Final-F	*Struc(F)
a.	(má ¶a)-(l̲à-n̲i)		(*γ)	*γ*β	(*β)	**!
b. C	(má ¶a)-l̲a-n̲i		(*γ *β)	* γ *β	(*γ *β)	*
c.	ma ¶a-l̲a-n̲i		(*α*β*γ)	*α*β*γ!	(*α*β*γ)	
d.	(má ¶a)-(l̲à)-(n̲ì)	*!*				***

The candidate in (27d) which violates top-ranked FtMin(σ) is rejected immediately. (Any candidate not shown containing a single degenerate foot would be similarly rejected.) The footless candidate (27c), in which no morpheme is properly edge-aligned, including bisyllabic {ma¶a}, is also rejected. This candidate violates morphemes α, β, and γ at both edges, a total of six violations, but only three violations are registered against the conjunction as a whole--one violation per morpheme. Once we understand that only a single violation per morpheme is counted against the conjunction, we see that there is no difference between the partially aligned candidate (27a) and (27b), in which the morphemes {la} and {ni} are completely unaligned: both candidates violate the conjunction once each for morphemes α and β, and so are tied. As the conjunction does not distinguish between (27a) and (27b), the decision is passed to *Struc(Ft), which selects (27b), the candidate with fewer feet, as optimal.[23] The templatic effect, then, is an artifact of the arrangement of the conjunction and *Struc(Ft) in the hierarchy: the generalisation that it is better to have no foot at all rather than one which spans a morpheme boundary is due not to the conjunction itself, but to *Struc(Ft) whose effects are asserted when all candidates fail the conjunction. Note that any constraint requiring that syllables be associated to foot structure must be ranked very low in this analysis, below *Struc(Ft), in fact. Otherwise, we would expect the fully footed candidate (má.¶a)-(l̲à-n̲i) to be chosen as optimal, and evidence for conjunctive behaviour would be obscured.

The account so far developed, which requires both edges of a morpheme to be aligned with a foot makes a clear prediction for trisyllables which requires a further modification. That is, trisyllabic morphemes should be footless: assuming a maximum as well as a minimum limit of two

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[23] We assume that unfooted syllables are linked to the PrWd.

syllables on foot structure, it is not possible to parse a trisyllabic morpheme evenly into well-formed feet. The only metrical analyses of an input like /{pinadu}/, (14b), which satisfy quantitative constraints on foot structure are (pí.na)du and pi(ná.du). However, as the presence of a foot at either edge of a trisyllabic morpheme violates the conjunction no more or less egregiously than a parse which posits no foot at all, *Struc(Ft) should decide for the unfooted candidate. Yet, Diyari has many trisyllabic roots, always in word-initial position, and all bearing initial primary stress. To account for these cases, our analysis requires that *Struc(Ft) be dominated by a constraint which directly or indirectly requires the introduction of foot structure. One possible solution is to place the constraint Main-Stress-Left in (28) above *Struc(Ft) in the hierarchy.[24]

(28) Main-Stress-Left: Align (PrWd, Left, Head(PrWd), Left)
("Every PrWd is left-aligned with its head"; One * per misaligned PrWd.)

As Main-Stress-Left is never violated, we assume the constraint to be undominated. This assumption is not crucial, however; all we require is that Main-Stress-Left be ranked above *Struc(Ft). The final version of the Diyari hierarchy is shown in (29).

(29) Main-Stress-Left, FtMin(σ) » Initial-Ft $\wedge^{\text{Morph}}$ Final-Ft » *Struc(Ft)

The treatment of *púl^{y}udu-n̲i-màt̲a* in (14e) under this analysis is shown in tableau (30).[25]

(30) Input: /{pul^{y}udu}$_\alpha$-{n̲i}$_\beta$-{mat̲a}$_\delta$/

Candidates		M-S-L	FtMin	Initial-F	$\wedge$Morph	Final-F	*Struc(F)
a. ☞	(pú l^{y}u)du-n̲i-(mà t̲a)			(*β)	*α*β	(*α *β)	**
b.	(pú l^{y}u)(dù-n̲i)-(mà t̲a)			(*β)	*α*β	(*α)	***!
c.	(pú l^{y}u) du-(n̲ì)-(mà t̲a)		*!		*α	(*α)	***
d.	(pú l^{y}u)(dù)-n̲i-(mà t̲a)		*!	(*β)	*β	(*β)	***
e.	pu l^{y}u du-n̲i-(má t̲a)	*!		(*α *β)	*α*β	(*α *β)	*
f.	pu (l^{y}ú du)-n̲i-(mà t̲a)	*!		(*α *β)	*α*β	(*β)	**

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[24] The Main-Stress-Left analysis succeeds under two separate sets of assumptions. The position assumed here is that primary stress is assigned to the head of a PrWd. If membership in the category Head(PrWd) is open only to feet, then ranking Main-Stress-Left above *Struc(Ft) produces an initial foot. Under the position, most recently articulated by v.d. Hulst (1997), that primary stress is an edge-based nonmetrical phenomenon, then Main-Stress-Left (or a constraint very like it) will still produce the desired results, but without requiring that the primary stress be associated with foot structure.

[25] We do not seriously consider candidates with a trisyllabic foot in (30).

The candidates in (30c,d) are non-optimal as all contain non-binary feet. Candidates (30e,f) are excluded through violations of Main-Stress-Right. This leaves the final competition to (30a) and (30b). As these candidates are tied with respect to the templatic conjunction (with violations assessed conjunctively), (30a) is selected since it has fewer *Struc(Ft) violations. Note once again that if the ALIGN constraints were independently rather than conjunctively ranked, (30b) would be incorrectly selected as optimal.

While an analysis which ranks Main-Stress-Left above the conjunction Initial-Ft $\wedge^{Morph}$ Final-Ft accounts successfully for initial stress in trisyllabic roots, we still predict that any trisyllabic suffixes should be entirely without foot structure. It is interesting in this regard, especially since Diyari has one quadrisyllabic suffix, that trisyllabic suffixes are unattested. While an accidental gap interpretation cannot be dismissed, the absence of trisyllabic suffixes is consistent with our analysis, and can in fact be interpreted as evidence in support of it. If the conjunction of Initial-Ft and Final-Ft were ranked above correspondence-theoretic DEP(ENDENCE)-IO constraints requiring input-output faithfulness for affixes, and which specifically ban deletion (MP 1995), then any trisyllabic suffixes might be expected to reduce to a maximum of two syllables. The same fate would be expected to befall any trisyllabic root which was grammaticalised as a suffix. On the other hand, DEP-IO constraints banning the deletion of segmental material in roots would have to dominate the conjunction; otherwise trisyllabic roots should be reduced as well. Therefore, the ranking schema required on this account is shown in (31).

(31) DEP-IO(ROOT) » INITIAL-FT $\wedge^{MORPH}$ FINAL-FT » DEP-IO(AFFIX)

If the situation on which we are speculating existed at some point in Diyari's history, then gradually, new generations of speakers might cease to posit trisyllabic suffixes at all. This explanation is similar to the one proposed by PS (1993) for the non-existence of roots consisting of a single light syllable in Latin.

3.3 Against an alternative analysis.

Kager (1994) presents an alternative analysis of Diyari structure which relies on two constraints, ALIGN-ST-R and ALIGN-ST-L in (32), which posit correspondences between the morphological and prosodic word structures.

(32)	a.	ALIGN-ST-R:	Align (Stem, Right, PrWd, Right) "Every stem is right-aligned with a prosodic word."
	b.	ALIGN-ST-L:	Align (Stem, Left, PrWd, Left) "Every stem is left-aligned with a prosodic word."

(Kager is vague on how these constraints are to be evaluated; we assume that one violation is assessed for every misaligned stem boundary, either right or left.) Following MP (1994), Kager assumes that the morphological structure of stems is self-embedding and recursive. The constraints Align-St-R and Align-St-L take such a structure, illustrated by $\{\{\{\text{pul}^{y}\text{udu}\}_{S}$-$\underline{\text{n}}\text{i}\}_{S}$-$\text{ma}\underline{\text{t}}\text{a}\}_{S}$ (= 14e), and yield isomorphic prosodic word structures, in this case, $[[[\text{pul}^{y}\text{udu}]_{PW}$-$\underline{\text{n}}\text{i}]_{PW}$-$\text{ma}\underline{\text{t}}\text{a}]_{PW}$. Kager attributes the ban on constructing feet across morpheme boundaries to a complete alignment between morphological stems and prosodic word structures. The effect of chained, minimally bisyllabic foot structures oriented to the left edge of every morpheme long enough is generated by the constraints FTBIN (his version of FTMIN(σ)), PARSE-SYLL, ("Every syllable belongs to a foot"), and ALL-FEET-LEFT ("Every foot is left aligned with some PrWd"; one * for every intervening syllable). While Kager is not fully explicit about the hierarchical relations between his constraints, his analysis apparently assumes the ranking in (33).

(33) ALIGN-ST-R , ALIGN-ST-L , FTBIN » PARSE-SYLL » ALL-FEET-LEFT

The treatment of *má¶ d̲a-n̲i* and = *ánda-na-mà̲a* under Kager's analysis appears in tableau (34). (We follow Kager's practice of rolling all penalties against Align-St-R and Align-St-L into one, a convention adopted for convenience; FtBin and its violators are also omitted.)

(34) Inputs: {{{ma¶a}l̲a}-n̲i}, {{{=anda}-na)-mat̲a}

Candidates:		Align-St	Parse-Syll	All-Ft-L
1a. C	[[[(má ¶a)]l̲a]-n̲i]		**	
1b.	[[(má ¶a)]-(l̲à-n̲i)]	*!		ma da
2a. C	[[[(=án da)]-na]-(mà t̲a)]		*	=an da na
2b.	[[[(=án da)]-na]-ma t̲a]		**! *	
2c.	[[(=án da)]-(nà-ma) t̲a]	*!	*	=an da

While Kager's analysis of Diyari is interesting, we find several reasons to prefer the conjunctive analysis developed above. First, Kager's analysis incorrectly predicts antepenultimate instead of penultimate stress for *wíntaranàya*. The problem cannot be resolved simply by inserting our constraint Final-Ft into Kager's hierarchy: the ranking All-Feet-Left » Final-Ft accounts for initial stress in trisyllabic roots but the contradictory ranking Final-Ft » All-Feet-Left is required for penultimate stress in five syllable roots. This problem could be resolved by replacing All-Feet-Left with Initial-Ft in (17b). With these changes, Parse-Syll may be demoted in Kager's hierarchy, as it is no longer required to generate a second foot in longer morphemes. Kager's account now looks considerably more like ours; the difference lies in that Kager's account prevents heteromorphemic foot-building by positing a PrWd boundary at the right edge of every morpheme,[26] as opposed to evaluating Initial-Ft and Final-Ft conjunctively, as we have proposed.

Second, Kager's account offers no explanation for the absence of trisyllabic suffixes. By contrast, this gap is predicted by our analysis as an effect of the interaction between the conjunction and affix faithfulness constraints.

A final consideration is that the embedded morpholgical and prosodic structures posited by Kager and their putative consequences for foot building essentially recapitulate in optimality-theoretic terms central properties of derivational accounts, notably by Poser (1989) and Hewitt (1992), which were considered problematic at the time they were proposed. These authors accounted for the morphemic stress domain effect indirectly, by applying cyclic rules of stress assignment in an unusual manner. Specifically, it was necessary either to metrify each morpheme

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[26] Kager's assumption, with which we find no fault, is that since the category Foot is dominated by PrWd in the prosodic hierarchy, the two syllables of a foot may not belong to different PrWds.

independently of others in the string, a new type of cyclicity (Hewitt 1992); or to apply a rule of stray syllable adjunction at the end of every cycle, turning what should be a post-lexical clean-up strategy into a lexically ordered rule. Rather than perpetuating undesirable elements of past analyses, the conjunctive account proposed here ties metrical behaviour in Diyari to a morpho-prosodic phenomenon--template--for which we find ample evidence in phonological systems.

3.4 Summary.

In §3, we have argued that the metrical system of Diyari displays evidence for a templatic correspondence between morphological and prosodic structures. Specifically, morphemes are required to be aligned at both edges with foot structure. The 'template', as such, has no special theoretical status; rather, its effects are generated by the constraints enforcing morpheme-foot alignment. However, to persist with the current analogy, our template is the structure in (35).

(35) $_F[$ ... $]_F$
{M o r p h e m e}

There are three possible ways to violate the template in (35): a foot can be missing at the left edge; at the right edge; or there might be a foot at neither edge. Any of these deviations from (35) counts as a violation of the template, none more or less egregious than any other. We have argued that this 'equality of failures' is the result of evaluating the templatic constraints conjunctively. However, conjunction is not generally limited to cases identified with templatic morphology. In §4 we show that conjunction produces very different effects associated with the distribution of H tone in Zezuru Shona.

4. Conjunction and the Complex Tone Pattern in Zezuru Shona.

Metrical patterns in which stress is assigned to a syllable at one edge of a domain when some condition is met, but defaults to the opposite edge of the domain in the 'otherwise' case, so called edge/-edge systems, are well documented in the phonological literature. Similar phenomena occurring in tonal systems, on the other hand, have received less attention. In this section, we analyze an edge/-edge pattern occurring with a high tone (H) in the Zezuru dialect of Shona, and argue that a mutual dependency between two phonological conditions should be formally expressed by co-ordinating the evaluation of two constraints independently of others. As we posited for Diyari in §3, this is done by combining the dependent constraints into a complex constraint whose overall evaluation is determined through the conjunctive evaluation of its members. Zezuru contrasts with Diyari insofar as the effects associated with conjunction are quite distinct in the two languages. One of the constraints to be conjoined in Zezuru is a gradiently evaluated alignment constraint. The discussion of Zezuru in this section makes the point that effects of gradient evaluation are almost completely suppressed under conjunction, an effect which may be interpreted as an identifying characteristic when certain types of constraints participate in the relation.

4.1 Facts and preminary assumptions.

The Zezuru Shona Complex Tone Pattern (CP) involves an inflectional morpheme consisting of a single high tone (H) whose association site within a verb stem varies depending on the tonal status of the verb root. A description of the phenomenon appears in (36).[27]

(36) *Shona Complex Tone Pattern:* An inflectional H tone links to the second syllable of a verb stem when the initial syllable is not also H-toned (i.e. when it is L-toned); otherwise, the inflectional H links to the stem-final syllable.

According to Myers (1987), the verb stem is comprised of an underlyingly H-toned or toneless verb root followed by a sequence of toneless morphemes terminating in the ubiquitous Bantu final vowel, in this case *-a*.[28] (Prefixes to the verb root, including the infinitive morpheme *ku-*, are not

[27] The Complex Tone Pattern (Goldsmith 1987) has also been discussed as Tone Conjugation 5/5a by Fortune (1985) and the Nonassertive Pattern by Odden (1981, 1984). Of the numerous theoretical accounts that have been proposed (e.g. Myers 1987, Hewitt & Prince 1989, Hewitt 1992, Downing 1996), ours is most closely allied with Hewitt's work. Goldsmith (1987) gives a brief overview of the distribution of this pattern among some of the Eastern Bantu languages. The primary sources for the general discussion of Zezuru tonology in this section are Myers (1987, 1995).

[28] In Shona, low (L) tones are phonologically inert; all patterns of tonal interaction involve H tones. This observation has led Myers (1987, 1995) and others to argue that L tones are not present at input. Rather, syllables with phonetic L are treated as phonologically toneless with L tones supplied by default. In using the descriptor *toneless* we are therefore assuming this theoretical position. As usual, H-toned vowels are marked here with an acute accent, while L-toned surface Vs are unmarked.

included in the verb stem.) The forms in (37) include verb stems beginning with the toneless roots *vereng* 'read' and *bik* 'cook'. The forms appearing in the Non-Complex column illustrate the completely L-toned melody of underlyingly toneless verb stems in the absence of the CP inflectional H. These forms should be compared with their Complex Pattern counterparts in the first column, in which the inflectional H is present and associates initially to the second syllable of the stem. The inflectional H spreads one syllable to the right, (37b,c,e), but never to the final vowel, (37a,d). (We are concerned with the association between H and the first V of a H-toned span. These are underlined, and inflectional H tones are italicised in the following examples.)[29]

(37) *Toneless root.*

	Complex Pattern		*Non-Complex Pattern*		
a.	bik-ís-a	L*H*L	bik-is-a	LLL	'caus.-cook-fv'
b.	bik-ís-ír-a	L*HH*L	bik-is-ir-a	LLLL	'cook-caus.-app.-fv'
c.	bik-ís-ís-ir-a	L*HH*LL	bik-is-is-ir-a	LLLLL	'cook-caus.-int.-app.-fv'
d.	veréng-a	L*H*L	ku-vereng-a	(L)LLL	'inf.-read-fv'
e.	veréng-és-er-a	L*HH*LL	vereng-es-er-a	LLLLL	'read-caus.-app.-fv'

The Complex Pattern with verb stems beginning with H-toned roots is quite different. H tone is an idiosyncratic property of verb roots which is systematically associated with the root-initial syllable. When no other H tones are present, root-specified H tones may spread two syllables to the right, up to and including the final V. Examples appear in the Non-Complex column of (38). The Complex Pattern forms in the first column represent the same verbal constituents augmented by the inflectional H. In the CP forms, the inflectional H associates to the rightmost syllable of the stem.

(38) H-toned root.

	Complex Pattern		*Non-Complex Pattern*		
a.	tór-es-á	HL*H*	tór-és-á	HHH	'take-caus.-fv'
b.	tór-és-er-á	HHL*H*	tór-és-ér-a	HHHL	'take-caus.-app.-fv'
c.	tór-és-és-er-á	HHHL*H*	tór-és-és-er-a	HHHLL	'take-caus.-int.-app.-fv'

Consonant with standard assumptions of autosegmental theory, spans of adjacent H-toned syllables in forms like *tór-és-er-á* and *tór-és-és-er-a* are represented as linked to a single H. Note that the pattern of spread displayed by the root-specified H in Non-CP forms is modified in the CP

[29] The causative, intensive, applicative, infinitive, and final vowel morphemes are abbreviated throughout as *caus.*, *int.*, *app.*, *inf.*, and *fv* respectively. Note that the infinitive marker *ku-* is not included in the verb stem.

forms: a root-specified H spreads only one syllable to the right when spreading two would bring spans of syllables associated to distinct H-tones into juxtaposition. In order to distill from (37) and (38) the essence of the Complex Pattern, we include in (39) a schematic representation of association sites for root-specified and inflectional H tones which abstracts away from the effects of H-spreading.

(39) *Complex Pattern*

```
        L-toned root:                H-toned root:
a.        H               b.     H         H          c.  *  HH
          |                      |         |                 | |
        σ σ σ  . . .  σ          σ σ σ  . . .  σ             σ σ σ  . . .  σ
```

Hewitt & Prince (1989) argue that the reversal in edge orientation represented in (39a) and (39b) occurs because the distribution of H tones in Shona is sensitive to the Obligatory Contour Principle (OCP), versions of which penalise adjacent sequences of identical features.[30] Under the specific version of the OCP required for Shona, it is forbidden for contiguous syllables to be associated to distinct H tones (Myers 1987, 1995). Thus, while the primary pattern of inflectional H association in the Zezuru Complex Tone Pattern is to the second syllable of the tonal domain, this pattern obtains only so long as the stem-initial syllable is not also H-toned. In the latter case, associating the inflectional H to the second syllable yields (39c), which runs afoul of the OCP. Thus, in verb stems containing an initial H-toned syllable, the inflectional H must seek an alternative to the preferred association site. We might expect the optimal output to satisfy the OCP while minimally violating leftmostness by associating the inflectional H to the third rather than the second syllable of the tonal domain. However, this does not occur. Instead, the primary pattern of orientation to the left edge is abandoned, and the inflectional H defaults to the right edge of the domain.

[30] The OCP, which originated in Leben (1973), forbade the adjacent occurrence of identical tones. Later versions banned adjacent sequences of identical features, whatever these might be (e.g. McCarthy 1986, Myers 1987, Yip 1988, Hewitt & Prince 1989). In optimalaity-theoretic work, the OCP is seen as a family of constraints, each restricting the distribution of a specific feature.

4.2 Toneless verb stems.

In the absence of conditioning factors, an analysis of CP inflectional H association in verb stems headed by toneless roots should be straightforward. The generalisation to be accounted for in these cases is that H associates to the leftmost-but-one syllable of a verb stem. That floating tones associate at all is required by the constraint *FLOAT in (40) (Myers 1995).

(40) *FLOAT: A tone must be associated with a syllable.
(One * per floating tone.)

When *Float is highly ranked, as Myers claims it is in Shona, all Hs in output representations will be associated. The left-edge orientation of the inflectional H can be expressed by the constraint H-LEFT in (41), stated in the alignment-theoretic notation of McCarthy & Prince (1993b).

(41) H-LEFT: Align (H, Left, Verb Stem, Left)
('Every H is left-aligned within some verb stem'; One * for every intervening syllable.)

H-Left is best satisfied when any Hs in the domain of the stem are linked to its first syllable. H-Left is evaluated gradiently, so that one violation is incurred for each syllable, including the first, which intervenes between H and the stem's left boundary. The mirror image counterpart of H-Left, expressed as H-RIGHT in (42), will be required later in the analysis.

(42) H-RIGHT: Align (H, Right, Verb Stem, Right)
('Every H is right-aligned within some verb stem'; One * for every intervening syllable.)

Inflectional Hs are in fact barred from associating to the site most optimal for H-Left, we assume, under pressure from a dominant constraint, NONINITIAL-H in (43):

(43) NONINITIAL-H: The initial syllable of a verb stem is not associated to H.
(One * for every initial H-toned syllable.)

Noninitial-H, an anti-prominence constraint with family ties to NONFINALITY constraints proposed in the early OT literature (e.g. PS 1993, Hung 1994), is violated by the very configuration which is optimal for H-Left. Under the usual OT assumptions concerning constraint ranking, the analysis would seem to require the subhierarchy in (44).

(44) *FLOAT, NONINITIAL-H » H-LEFT » H-RIGHT

The tableau in (46) shows that the ranking in (44) correctly predicts second syllable H association with the input in (45), to yield the verb stem *veréng-és-er-a*. (In this and subsequent tableaus, we abstract away from the effects of tonal spread.)

(45) Input:

```
          H

ve re nge se ra
```

(46) *Float, Noninitial-H » H-Left » H-Right

Candidates	*Float	Noninit-H	H-Left	H-Right

a. C `H`
 `|`
 `ve re nge se ra`
			*!	***

b. `H`
 `|`
 `*ve re nge se ra`
			**!	**

c. `H`
 `|`
 `*ve re nge se ra`
			**! **	

d. `H`
 `|`
 `*ve re nge se ra`
		*!		****

e. `H` `*ve re nge se ra`	*!			

Under the proposed ranking, candidate (46e) in which H remains unassociated is rejected as it violates top-ranked *Float. The initially-H-associated candidate in (46d) loses to optimal (46a) due to Noninitial-H's ranking above H-Left. (*Float and Noninitial-H do not conflict and can therefore not be ranked.) H does not associate further to the right than the second syllable, as in (46b,c), as this gratuitously violates H-Left. Finally, as no effects of H-Right are observed in toneless verb stems H-Left must be more highly ranked; otherwise, the unattested candidate in (46c) should be the optimal one.

4.3 Root-specified H-tones, H-spread, and the OCP.

Before completing the analysis of the CP, we pause to state some assumptions concerning H-toned verb stems and about the OCP. Myers (1987, 1995) tells us that H tone is idiosyncratically specified for verb roots and that it invariably docks to the root's first syllable. For present purposes, we assume that this initial association between H and the appropriate tone bearing unit (TBU) is present in the input for the CP. In other words, we assume inputs such as (47), in which only the initial V is H-toned, and in which the inflectional H floats.

(47)

```
 H       H
 |
to re se se ra
```

The assumption that root-specified H tones are associated at input is necessary because this association is asserted even though it violates the highly ranked Noninitial-H. On the other hand, recall that inflectional H association does *not* violate Noninitial-H. This difference can be explained if the initial tone-TBU association, as a property of the input, is subject to the Correspondence constraint MAX-IO(ASSOC) in (48), while the inflectional H, which floats in the input, is not.

(48) MAX-IO(ASSOC): If a TBU and tone T are associated in an input representation, then their correspondents are associated in the output.

Max-IO(Assoc) prohibits the deletion of association lines present at input. Thus, this constraint is violated whenever a tone-TBU pair associated at input is unmatched in the corresponding output. The ranking required to preserve the association shown in (47) is that in (49):

(49) MAX-IO(ASSOC) » NONINITIAL-H

There are at least two explanations for the presence of the association in (47) at input. One is that H-toned roots are lexically represented with an initially associated H. Even though the location of the initial association is predictable, Myers points out that in OT it is not necessary, or even necessarily desirable, to assume that all predictable information is purged from lexical representations. As Anderson (199x) notes, this assumption led to well-known and apparently irresolvable paradoxes in earlier generative theories. The second possibility would be to assume a sequentially-ordered series of phonological levels, or co-phonologies for Inkelas (1995), such that the output of one level is the input to the next. Derived inputs, in this sort of Lexical Phonology for OT, are subject to Faithfulness constraints at the new level. Under this second alternative, H would be associated to the initial syllable of a verb root at an early level, and this output would be fed as input to a subsequent level. We take no specific position on this point.

The problem to be dealt with in the next section is that leftmost association is blocked when the outcome is (50), which violates the OCP.

(50)
```
*  H  H
   |  |
  to re se se ra
```

The specific version of the OCP required for Shona, stated in (51) (Myers 1987, 1995), prohibits adjacent H tones, where 'adjacent' is interpreted as 'associated to contiguous syllables'.[31]

(51) OCP:
```
* H  H
  |  |
  σ  σ
```
(One * for every pair of adjacent H tones.)

The OCP's prominence as a player in Shona phonology is well-documented (see Myers 1987, and Hewitt & Prince 1989 for derivational accounts, and Myers 1995 for detailed arguments from an OT perspective). We will be content to summarise only one of Myers' arguments: that H-spread in Zezuru is sensitive to the OCP, and that this sensitivity is evident in limitations on tonal spread in CP forms such as *tór-és-er-á* in (38). We observed earlier that a H tone specified in the

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31 Constraints on identical sequences, or OCP constraints, appear at first glance to be exceptions to the schema discussed in section 2 under which every constraint has two arguments, of which one is universally quantified and corresponds uniquely to the focus of the constraint. Since the arguments specified by OCP constraints are identical, it is difficult to distinguish between them. We see at least two possible interpretations of OCP constraints. One is that they differ from other constraints in universally quantifying both arguments. In this case, pairs of H tones (in Zezuru) are evaluated by the constraint. The other possibility is that only one argument is universally quantified (it makes no difference which). In this case, every individual H tone in a representation is scrutinised, and if it is adjacent to another H tone, the OCP is violated. Either way, the end result should be the same.

lexical representation of a Zezuru verb root may spread up to two syllables to the right, and may spread to the final V. (Other dialects differ in this regard; see Myers 1987 for a detailed examination.) That is, while a root-specified H *may* spread two syllables, as in *tór-és-és-er-á*, the form *tór-és-er-á* shows that it does not always do so. In particular, Myers (1987, 1995) argues that a root-specified H spreads only one syllable when spreading two would create the OCP-violating representation in (52).

(52)
```
 *  H     H
   / | \   |
 to re se ra
```

For a detailed OT analysis of tone spreading and blocking in Zezuru, we refer readers to Myers (1995).[32] H-spread is subject to variation determined by different morphosyntactic contexts; as an example, recall that the CP inflectional H contrasts with root-specified Hs in spreading no more than one syllable to the right, and never to the final V (Odden 1981, 1984; Myers 1987). We do not attempt a comprehensive account of H-spread, but remain focussed on developing an analysis of the alternation in association sites for the inflectional H.

4.4 H-toned verb stems and the CP.

Taking stock, we saw in §4.2 that the subhierarchy **Float, Noninitial-H » H-Left » H-Right* correctly predicts second syllable H-association in toneless verb stems. However, this pattern is blocked with H-toned inputs like (47), motivating an active role for the OCP in (51). The OCP must be ranked highly enough for its effects to be asserted in the right places. If it were ranked lower than H-Left in Shona, the unattested structure in (50) should occur. Inserting the

32 In general terms, Myers proposes that H-spread is driven by a constraint SPECIFY(T), which requires that every syllable be associated with a tone. (This constraint descends from Goldsmith's (1976) Wellformedness Condition.) Once the initial anchoring site for H has been determined, either due to an association present at input or to constraints which force the association of floating tones, H spreads at the expense of a Correspondence constraint, DEP-IO(A), which penalises the insertion of associations not present at input. (For an overview of Correspondence Theory, see McCarthy & Prince 1995.) Dep-IO(A) is violated by any pair associated at output which are not associated in the correpsonding input. Both an initial association between H and a TBU to satisfy *Float and spread to satisfy Specify(T) create representations which violate Dep-IO(A); therefore, Dep-IO(Assoc) must be ranked below the other two constraints: *FLOAT, SPECIFY(T) » DEP-IO(A)). Specify(T) and Dep-IO(Assoc) are omitted from tableaus in this paper as they are not central to our argument. However, our analysis of the CP pattern is generally compatible with the analysis presented in Myers (1995).

OCP into the hierarchy above H-Left, on the other hand, is no more successful at predicting the correct outcome: while the ranking *OCP » H-Left* predicts the attested outcomes with toneless stems, the tableau in (53) shows that in H-toned stems the inflectional H is predicted link to the third syllable, not to the final syllable.[33]

(53) Input: {tór-es-er-a, *H*}

Candidates	Noninit-H	OCP	H-Left	H-Right
a. H (to) *H* (ra) *to re se ra	*		***!	
b. D H (to) *H* (se) *to re se ra	*		**	*
c. H (to) *H* (re) *to re se ra	*	*!	*	**

Thus, an analysis which assumes the subhierarchy in (44) in which the OCP is ranked with other constraints in the usual manner yields no insight into the shift of the inflectional H's docking position from the second to the final syllable.

Whatever the theoretical remedy, it must be capable of expressing an odd generalisation not often noticed: the optimal candidate is one which passes both H-Left and the OCP, modulo noninitiality. A candidate which passes the OCP but not H-Left is as bad as one which fails both. This is not what we expect if constraints are dominance-ranked in the usual optimality-theoretic sense. Dominance in OT is interpreted to mean that the survivors of one constraint are passed to the next, which must do as well as it can with what it is given. Here, on the other hand, it is as though the best candidate(s) for each constraint is determined independently, and then, the winners are compared. If there is a match, that is, if (one of) the best candidate(s) for the OCP can be matched with the best candidate for H-Left, then that candidate succeeds. If no such match can be made, then the procedure 'aborts' and the candidate set under consideration is passed to the next constraint in line.

---

33 This prediction is the same if the OCP and H-Left are *co-ranked* in the sense of Crowhurst (1994, 1997), so that violations of the two constraints count equally.

This is exactly what we expect if the OCP and H-Left are conjoined. The macro-constraint which results from conjunction is (54).

(54) H-LEFT $\wedge^{H}$ OCP

The focus of the conjunction is a high tone (raised to the right of the operator $\wedge$). The constraint subhierarchy we require for the conjunctive account appears in (55).

(55) NONINITIAL-H » H-LEFT $\wedge^{H}$ OCP » H-RIGHT

Tableau (56) shows how the conjunctive analysis deals with inflectional H association in H-toned verb stems (cf. the input in (47)). (As in the analysis of Diyari, the conjunction is represented by three columns; the cenrtal column registers violations of the macro-constraint.)

(56) Input: {tór-es-er-a, *H*}

Candidates	Noninit-H	H-Left	$\wedge^{H}$	OCP	H-Right
a. C H *H* to re se ra	*	(**! *)	*		
b. H *H* *to re se ra	*	(**!)	*		*!
c. H *H* *to re se ra	*	(*)	*	(*)	*! *

Since all candidates violate top-ranked Noninitial-H, this constraint does not narrow the field, and the entire set is inherited by the conjunction. The best candidate for H-Left is (56c); the others fail H-Left, and therefore also the macro-constraint. However, the candidate (56c) which passes H-Left fails the OCP--leading to a penalty against the conjunction in this case as well. Thus, the conjunction is failed by every candidate, and like Noninitial-H, it cannot act on the candidate set. The deciding role therefore falls to H-Right, the next constraint in line, and the conjunction's effects are neutralised.

The conjunctive analysis also succeeds with CP forms based on toneless verb stems. The analysis of *veréngésera* (cf. the input in (45)) is shown in tableau (57).

(57) Input: {vereng-es-er-a, *H*}

Candidates	Noninit-H	H-Left ^H OCP	H-Right
a. C *H* | ve re nge se ra		(*)	***
b. *H* | *ve re nge se ra		* (**! *)	**
c. *H* | *ve re nge se ra		* (**! **)	
d. *H* | *ve re nge se ra	*!		****

Tableau (57) shows that the predictions of the conjunctive and nonconjunctive analyses are parallel (cf. tableau (46)). However, if the conjunctive analysis of CP forms like *veréngésera* is correct, then the manner in which evaluation *must* proceed for the correct output to be selected has interesting broader implications for the manner in which EVAL processes a set of candidates in any optimality-theoretic analysis. A common theme in OT is that a candidate for output status is 'knocked out of the running', or 'falls by the wayside', when it fails--but others pass--a high-ranking constraint. If taken seriously, what does 'sudden death' really mean?

4.5 Discussion: EVAL and candidate elimination.

With respect to tableau (57), all candidates pass the OCP; as no OCP violation results in a penalty against the conjunction, the effects of other constraints in the analysis are especially clear. In particular, note that the best candidate overall for H-Left, (57d), is rejected by Noninitial-H. If EVAL compares all candidates in the starting set against H-Left, then the best candidate (57d) should be the only one which passes H-Left; a mark should be assessed against the conjunction for all of the other candidates, including optimal (57a). Furthermore, if we are to maintain our assumption that only one violation is counted against a macro-constraint for any individual H tone (that is, macro-constraints are evaluated categorically, not gradiently), then if EVAL compares all candidates in (57) against H-Left, then (57a,b,c) should all fail H-Left and incur one (and only one) mark against the conjunction. But this can't be the case: now all candidates which pass Noninitial-H are conjunction violators, and the decision should fall to H-Right, which would incorrectly select (57c) as optimal. Clearly, this is not what happens: rather, once (57d) is rejected by Noninitial-H, the next best candidate for H-Left, (57a), is the one which passes the conjunction. It is as though once (57d) fails Noninitial-H, this candidate isn't seen by the conjunction. We propose that this is literally the case, not only in our conjunctive analysis, but in optimality-theoretic analyses more generally. In other words, once a candidate is rejected by some constraint, the set of candidates compared by EVAL against the next constraint in line is literally reduced, and the candidate left behind is no longer evaluated for goodness against constraints lower in the hierarchy. The same logic holds for successful candidates: once EVAL has a winner, let us say that it is no longer necessary to compare that winner against lower-ranked constraints. In *other* words, the violations represented in shaded boxes in OT tableaus for failed and for optimal candidates are not merely irrelevant--*they are never assigned*.[34] This manner of viewing EVAL's role in slimming down candidate sets has one broader implication for the theory: it is not really the case that higher ranking constraints have absolute veto power over subordinate constraints; the appearance of absolute veto power occurs because there is no feedback from below. Veto power is limited to deciding which candidates are in, and which are out. Several violations of a low-ranking constraint don't overpower a single violation of a dominant one because the lower-ranked penalties have not been assessed. The issue of whether potential low-ranking violations are irrelevant or literally unassigned is subtle, and cannot be decided based on analyses in which constraints are evaluated independently. The decisive effect is evident in this case only because in conjoining H-Left with the OCP, the usual gradience of one constraint (H-Left) is in effect converted to non-gradience at the level of the conjunction, with unexpected consequences.

As noted at the beginning of this section, edge/-edge patterns in tonal systems have largely been overlooked. A pattern almost identical to the Zezuru pattern found in Carib of Surinam, an unrelated language of South America described by Hoff (1968, 1997). In Carib of Surinam, a H

[34] This is not to say that representning unassigned violations is not useful for expository reasons; however, it is important to make the distinction.

tone associated with phrasal accent associates to the leftmost noninitial foot, otherwise to the rightmost syllable. Given the similarity between the two patterns, an account of Carib tone in this section would be redundant. However a conjunctive analysis is proposed in Crowhurst (in prep.).

4.6 Discussion: constraint neutralisation and conjunctive evaluation.

Conjunctive behaviour, as illustrated in (56) and (57), underscores in an original way two points about violation which have often been made about individual, non-conjunctively evaluated constraints. The first point is that conjunctive evaluation is not about violations in the mechanical sense, but about optimisation in a conjunction-internal sense. It doesn't work to assess a mark against the conjunction simply if either conjunct is violated; this is because H-Left is evaluated gradiently, so that even though all contending candidates violate H-Left technically, it is still possible to identify a winner. The factor behind (56a)'s success is that the best possible outcome for H-Left also passes the (categorically evaluated) OCP. H-Left's treatment under conjunctive evaluation is, of course, just the way gradiently evaluated constraints are treated in OT more generally. The difference is that conjoined constraints behave as though they form a subroutine within the larger program of the constraint hierarchy. Note that the macro-constraint formed under conjunction (e.g. (54)) is evaluated categorically--a given candidate passes it, or it does not. But the value returned for the macro-constraint depends on whether the candidate in question passes each of the conjuncts; so, the decision for any candidate with respect to conjoined constraints is fed up to the macro-constraints which co-ordinates them, not down to the next constraint in the hierarchy.

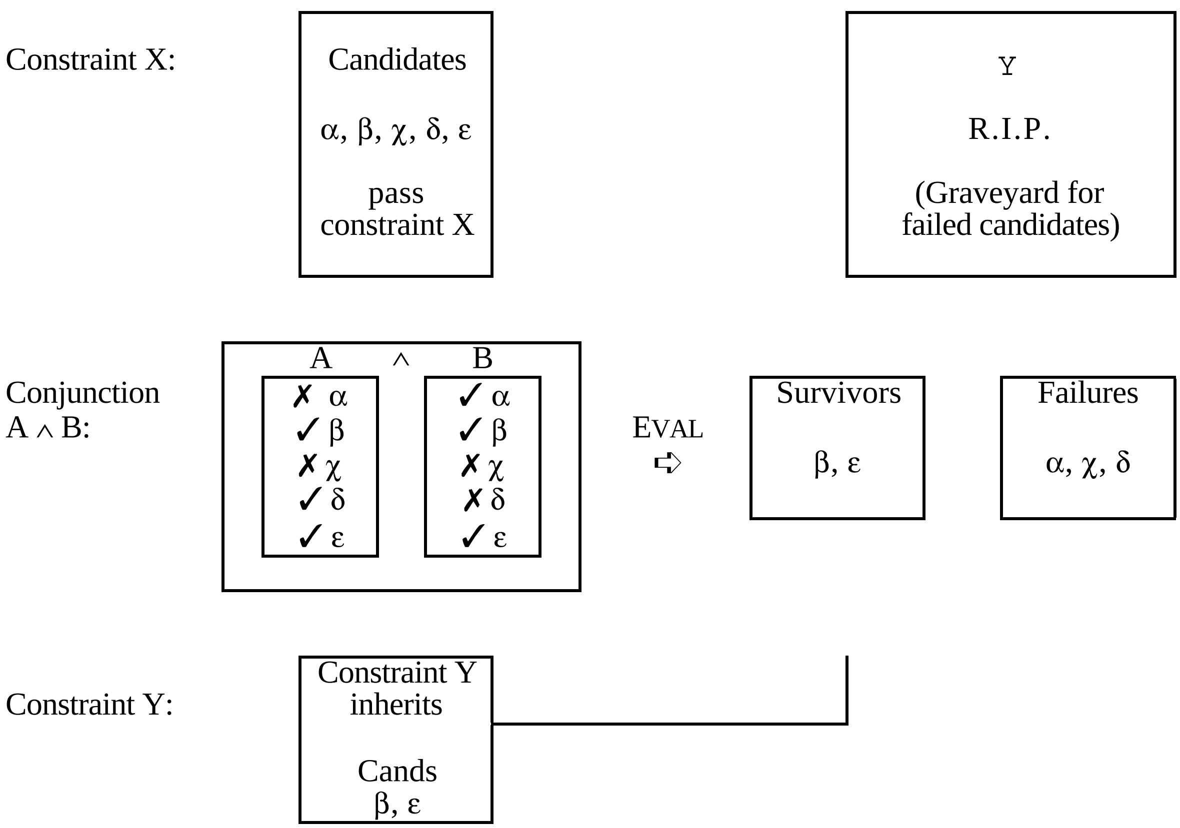
Now that we understand that conjunctions function as complex, categorically evaluated constraints, we can proceed to the second point emphasised by the analysis developed above, which concerns neutralisation. Specifically, the effects of conjoined constraints are neutralised when no candidate passes the macro-constraint. In this case, the conjunction fails to 'act on' the set of contending candidates inherited by the conjunction, and the full set of contenders is passed to the next constraint in line. This is exactly what happens with any categorically evaluated constraint when no candidate passes it. An example from the Zezuru analysis is provided by Noninitial-H in

(57). When an input contains an initially-associated H, only faithful candidates are passed to Noninitial-H, due to the high ranking of Max-IO(Assoc). Thus, the effect of Noninitial-H is neutralised (by Max-IO(Assoc)); it cannot act on the surviving candidate set because all candidates violate it. 'Acts on' a set of candidates is usually interpreted to mean 'separates wheat from chaff' in the sense that some candidates are rejected (because they violate the acting constraint *at all*, for categorically evaluated constraints, or *more than* another candidate, for gradiently evaluated constraints), while others candidates are assessed as relatively harmonic (because they pass the acting constraint outright, or do the least damage). However, if 'acts on' is interpreted more broadly to mean 'returns a decision about which candidates are optimal', then a constraint passed by all contenders also acts on the candidate set, though perhaps in a vacuous sense. When no candidate passes some (categorically evaluated) constraint, that constraint fails to act on the candidate set, and its effects are neutralised. Neutralisation means that the affected constraint literally shuts down; it no longer applies. This is hard to see with non-conjunctively evaluated constraints, because here the effect of neutralisation is the same as that of vacuous 'acting', as just described: when all candidates are *equally bad* with respect to some constraint, they are passed down the hierarchy; this is also the case when all candidates are *equally good*. However, the 'shutting down' effect of neutralisation becomes visible under the conjunctive evaluation of H-Left and the OCP in the Zezuru analysis because here, the effect of H-Left, a gradiently evaluated constraint not subject to neutralised when evaluated non-conjunctively, is completely suppressed when all members of the candidate set fail the conjunction.

4.7 Summary.

In this section, we not only presented a second argument for the conjunctive evaluation of constraints, we also argued for a specific view as to how EVAL processes sets of candidates, and discussed certain implications of this proposal for OT. Specifically, we argued based only evidence from Zezuru that when a candidate is rejected because it violates some constraint (while competing candidates pass the same constraint), the rejected candidate literally does not finish the race: it is not compared for goodness against constraints lower in the hierarchy. What this means for conjunctive evaluation in particular is that only candidates passed by the last constraint are 'seen' by the macro-constraint. EVAL compares all inherited candidates against both conjoined constraints simultaneously, on an equal footing. In determining infringements of the conjunction, the results of these twin comparisons are merged in such a way that only candidates which pass both conjuncts also pass the conjunction. We represent our view of conjunctive evaluation in (58).

(58) *Schematic representation of conjunctive evaluation.*



A broader implication of this view of evaluation is that since rejected candidates are effectively removed from competition, they are not compared against lower-ranked constraints, and therefore do not actually incur further violations. As noted above, this means that we cannot conclude that dominant constraints have true veto power over subordinate ones in optimality-theoretic grammars; this power should not be attributed to constraints themselves, but rather to EVAL in its role as gatekeeper.

5. Implication and constraint evaluation.

In §§ 3 and 4 we argued that certain types of dependencies between phonological requirements should be formally expressed by evaluating of a set of individual constraints conjunctively. Not all phonological patterns providing evidence for dependency can be analysed in this manner, however. In other cases, the emergence of one pattern is contingent on, or conditioned by, another. We argue in this section that constraints which generate such contingent patterns are related in much the same way as expressions in a logical implication. Below, we discuss a phonological pattern from Dongolese Nubian (Armbruster 1960, 1965) which motivates a relation of implication between constraints.

5.1 Data and analysis.

The behaviour of stress in Dongolese Nubian reveals an edge/-edge system with superficial similarities to the Complex Tone Pattern of Zezuru, analysed in §4. Dongolese contrasts with Zezuru in our analysis in showing that not all edge/-edge stress behaviour submits to a conjunctive analysis.[35] The generalisation for Dongolese stress is stated in (59). Representative examples from Armbruster (1960) appear in (60).[36]

(59) Dongolese stress:
(i) In forms with one or more heavy syllables (CVV), stress the rightmost heavy;
(ii) When only light syllables (CV, CVC) are present, stress the initial syllable.

(60)a.	bE Ekattø	'to be killed' xiii	b.	búrun	'it is a girl' xiii
	dogóogØr	'raise it' xiii		táraga	'page, leaf' 193
	tElEgráafkØ	'a telegram' 90		múgosan	'tell to leave' 145
	tØntØnE ENkEgØd	'their maternal aunt' 199		g&Ø ñØrán	'tell him (her) to go and wait' xiii
	maasúura	'tube, pipe' 139			
	maalE ES	'it doesn't matter' 136			
	sErEEgØrSuglEErEdáag	'be in the situation of having worked well' 175			

---

35 The account presented here is a reanalysis of that in Hewitt & Crowhurst (1996). We are grateful to Scott Myers for suggesting that Dongolese should be reanalysed as a case of implication rather than as conjunction.

36 The pattern described here is reported by Hayes (1980/5). A survey of Armbruster (1965) seems to confirm (59) as the unmarked stress pattern, though exceptions are not uncommon. Interested readers are referred to the works cited. The transcriptions given here differ from Armbruster's only in that we show long vowels as doubled.

Sensitivity to quantity in Dongolese stress assignment can be accounted for by appealing to the constraint HEAVYHEAD in (61).[37]

(61) HEAVYHEAD: The head σ of a Foot is bimoraic, μμ.

HeavyHead requires stressed syllables to be heavy, and returns a violation for any stress-bearing light syllable. The leftward or rightward orientation of the stressed syllable within the metrical domain is governed by HEADS-RIGHT and HEADS-LEFT in (62).[38]

(62) a. HEADS-RIGHT: Align (Head(F), Right, PrWd, Right)
b. HEADS-LEFT: Align (Head(F), Left, PrWd, Left)

Heads-Right and Heads-Left require that any stress-head (Head(F)) be right and left-aligned within the prosodic word containing it. Violations are assessed gradiently, so that a mark is returned for every syllable separating the stress-head from the specified edge.

To capture the basic descriptive generalisation that stress falls on a heavy syllable in Dongolese if there is one, HeavyHead must be highly ranked in any account. However, as in Zezuru, any conventional ranking of the constraints in (61) and (62) fails to capture the right-to-left-edge stress shift in words with no heavy syllables: Heads-Right must dominate Heads-Left in forms containing heavy syllables, otherwise Dongolese would stress the leftmost and not the rightmost heavy syllable (e.g. **máa.suu.ra*); but the opposite ranking, Heads-Left » Heads-Right, is needed to account for initial stress in forms with no heavy syllables (e.g. *mú.go.san*).

Tableau (63) shows that the ranking HeavyHead » Heads-Right » Heads-Left predicts the correct output for forms containing heavy syllables, but not for forms with only light syllables.

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[37] This constraint reflects the proposals of Crowhurst (1991) for placing minimality conditions on heads, and has obvious ties to WEIGHT-TO-STRESS (PS 1993). An alternative statement of this constraint would explicitly prohibit light heads:

Avoid-Light-Heads: $*_{\text{Head(F)}}[\sigma_{\mu}]$

[38] The analysis suggested here abstracts largely away from foot structure. However, we assume that stressed syllables are heads of bimoraic feet, so that the PrWd dominates at least one foot, as required by the Prosodic Hierarchy (Selkirk 1980, 1981, 1984). Nothing crucial hinges on this assumption; it would be a trivial matter to recast this analysis in terms of constraints that do not refer to foot structure.

(63) HeavyHead » Heads-Right » Heads-Left; Inputs: /maasuura/, /mugosan/

Candidates:		HeavyHead	Heads-Right	Heads-Left
1a.C	maa (súu) ra		*	*
1b.	(máa) suu ra		**!	
1c.	maa suu (rá)	*!		**
2a.	(mú go) san	*	*! *	
2b.	mu (gó san)	*	*!	*
2c.D	mu go (sán)	*		**

Tableau (64), on the other hand, shows that the alternative ranking HeavyHead » Heads-Left » Heads-Right predicts the correct outcome for light-syllabled forms, but not for those containing heavy syllables.

(64) HeavyHead » Heads-Left » Heads-Right; Inputs: /maasuura/, /mugosan/

Candidates:		HeavyHead	Heads-Left	Heads-Right
1a.	maa (súu) ra		*!	*
1b.D	(máa) suu ra			**
1c.	maa suu (rá)	*!	**	
2a.C	(mú go) san	*		**
2b.	mu (gó san)	*	*!	*
2c.	mu go (sán)	*	*! *	

Conventional ranking, then, leads to an ordering paradox in an OT analysis of Dongolese stress.

Intuitively, it is clear that a dependency between Heads-Right and HeavyHead is to be accounted for: both prevail when the relevant quantitative condition is met, but when no heavy syllables are present, neither is enforced. Consistent with the general approach in this paper, we will express this dependency by co-ordinating the evaluation of Heads-Right and HeavyHead, effectively bundling them into a complex constraint. An analysis structured along the lines of that proposed for Zezuru would posit the conjunction HeavyHead $\wedge^{Head(F)}$ Heads-Right. Heads-Right and HeavyHead may be conjoined because they are both focussed on the metrical head; this focus is inherited by the conjunction. Recall that if Heads-Right and HeavyHead are evaluated conjunctively, then optimal outcomes must pass both constraints to pass the conjunction. Despite the superficial similarities between Zezuru and Dongolese, however, a conjunctive analysis does not capture the Dongolese pattern. Tableau (65) shows that conjoining Heads-Right and HeavyHead correctly predicts initial stress in forms containing no heavy syllables.

(65) HeavyHead $\wedge^{\text{Head(F)}}$ Heads-Right » Heads-Left; Input: /mugosan/

Candidates:		HeavyHead	$\wedge^{\text{H(F)}}$	Heads-Right	Heads-Left
a. C	(mú go)san	(*)	*	(**)	
b.	mu (gó san)	(*)	*	(*)	*!
c.	mu go (sán)	(*)	*		*! *

Assuming that candidates with lengthened vowels are ruled out by higher-ranking constraints, all candidates inherited by the conjunction contain only light syllables. Although (65c) is optimal for Heads-Right, no candidate under consideration passes HeavyHead. A single violation is assessed against the conjunction for every candidate, and the decision is correctly passed to Heads-Left.

However, tableau (66) shows that the conjunctive account predicts the wrong outcome for many forms with heavy syllables. In (66), as in (65), no candidate is optimal for both HeavyHead and Heads-Right. Once again, every candidate incurs a violation against the conjunction, and the decision is passed--this time incorrectly--to Heads-Left, resulting in initial stress.

(66) HeavyHead $\wedge^{\text{Head(F)}}$ Heads-Right » Heads-Left; Input: /maasuura/

Candidates:		HeavyHead	$\wedge^{\text{H(F)}}$	Heads-Right	Heads-Left
a.	maa (súu) ra		*	(*)	*
b.D	(máa) suu ra		*	(**)	
c.	(màa)(súu) ra		*	(***)	*
d.	maa suu (rá)	(*)	*		**

The one context in which effects of the conjunction HeavyHead $\wedge^{\text{Head(F)}}$ Heads-Right should be asserted is with forms with a final heavy syllable. The tableau in (67) shows that in this case alone, rightmost stress is predicted.

(67) HeavyHead $\wedge^{\text{Head(F)}}$ Heads-Right » Heads-Left; Input: /maalEES/

Candidates:		HeavyHead	$\wedge^{\text{H(F)}}$	Heads-Right	Heads-Left
a. C	maa (lE ES)				*
b.	(máa) lEES		*!	(*)	

Thus, evaluating HeavyHead and Heads-Right conjunctively in the manner proposed for Zezuru does not predict the stress pattern attested in Dongolese, but rather the one in (68).

(68) HeavyHead $\wedge^{\text{Head(F)}}$ Heads-Right:
Stress a syllable which is rightmost and heavy; otherwise stress the initial syllable.

What is the difference between Zezuru and Dongolese, then, and what approach is available to us to capture the facts of Dongolese, if not through conjunctive evaluation? The difference between Dongolese and Zezuru is that effects of gradient evaluation under co-ordination are suppressed in Zezuru, but not in Dongolese. In Zezuru, H is associated either to the second syllable, or to the final syllable, and nowhere in between. H's orientation to the left edge is governed by a gradiently evaluated constraint H-Left; the flexibility permitted by gradient evaluation is required, because absolute left-edge association is compromised under pressure from a dominant constraint, Noninitial-H. However, gradient H-Left effects do not emerge under conjunction with the OCP; that is, H is never associated further away from the left edge (for example, to the third syllable) to satisfy the OCP. (In the last section we argued that the uncharacteristically non-gradient behaviour of H-Left in co-ordination with the OCP in Zezuru follows straightforwardly under conjunctive evaluation.) In Dongolese, on the other hand, this is exactly what happens, but only in forms containing heavy syllables: stress moves as far inward as necessary to lodge on a heavy syllable. In other words, although the evaluation of HeavyHead and Heads-Right must be co-ordinated, HeavyHead is still the primary constraint: as long as there are heavy syllables, it is more important that stress fall on one of them than that stress occur exactly at the right edge. But when no heavy syllables are present, H-Right effects are neutralised. In fact, it is as though HeavyHead is the gateway to Heads-Right: only candidates which pass HeavyHead are compared against Heads-Right. The result in forms in which a heavy syllable is separated from the right edge by one or more light syllables (as in (66)) is that a candidates with right-edge stress, but which fail HeavyHead, are rejected (and, under our assumptions, are not evaluated by Heads-

Right).[39] The result in forms which contain only light syllables, in which case all candidates fail HeavyHead, is that Heads-Right is effectively passed over, and the deciding role is handed to Heads-Left.

The effects described above for Dongolese are captured if the evaluation of HeavyHead and Heads-Right is co-ordinated as a unit--a macro-constraint. However, the Dongolese macro-constraint is not a conjunction, in which the satisfaction of all co-ordinated conditions is equally critical, but rather takes the form of an implication, in which the satisfaction of one requirement is unilaterally dependent on the satisfaction of another. In boolean logic, the truth value for an implication A > B depends primarily on the truth value of proposition A, secondarily on that for proposition B. Under our optimality-theoretic interpretation of implicational evaluation, whether a candidate C passes A > B, depends primarily on C's success on constraint A, secondarily on C's success on constraint B. Definitions appear in (69a).

(69) *Implication:* A > B

a. *Boolean:* If A is true, then the truth value for B determines the truth value of A > B:
 If B is true, then A > B is true;
 If B is false, then A > B is false.
 If A is false, then A > B is false, and the truth value of B is irrelevant.

b. *Constraints:* If Cand passes A, then Cand is evaluated with respect to B:
 If Cand passes B, then Cand passes A > B;
 If Cand fails B, then Cand fails A > B.
 If Cand fails A, then Cand fails A > B and Cand's success on B is irrelevant.

As in the case of conjunction, and for the same reasons (see §2), we propose that only constraints which share an argument may combine to form implications.

The subhierarchy we propose appears in (70). Tableau (71) illustrates the implicational analysis with the forms *maasúura* and *múgosan*.

(70) HEAVYHEAD $>^{\text{HEAD(F)}}$ HEADS-LEFT » HEADS-RIGHT

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39 In fact, any candidate containing a stressed light syllable must be rejected, leaving only candidates with a stressed heavy syllable in the evaluation set. This has the effect of making light syllables at the right edge seem invisible.

(71) Inputs: /maasuura/, /mugosan/

Candidates:		HeavyHead	>Hd(F)	Heads-Right	Heads-Left
1a.☞	maa (súu) ra			(*)	*
1b.	(máa) suu ra		*!	(**)	
1c.	(màa)(súu) ra		*!	(***)	*
1d.	maa suu (rá)	(*)	*!		**
2a.☞	(mú go)san	(*)	*	(**)	
2b.	mu (gó san)	(*)	*	(*)	*!
2c.	mu go (sán)	(*)	*		*! *

The form *maasúura* containing heavy syllables is analysed in (71.1). Another way of looking at implications is to view them as fragments of a constraint hierarchy embedded within larger hierarchies, much as subroutines may be embedded in a larger computing program. As top-ranked constraint in the implicational 'subroutine', HeavyHead effectively functions as a filter in restricting the evaluation set for the contingent constraint (Heads-Right) to just the set of candidates which satisfy HeavyHead. Thus, the HeavyHead violator (71.1d) incurs a violation of the implication and is rejected; this candidate is not evaluated by Heads-Right. The remaining candidates, all of which pass HeavyHead, are compared on Heads-Right. With (71.1d) excluded, the winner is (71.1a), in which the rightmost heavy syllable is stressed. A violation is assessed against the implication for the losers (71.1b,c). Thus, the only candidate which passes the complex constraint is (71.1a); in this circumstance, Heads-Left does not act on the candidate set. In candidates containing only light syllables, however, the set of candidates which pass HeavyHead is null. An example, *múgosan*, is analysed in (71.2). Here, all candidates violate HeavyHead, and therefore, the complex constraint. These candidates are not evaluated with respect to Heads-Right, so that this constraint's effects are neutralised.[40] The decision is passed to Heads-Left, and the initially stressed (71.2a) is selected as optimal.

Superficially, there appear to be few differences between the predictions of conjunctive evaluation and those of the implicational mode of evaluation we introduce here: the same candidates are usually selected as optimal. There is, however, one circumstance in which

[40] Recall that under our assumptions, when a candidate is rejected and therefore not evaluated with respect to a lower-ranked constraint, this means that violations of lower-ranked constraints are not assessed. As is traditionally the case, we represent such (unassigned) violations, but only for convenience.

differences between conjunction and implication become apparent: this is when a candidate which fails constraint A is optimal for constraint B, but none of the candidates which pass A are optimal for B. This case is exemplified by the analysis in (71.1). Under conjunctive evaluation, all candidates in (71.1) should violate the conjunction, and the decision should be passed to the next constraint in line (cf. tableau (56) in the analysis of Zezuru). As tableau (71) above shows, the outcome is different in an implicational relation. Once we have established that a dependency between two conditions should be analysed in terms of a complex relation between the constraints, it is a simple matter to determine whether the relation is conjunctive or implicative. Conjunctive relationships are bidirectional implications. Thus, any conjunction may be analysed as an implication no matter which conjunct fills the role of A or B in the expression A > B. This is easily verified by switching columns in the tableau for a conjunctions: the same outcome is predicted under either order (cf. the conjunctive tableaus for Zezuru in §4). This is not the case in implication. As readers may verify, inverting the positions of Heads-Right and HeavyHead in (71) leads to the selection of unattested candidates *maasuurá* and *mugosán* with final stress as optimal.

5.2 An alternative proposal.

In a recent paper, Zoll (1997) proposes to account for an identical metrical pattern found in Selkup (Ostyak-Samoyed). In this language, as in Dongolese, stress is assigned to the rightmost heavy syllable if there is one, otherwise to the word-initial syllable. The analysis proposed by Zoll (1997) may be summarised as follows. First, she assumes that heavy syllable stress represents the unmarked case crosslinguistically, and that stress on light syllables is a marked option licensed only in peripheral positions. The "stress the rightmost heavy syllable" pattern is an effect of an interaction between the constraints ALIGN-RIGHT and ALIGN-LEFT in (72a) and (72b) (Zoll's figures (42) and (43) respectively).[41]

(72)a. ALIGN-RIGHT (σ , PrWd) 'stressed syllable should be word final.'

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[41] Zoll's constraints are equivalent to the following in the alignment notation we have been using.

ALIGN-RIGHT: Align (σ , Right, PrWd, Right)

ALIGN-LEFT: Align (σ , Left, PrWd, Left)

Note that the notion 'stressed syllable' used by Zoll is equivalent to our Head(Foot).

b. ALIGN-LEFT (σ μ, PrWd) 'light stressed syllable should be word initial.'

Align-Right demands that any stressed syllable should be oriented to the right edge. By contrast, Align-Left requires that if a stressed syllable is light, it must be at the left edge. Align-Left says nothing about heavy stressed syllables. Tableau (73) shows that by ranking Align-Left above Align-Right, Zoll derives the correct outcomes in all cases. (The forms analysed here are u: O :mIt 'we work' and ü NNIntI 'wolverine'. This tableau represents Zoll's figures (44) and (45).)

(73) Align-Left » Align-Right; Inputs: /u: O:mIt /, /üNNIntI/

Candidates:	Align-Left	Align-Right
1a. u: O: (mI t)	*!	
1b.C u: (O :) mIt		*
1c. (u :) O: mIt		**!
2a. üN NI (ntI)	*! *	
2b. üN (NI) ntI	*!	*
2c.C (ü N) NI ntI		**

While Zoll's analysis succeeds with a conventional ranking of the constraints Align-Left and Align-Right, it does so only because Align-Left combines two separate requirements: If a syllable is the head of a foot, *and* if it is light, *then* it must occur at the left edge. In other words, Zoll's constraint Align-Left in (72b) is really a complex constraint and should be unpacked. Thus, Zoll's account does not represent an alternative to our claim that a complex interaction is required to capture metrical systems such as Dongolese; the real difference lies in which individual constraints are to be co-ordinated.

6. Local conjunction -- or disjunction?

In this section, we compare the model of conjunction developed in this paper with the interaction of *local conjunction* introduced by Smolensky (1995, 1997) and developed in work by Suzuki (1995), Fukazawa & Miglio (1996), Kirchner (1996), and Alderete (1997). In local conjunction, two constraints are co-ordinated to form a single macro-constraint, as we have proposed here. However, in contrast to the foregoing, a candidate violates a local conjunction just in case it *fails* all of the co-ordinated constraints. From Smolensky's perspective, then, conjunction is defined with respect to failure, or (to draw once again on our analogy with logical operations) the value *False* in the truth table for a classical conjunction, as illustrated (74).

(74) (a) Boolean conjunction

	Proposition A	∨	Proposition B
i.	T	**T**	T
ii.	T	**T**	F
iii.	F	**T**	T
iv.	F	**F**	F

(b) Local conjunction (Smolensky)

	Constraint A	∨	Constraint B
i.			
ii.			(*)
iii.	(*)		
iv.	(*)	*	(*)

The difference between Smolensky's conjunction and the conjunctive mode of evaluation proposed here is summarised in (75):

(75) *Conjunction*

a. Crowhurst and Hewitt: A candidate *passes* a conjunction if and only if it passes every conjunct.

b. Smolensky: A candidate *fails* a conjunction if and only if it fails every conjunct.

What one likens to conjunction in OT depends on the angle from which one approaches the issue of constraint evaluation. The observation on which the current authors base their view is that in some cases, it is necessary for a candidate to pass more than one constraint simultaneously in order for an analysis to succeed. By contrast, Smolensky's interpretation has been violation oriented, thus based on the equation: violation & violation = fail. This perspective arises from the observation that in some cases, an apparently high-ranked constraint C can be overridden when two apparently subordinate constraints A and B are violated simultaneously. (Smolensky's 1997 solution is to conjoin A and B and rank the conjunction above C in the hierarchy, much as we do in our model.) Clearly, both interpretations of conjunction are required to account for naturally occurring patterns. It is possible that these interpretations correspond to alternative modes of conjunction behaviour, which we might dub *positive conjunction* on the one hand, and *negative conjunction* on the other.

However, another possibility within the model developed here emerges straightforwardly: if a candidate fails a local conjunction when it fails every conjunct, then that candidate *passes* the local conjunction if it passes *either* of the co-ordinated constraints. Under this reasoning, local conjunction can legitimately be reinterpreted as an optimality-theoretic analog of classical *disjunction*. Definitions of disjunction are presented in (76).

(76)a. *Boolean Disjunction:* The disjunction A ∨ B is true iff proposition A is true *or* proposition B is true.

b. *Constraint Disjunction:* (a.k.a. *Local Conjunction*) A candidate Cand passes a disjunction A ∨ B iff Cand passes constraint A *or* Cand passes constraint B.

If a disjunction is evaluated as true when either of its disjuncts is true, then it is true also when both disjuncts are true. Thus, the only circumstance under which a disjunction is false is when neither disjunct is true. This corresponds exactly to the manner in which local conjunctions have been evaluated in the literature. For now, then, to be consistent with our model, we will refer to local conjunctions as *disjunctions*. The correspondence between (76a,b) is represented in the format of a truth table in (77).

(77) (a) Boolean disjunction (b) Constraint Disjunction

	Proposition A	∨	Proposition B			Constraint A	∨	Constraint B
i.	T	**T**	T	C	C			
ii.	T	**T**	F	C	C			*
iii.	F	**T**	T	C	C	*		
iv.	F	**F**	F			*	*****	*

Since work motivating disjunctive analyses (i.e. local conjunction) is readily available, we do not summarise existing accounts, but rather refer readers to the works cited earlier. It will, however, be worthwhile to discuss a special type of disjunction known in the literature as *self-conjunction,* or *self-disjunction* in our terms. In self-disjunction, a constraint is disjunctively co-ordinated with itself. Alderete (1997) uses self-disjunction to account for effects of dissimilation in which some marked property P is tolerated just in case only one instance of P is present in a representation, but not when P occurs twice. Assuming the existence of a constraint such as (78) which penalises occurrences of P in output representations, the disjunction of *P with itself yields the tableau in (79) (loosely adapted from Alderete's figure (3)). In (79), the self-disjunction $*P\ v^{P}\ *P$ is ranked above a constraint MAX-IO(P), which requires that any P in an input representation be present in the output.

(78) *P: The marked property P is banned. (One * for every occurrence of P.)

(79) Input:
α β
| |
P P
(where α and β are P-bearing units)

<table>
<tr><th colspan="2">Candidates:</th><th>*P v^{P} *P</th><th>Max-IO(P)</th></tr>
<tr><td>a.</td><td>α β</td><td></td><td>**!</td></tr>
<tr><td>b. ☞</td><td>α β
|
P</td><td>(*)</td><td>*</td></tr>
<tr><td>c.</td><td>α β
| |
P P</td><td>(*) *! (*)</td><td></td></tr>
</table>

Self-disjunction yields a threshold effect: One violation of any self-disjoined constraint is as good as no violations, but more than one penalty is crippling. Thus, in (79), candidate (79c) fails the disjunction because both disjuncts are violated, but candidates (79a) and (79b), with zero and one mark respectively, both pass. The optimal candidate is determined by Max-IO(P), which demands that input features be preserved.

To summarise, self-disjunction leads to a two-way distinction in which the effect of a single violation is neutralized. This is distinct from the result expected if *P is not self-disjoined. In that case, we would encounter the conventional three-way distinction in which one violation is worse than no violations, and two penalties are worse than one. Before concluding, we comment comment briefly on a difference between self-disjunction on the one hand and conjunctions and implications on the other. John McCarthy (personal communication) has commented that self-disjunction is consistent with the shared-argument criterion for constraint co-ordination[42] proposed here in that both disjuncts share an argument under complete identity. It should be asked, then, whether we are likely to find cases in which constraints may be self-conjoined (in the sense developed in this paper), or co-ordinated into implicational relations. While theoretically possible, we note that no argument based on direct evidence will be possible. Self-disjunction leads to effects distinct from those of the non-disjoined constraint because of the threshold effect created by self-disjunction (i.e. the neutralisation of a single violation). However, no such distinction emerges under self-conjunction, because in the case of conjunction, failing either conjunct leads to failing the macro-constraint.[43] For this reason, for conjunctions which are evaluated (in our sense) relative to *passing*, a macro-constraint in which a constraint C is conjoined with itself makes the same predictions as an analysis which posits the same constraint in the conventional, unconjoined manner. An analysis in which a single constraint is implicatively co-ordinated with itself likewise fails to yield predictions distinct from an analysis which employs the same constraint individually (though we invite readers to verify this point independently). Therefore, effects of conjunction and implication are apparent only when distinct constraints are co-ordinated, never when a single constraint is conjunctively or implicatively co-ordinated with itself.

In the following section we present a case of self-disjunction which helps to clarify the role of shared arguments which provide the focus for macro-constraints.

7. Self-disjunction and secondary stress in Bolivian Guaraní.

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[42] In contrast to the proposals of this paper, Fukazawa & Miglio (1996) propose to restrict constraint co-ordination (specifically, disjunction) to constraints from the same family. (We are grateful to John Alderete for bringing this work to our attention.) Under the proposal of these authors, for example, any two OCP constraints may be co-ordinated, even if they do not share an argument. However, an OCP constraint referring to some property P could not be co-ordinated with, say, an IDENT constraint which also refers to P--a co-ordination which would be permitted in our model. While we agree with Fukazawa & Miglio's intuition that co-ordination should be restricted, we note that the 'same constraint family' limitation seems arbitrary, and it is not clear to us from what such a criterion would follow. We note also that in each of Fukazawa & Miglio's examples, the co-ordinated constraints may be interpreted as sharing an argument, even when this argument is not explicitly identified by Fukazawa & Miglio. For example, if OCP[place] and OCP[stop] are interpreted as restrictions on *segments* which are linked to the relevant features, then the segment would be the argument shared by the co-ordinated constraints. (Similar reanalyses are available for other examples discussed by Fukazawa & Miglio.) Under this interpretation, Fukazawa & Miglio's example falls into line with the model developed here, and membership within a single family of constraints is accidental.

[43] This is true whether or not violations of some self-conjoined constraint are distributed across the columns of the macro-constraint.

In this section we provide an example of self-disjunction in Bolivian Guaraní (BG). This language, also known as Chiriguano, is so far unrepresented in the phonological literature. As reported by Schuchard (1979), Dietrich (n.d. [1985]) and Gustafson (1996), primary stress in BG falls on the penultimate syllable of the prosodic word (PrWd). Here we are concerned with a previously undescribed pattern of secondary stress reported by Crowhurst (1997) based on original fieldwork. Secondary stress in BG is optional. When present, however, it falls systematically on the initial syllable of the PrWd when at least two syllables precede the main stress. The patterns of primary and secondary stress just described are illustrated by the verbal forms in (80).[44] Note especially that secondary stress is absent in (80b,c) where primary stress falls on the second syllable, and that (80i,j) shows that only one syllable in the PrWd receives secondary stress; syllables occurring between accented syllables are unstressed.

(80)a.	/pe-yu/	pé.yu	'2pl-come ? '
b.	/a-g^{w}ata/	?a.g^{w}á.ta	'1sg-walk'
c.	/re-pua/	re.pú.?a	'2sg-get.up'
d.	/re-pua-ta/	rè.pu.?á.ta	'2sg-get.up-FUT.DEF'
e.	/a-ye-kañɪ/	?à.ye.ká.ñɪ	'1sg-REFL-lose'
f.	/a-ye-kañɪ-a/	?à.ye.ka.ñɨ .?a	'1sg-REFL-lose-NEG'
g.	/o-mo-g^{w}ata/	?ò.^{m}bo.g^{w}á.ta	'3sg-CAUS-walk'
h.	/o-mo-g^{w}ata-ta/	?ò.^{m}bo.g^{w}a.tá.ta	'3sg-CAUS-walk-FUT.DEF'
i.	/o-mo-g^{w}ata-ta-a/	?ò.^{m}bo.g^{w}a.ta.tá.?a	'3sg-CAUS-walk-FUT.DEF-NEG'
j.	/a-ye-kañɪ-ta-a/	?à.ye.ka.ñɪ.tá.?a	'1sg-REFL-lose-FUT.DEF-NEG'

Exceptions to the pattern of word-initial secondary stress in (80) are systematically observed in a single context: when no more than one syllable of prefixed material separates the verb root from the left edge of the PrWd, secondary stress falls on the root-initial syllable--that is, on the second syllable of the PrWd instead of the first. Typical examples appear in (81).[45]

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44 Verbal forms are used because nouns are generally not long enough for secondary stress to surface. The patterns of stress assignment discussed here are attested both in the Ava and in the Isoso dialects of Bolivian Guaraní. The forms cited here are from the Isoso dialect. Isoso forms have been chosen because Isoso lacks almost completely the effects of nasal harmony which result in richer surface alternations in Ava. Citing data from the non-nasalising dialect here allows us to focus without distraction on the metrical facts under discussion.

45 There are two types of exceptions to the general rule of penultimate primary stress. The first occurs in forms containing the suffix *ye* , which indicates repetition. *Ye* always receives primary stress and is never followed by a stressed syllable, even when the penult and ultima are unstressed. The examples in (81) show that primary stress may occur finally, on the penult, or on the antepenult, depending on the position of *ye*.

?a.ka.ñɨ .yé 'I moved repeatedly'

(81)a.	/o-g^wata-ta-a/	?o.g^wà.ta.tá.?a	'3sg-walk-FUT.DEF-NEG'
b.	/re-pua-ta-a/	re.pù.?a.tá.?a	'2sg-get.up-FUT.DEF-NEG'
c.	/o-kañI-ye-ta/	?o.kà.ñI.yé.ta	'3sg-lose.oneself-REPET-FUT.DEF'
d.	/o-tini-ye-ta/	?o.tì.ni.yé.ta	'3sg-dry-REPET-FUT.DEF'

Summing up, the root-initial syllable is stressed when it coincides with the first or second syllable of the PrWd. Otherwise, secondary stress defaults to the word-initial syllable, a prefix.

Stressing the root is clearly a priority, but not when it is situated more than one syllable from the beginning of the prosodic word. We attribute pressure toward stressing root-initial syllables to the constraint INITIAL-FOOT(ROOT) in (82).

(82) INITIAL-FOOT(ROOT): Align (Root, Left, Foot, Left)
('Every root is left-aligned with a foot'; One * for every root which does not begin with a foot.)

When higher-ranking constraints preclude stressing the root-initial syllable, stress defaults to the first syllable of the PrWd. This result is an effect of INITIAL-FOOT(PRWD) in (83).

(83) INITIAL-FOOT(PRWD): Align (PrWd, Left, Foot, Left)
('Every PrWd is left-aligned with a foot'; One * for every PrWd which does not begin with a foot.)

The emergence of root stress in forms like *? o.g^w à.ta.tá.? a* is evidence for the ranking Initial-Foot(Root) » Initial-Foot(PrWd); under the alternative, root stress should never occur.

Of particular interest from our point of view is the disyllabic window effect observed in the BG data: even though stress is optimally assigned to root initial syllables, stress assignment may skip no more than one syllable at the left edge of the word to secure this outcome. (Thus, forms

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?a.ka.ñɨ .yé.ta.?ã 'I didn't move repeatedly"

The second exception involves a class of suffixes exemplified by *-ma* 'past?', the interrogative morphemes -*pa* and -*ra*, and the relativizer -*vae*. These suffixes exhibit two properties relevant for this discussion. First, they are positionally restricted. The forms in (82) show that when one or more of these suffixes is present, they occur in a block at the right edge of the verb. Second, suffixes in this class are never stressed. Primary stress falls on the second syllable preceding the first in any string of these suffixes (≥ 1) present in a verb. Finally, the relevant generalization concerning the behaviour of the suffixes -ma, -pa, -ra, -vae is that they are not counted by the stress-assigning processes in BG. The neutral behaviour of these suffixes follows under the assumption that they are clitics, and are not included in the domain of stress assignment (usually the prosodic word) in BG.

such as *? *o.ᵐbo.gʷ à.ta.tá . ? a* do not occur in Crowhurst's data, and multiply stressed forms such as *? *ò.ᵐbo.gʷ à.ta.tá . ? a* are likewise unrepresented.) This is a threshold effect similar to others discussed by researchers who have discussed self-disjunction (e.g. Alderete 1997). Within the model we are developing, movement one and no more than one syllable to the right is the result of self-disjoining the constraint ALL-FEET-LEFT (AFL) in (84).

(84) ALL-FEET-LEFT: Align (Foot, Left, PrWd, Left)
('Every foot is left-aligned with some PrWd'; One * for every intervening syllable.)

The disjunction required to account for the BG data is shown in (85). The focus of the disjunction will be the foot.

(85) ALL-FEET-LEFT v^{FOOT} ALL-FEET-LEFT

In BG, the prohibition on excessive rightward movement takes precedence over the requirement to stress root-initial syllables, showing that the disjunction in (85) outranks Initial-Foot(Root). The partial ranking we have motivated so far is shown in (86).

(86) ALL-FEET-LEFT v^{FOOT} ALL-FEET-LEFT » INITIAL-FOOT(ROOT) » INITIAL-FOOT(PRWD)

The tableau in (87) presents the analysis of the form *? o.gʷ à.ta.tá.? a* under this account[46].

(87) Input /o-gʷata-ta-a/

Candidates		AFL $_v$FT AFL	Init-Ft(R)	Init-Ft(PW)
a. C	o (gʷà ta)$_\alpha$(tá ?a)$_\beta$	(*)α		*
b.	(ò gʷa)$_\alpha$ ta (tá ?a)$_\beta$		*	
c.	o gʷa ta (tá ?a)$_\beta$		*	*

46 Note that no initial foot is constructed in this form, to satisfy Initial-Foot(PrWd). An initial foot is ruled out by FtMin. Degenerate are generally not tolerate in BG. The only exception occurs in cases where the accented suffix *yé* occurs in word-final position. Thus, it must be the case that FtMin dominates the other constraints required in this analysis, though FtMin must itself be dominated by faithfulness constraints leading to the preservation of input accentual structure.

In *? o.g*^{w} *à.ta.tá.? a*, the root-initial syllable may be stressed because under the self-disjunctive analysis, the single violation of All-Feet-Left by the foot labelled *α* is not enough to violate the disjunction. All candidates under consideration pass the macro-constraint, and the decision is passed to Initial-Foot(Root), resulting in the selection of candidate (87a) as optimal.

In presenting the analysis of *? o.g*^{w} *à.ta.tá.? a*, we have represented for All-Feet-Left only the penalty incurred by Foot$_{\alpha}$, abstracting away from penalties assessed for Foot$_{\beta}$. As shown in (88), Foot$_{\beta}$ earns three violations of All-Feet-Left for each of the candidates in (87).

(88) Input /o-g^{w}ata-ta-a/

Candidates		AFL	$_{v}$FT	AFL	Init-Ft(R)	Init-Ft(PW)
a. C	o (g^{w}à ta)$_{\alpha}$(tá ?a)$_{\beta}$	(*)α (*)β	*	(**)β		*
b.	(ò g^{w}a)$_{\alpha}$ ta (tá ?a)$_{\beta}$	(*)β	*	(**)β	*	
c.	o g^{w}a ta (tá ?a)$_{\beta}$	(*)β	*	(**)β	*	*

Recall from the initial discussion that primary stress in BG is always penultimate. We assume that Foot$_{\beta}$ must be present, even though it incurs violations, due to a possibly undominated constraint MAIN-STRESS-RIGHT, which requires right alignment between the PrWd and the main stress foot. As all candidates tie on violations by Foot$_{\beta}$, we do not represent these in tableaus that follow. Crucially, however, it must not be possible to combine micro-violations assessed for Foot$_{\alpha}$ and Foot$_{\beta}$ in (87a); otherwise, this candidate would incur two marks against the disjunction, enough to exclude it from the candidate set.

The preceding analysis of the form *? o.g*^{w} *à.ta.tá.? a* is insufficient to make the case for a disjunction All-Feet-Left v^{FT} All-Feet-Left, however. The attested results in this case alone are also predicted by a non-disjunctive analysis which posits the ranking Initial-Foot(Root) » All-Feet-Left » Initial-Foot(PrWd). The case for disjoining All-Feet-Left with itself rests on forms like *? ò.*^{m}*bo.g*^{w} *a.ta.tá.? a*, in which the root lies two syllables from the beginning of the PrWd. In this case, the ranking Initial-Foot(Root) » All-Feet-Left » Initial-Foot(PrWd) predicts the unattested **? ò.*^{m}*bo.g*^{w} *à.ta.tá.? a*: in particular, the fragment Initial-Foot(Root) » All-Feet-Left predicts root-initial stress at the expense of All-Feet-Left. A word-initial foot should still occur, because it violates neither of the higher ranked constraints under this analysis. Only the analysis which posits the the disjunction of All-Feet-Left with itself predicts the attested outcome, as the tableau in (89) demonstrates.

(89) Input /o-mo-g^wata-ta-a/

Candidates		AFL	$\vee$FT	AFL	Init-Ft(R)	Init-Ft(PW)
a. ☞	(ò ^{m}bo)$_\alpha$ g^wa ta (tá ʔa)$_\beta$				*	
b.	o ^{m}bo g^wa ta (tá ʔa)$_\beta$				*	*!
c.	o (^{m}bò g^wa)$_\alpha$ ta (tá ʔa)$_\beta$	(*)α			*	*!
d.	(ò ^{m}bo)$_\alpha$(g^wà ta)$_\gamma$(tá ʔa)$_\beta$	(*)γ	*!	(*)γ		
e.	o ^{m}bo (g^wà ta)$_\gamma$(tá ʔa)$_\beta$	(*)γ	*!	(*)γ		*

As in the previous tableau, we abstract away from violations of the main stress foot. Candidates (88d,e), each with a root-initial foot, incur two All-Feet-Left violations, and therefore violate the disjunction. The remaining candidates do not violate the disjunction. All of these candidates violate Initial-Foot(Root), however, so this constraint cannot act on the candidate set, and the decision defaults to Initial-Foot(PrWd).

Before concluding, we comment on another type of analysis which might be imagined as a solution for the BG threshold effect: could a disyllabic window effect at the periphery of the PrWd in this case not be accounted for by an analysis which places the constraint *LAPSE in (90) in dominant position?

(90) *LAPSE: An unstressed syllable may not occur adjacent to an unstressed syllable. (One * for every weak-weak pair of syllables.)

The one-syllable movement restriction on secondary stress could indeed be accounted for by an anti-lapse treatment. However, under an analysis which prohibits weak-weak lapses word-initially, we would have no explanation for the extensive medial lapses occurring in forms such as *ʔò.^{m}bo.g^wa.ta.tá.ʔa*. The failure of the anti-lapse analysis in this respect is demonstrated by the tableau in (91).

(91) *Lapse » Initial-Foot(Root) » Initial-Foot(PrWd); Input /o-mo-g^wata-ta-a/

Candidates		*Lapse	Init-Ft(R)	Init-Ft(PW)
1a.	(ò ^{m}bo) g^wa ta (tá ?a)	*! *	*	
1b.	o ^{m}bo g^wa ta (tá ?a)	*! **	*	*!
1c.	o (^{m}bò g^wa) ta (tá ?a)	*!	*	*!
1d. D	(ò ^{m}bo)(g^wà ta)(tá ?a)			
1e.	o ^{m}bo (g^wà ta)(tá ?a)	*!		*
2a. C	o (g^wà ta)(tá ?a)			*
2b.	(ò g^wa) ta (tá ?a)	*!	*	
2c.	o g^wa ta (tá ?a)	*! *	*	*

An account which posits the sub-hierarchy *Lapse » Initial-Foot(Root) » Initial-Foot(PrWd) predicts the right result for *o.g^w à.ta.tá.? a* in (91.2) (an accident of the number of syllables following the root), but the wrong result for ? *ò.^{m}bo.g^w a.ta.tá.?a* in (91.1).

8. Conclusion.

The previous sections have been devoted to developing an OT-based model within which to represent certain cases of complex phonological behaviour in which a primary pattern is conditioned not by a single (morpho-) phonological factor, but by a set of mutually reinforcing requirements. Typically, when one (or more) of these requirements cannot be satisfied, the primary pattern is blocked and a secondary pattern is realised by default. We argued that such cases provide evidence that subsets of constraints may participate in relationships of dependency which do not characterise other subsets of constraints within the same systems. The approach taken was to combine the dependent constraints into derived macro-constraints, whose overall evaluation is determined by the co-ordinated evaluation of the individual constraints. The meaning and implications of *co-ordinated evaluation* has been developed on analogy with operations familiar from boolean logic. We argued that complex morpho-phonological patterns found in Diyari and Zezuru Shona motivate the existence of co-ordinated pairs of constraints whose evaluation as a unit is parallel to the evaluation of a boolean conjunction, with *True* in the case of boolean conjunction correponding to *passing evaluation* in the optimality-theoretic interpretation. A third pattern found in Dongolese, though superficially similar to the Zezuru example, was shown to motivate a macro-constraint whose evaluation is parallel to the evaluation of a boolean implication. Finally, we noted that the relation of local conjunction proposed by Smolensky (1995, 1997) is parallel to boolean disjunction in terms of our system, but does in fact correspond to boolean conjunction if *True* in the boolean case corresponds to *failing evaluation* in terms of the OT case. (Similarly, our conjunction corresponds to disjunction under Smolensky's interpretation.) Definitions for the boolean operations explored in this paper are repeated in (92).

(92) *Boolean operations.*

a. *Conjunction:* The conjunction $A \wedge B$ is true iff proposition A is true *and* proposition B is true.

b. *Implication:* If A is true, then the truth value for B determines the truth value of $A > B$:
If B is true, then $A > B$ is true;
If B is false, then $A > B$ is false.

If A is false, then A > B is false, and the truth value of B is irrelevant.

c. *Disjunction:* The disjunction $A \vee B$ is true iff proposition A is true *or* proposition B is true.

The optimality-theoretic interpretations of boolean conjunction, disjunction, and implication adopted in our model are reviewed in (93).

(93) Optimality-theoretic interpretations of boolean operations.

a. *Conjunction:* A candidate Cand passes a conjunction $A \wedge B$ iff Cand passes constraint A *and* Cand passes constraint B.

b. *Implication:* If Cand passes A, then Cand is evaluated with respect to B:
If Cand passes B, then Cand passes A > B;
If Cand fails B, then Cand fails A > B.
If Cand fails A, then Cand fails A > B and Cand's success on B is irrelevant.

c. *Disjunction:* A candidate Cand passes a disjunction $A \vee B$ iff Cand passes constraint A *or* Cand passes constraint B.

While the model we have proposed represents an attempt to make explicit some of the details underlying complex interactions between constraints, we do not claim to have offered an exhaustive account. It is therefore important to note that a number of issues are left for future study. First of all, each of the cases used in developing our model involves a prosodic phenomenon, either stress or tone. This bias represents nothing more than the primary interests of the authors. We do not expect the relations discussed in this paper to be limited to prosody, or to the prosody-morphology interface. Examples of disjunction (a.k.a. local conjunction) in the analysis of segmental phenomena have been discussed by Fukazawa & Miglio (1996), Kirchner (1996), and Alderete (1997), and we expect that examples of conjunctive and implicational constraint co-ordination will also be found to occur. As a preliminary example, Tivoli Majors has observed (personal communication, March 1997) that transparency in systems with iterative vowel harmonies may be analysed as a case of implication. Chip Gerfen (personal communication, August 1997) comments that nasal docking in Coatzospan Mixtec exhibits behaviour very like the assignment of metrical feet in Diyari, and suggests that a conjunctive analysis along those lines might successfully account for the pattern.

A second issue concerns our claim regarding the management of candidate sets under constraint failure. We argued that when some constraint C acts on a candidate set such that some candidates pass and other fail C, the failing candidates are literally excluded from further consideration. That is to say, once their fate has been determined, candidates are no longer evaluated for performance on lower-ranked constraints. If our argument has been successful, the broader implication for OT is that multiple violations of low-ranked constraints do not truly fail to outweight single violations of dominant constraints, because the lower-ranked violation are never actually assigned. Under this view, dominant constraints do not truly have absolute veto power over lower-ranked ones; dominant constraints rule only because there is no feedback from below. If there is no feedback from below once a candidate dies, this makes the strong claim that low-ranked constraint *can never* outweigh a dominant one that acts on a candidate set. This is not merely a stipulation but rather an impossibility, argued for on principled grounds. This strong claim could be falsified if further study should reveal good counter-examples. (Of course, the right kind of counter-example should not involve disjunction, a mechanism developed specifically as a means of neutralising the effect of apparently high-priority requirements.)

The shared argument criterion discussed throughout the paper imposes a strong restriction on co-ordination. Even so, the questions of how many constraints, and how many distinct operations may be co-ordinated within a single macro-constraint have not been resolved. The case studies presented in support of our model so far have all involved patterns whose analyses have required the co-ordination of only two constraints, or of a single constraint with itself. However, nothing in our model requires an upper limit of two on the number of constraints which may participate in a co-ordinated interaction, and we see no principled reason for imposing such an arbitrary restriction. This raises the question of exactly how complex co-ordinated interactions may be. Moreover, if more than two constraints may be co-ordinated, an additional question arises: will pairs of constraints in co-ordinated sets be linked by a single operator, or may different operators be involved? In other words, could a single co-ordination combine not only different constraints, but also different relations? Complex expressions such as (94), in which a pair of arguments *A* and *B* are disjunctively related and in which the string *(A ∧ B)* participates in an implication with a third argument *D* are possible in boolean logic.

(94) $(A \vee B) \rightarrow D$

A final question is whether the focus of a macro-constraint is inherited transitively from its members. We reasoned in §2 that the focus of a conjunction must correspond to an argument common to the statement of every conjunct. Our model extends the shared argument requirement to all types of co-ordinated relations (macro-constraints). This correspondence is necessary so that the focus of the macro-constraint coheres with the requirement of each member constraint. Transitivity of focus would mean that a macro-constraint inherits the focus of both its constituents. In this case, only constraints which have the same focus (identified by the primary argument) may be co-ordinated. However, we may ask whether this must be the case, or whether the focus of the macro-constraints could possibly correspond to a shared argument which for at least one of the co-ordinate constraints is not focal. In other words, consider FOOT-TO-σ in (95a), which is the inverse of σ-to-Foot in (7b), repeated in (95b); its focus (identified with the universally quantified argument) is a foot, not a syllable.

(95)

a.	FOOT-TO-σ:	Link (**Foot**, σ)	"**Every F** is associated to some σ."
b.	σ-TO-FOOT:	Link (σ, Foot)	"**Every** σ is associated to some F"
c.	NOCODA :	Align (σ, Right, Vowel, Right)	"**Every** σ ends with some vowel."

The question being considered is whether a constraint like NoCoda in (95c) (=7a), which has the syllable as its primary argument (focus) could be conjoined with Foot-to-σ, for which the syllable is non-focal, or even whether Foot-to-σ could be co-ordinated with some other constraint which specifies the syllable as the nonprimary argument. We see no reason in principle why primary-nonprimary or even nonprimary-nonprimary combinations could not be possible. However, as the examples examined in the following sections involve only macro-constraints which co-ordinate constraints sharing primary arguments, the possibility of other combinations is left open. We note, however, that at least in the case of conjunction, the more restrictive position that focus-inheritance is transitive (in the respect discussed here) is consistent with the defining property of conjunctions that neither constituent is dominant, as would be suggested if the conjunction were to inherit the focus of one conjunct and not the other.[47]

We believe these to be questions which can and should be explored, and that understanding them will most likely produce gains for optimality-theoretic approaches to natural language phenomena.

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[47] To take an analogy from syntax, two syntactic constituents may be conjoined if they have the same phrasal category; for example, two noun phrases may be conjoined in English, and the parent node inherits the category of both conjuncts. Noun phrases and verb phrases, however, are not similarly conjoined.

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